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"So, the World Isn't Just Old White Guys?": Student and Teacher Experiences in a Culturally Relevant Advanced Placement Chemistry Class

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DEDICATION

This work is dedicated to my students—past, present, and future. You are the heart of my work, and I am grateful to those who taught me lessons along the way. To the students who participated in this study, I am extremely grateful of your time and effort. Your kindness and encouraging words gave me confidence to try new things and helped me become a better teacher. I hope the lessons we shared and conversations we had will serve you well. To my future students, I hope my heart and desire to do what's right for you is as true as it is today.

I also dedicate this work to my children, Alston and Anna Kate. You two are the craziest, silliest, and sweetest kiddos I know! You both make me extremely proud to be your dad. In my lifetime of education, you two will teach me more than anyone else. I am so thankful to watch you grow and excited to see the great things you will do in this world.

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ABSTRACT

This action research case study explores the impact of a culturally and socially diverse Advanced Placement Chemistry curriculum on student and teacher experiences. This study emerged due to my lack of multicultural teaching practices, which limited meaningful connections for students of diverse backgrounds. Once aware of this deficiency, I created four thematic units that blended chemistry content with aspects of culturally relevant pedagogy and social reconstructionism. Surveys, reflection logs, observations, and a focus group interview captured data related to student and teacher experiences throughout the intervention period, which suggest the culturally relevant pedagogy supported students' understanding of content, increased student engagement, shaped both immediate and long-term perspectives, and led to improved classroom relationships. Additional benefits for me as a teacher included improved relationships with students, improved confidence, and improved awareness of cultural biases in my teaching practices. Based on these outcomes, I recommend that educators use problem-based approaches to support critical investigations, student presentations to support student choice and meaningful self-reflection, and an overall expansion of culturally relevant themes in other curricula to encourage and support personally meaningful and relevant connections for students.

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LIST OF ABBREVIATIONS

AP ..... Advanced Placement

CRP ..... culturally relevant pedagogy

CSP ..... culturally sustaining pedagogy

LDC..... less developed country

CHAPTER 1

INTRODUCTION

As a teacher with 17 years of experience and a master's degree centered on science teaching, I should be pretty good at my job. If asked, I could articulate the thoughtful structure and progression of my long-range plans, which lay out the entire Advanced Placement (AP) curriculum built upon scaffolding practices and crosscutting concepts bridging one standard to the next. Anyone who enters my classroom can witness my Socratic-style lessons prioritizing teacher–student discussions, designed to assess not only what students know but also their ability to prove it. I have been nominated for our school's Teacher of the Year award several times and recently won, so I must be doing something right.

For many years, I followed the same template for success, which represented my belief of what a responsible science classroom should be. My highest priorities were strict alignment to state and district standards and facilitating a rich understanding of scientific principles and concepts to prepare my students for their next steps in science education. However, my focus on factoids and subject matter inhibited my ability to create meaningful learning experiences for all students in my classroom. Although my approach laid the foundations for their content knowledge, it was not conducive to the sort of relevant experiences that can prepare the next generation for real-world complexities. In a world that is intricate and unique, my narrow, monochromatic

perspective likely robbed students of opportunities to immerse themselves and explore the content in meaningful and relatable ways and excluded the diverse perspectives in my classroom.

Problem of Practice

Analyzing my past experiences and registering my identity as a White male educator, I realized my curriculum and pedagogy should be more inclusive of the diversity in my classroom. The chemistry textbook highlights the achievements of famous White scientists such as Albert Einstein, Niels Bohr, John Dalton, and Amedeo Avogadro. Notably missing from those same pages are the scientific contributions of women and people of color. This imbalance creates a skewed perception of STEM fields, such that students who are not White and male lack a sense of belonging (Peters-Burton, 2018). The disconnect that can exist between an individual's personal identity and social identity in the classroom can manifest in a belief that if a student cannot relate to the content of a course, they cannot succeed in the course. Self-efficacy is a known predictor of academic achievement (Miles & Naumann, 2021; Zeldin & Pajares, 2000), so educational practices that acknowledge and celebrate diversity are vital for student success.

U.S. classrooms have become increasingly diverse over the past decade (National Center for Education Statistics, 2019). Reflecting these national trends, my classroom is more diverse than ever, with over 30% of students identifying as Asian and two other students who have recently lived outside of the United States. As the population continues to diversify, creating equitable learning

opportunities to support students' unique perspectives and experiences is crucial. Teachers and learners are unique individuals with complex identities, histories, and contexts (Ginsberg & Wlodkowski, 2019). Recognizing and responding to these differences requires a commitment to culturally relevant pedagogy (CRP), which can improve student motivation, academic success, and cultural competence (Gay, 2002; Ladson-Billings, 1995a, 1995b). My pedagogy lacked such a commitment, prompting a reconstruction of my definition of success to extend beyond my previous benchmark of academic success and instead target the development of culturally and critically minded students.

A commitment to culturally relevant teaching goes beyond making students feel good; rather, success comes when students choose to pursue academic excellence (Ladson-Billings, 1995a). The end-of-course averages and passing rate on the AP exam suggest my students are academically excellent, but I wonder how many of them make a conscious choice to pursue excellence. Teaching AP science courses affords me the privilege of teaching the most academically gifted students who are naturally "good" at doing school. Their mastery of school norms and systems allows many students to avoid thinking too deeply. Beyond preparation for a standardized test, my charge as a teacher should be to inspire students to think deeply on connections between their experiences and scientific knowledge. Lessons that are critically and socially mindful of student perspectives create a classroom that embodies cultural competence and models an atmosphere of respect for the values and perspectives of others (Ladson-Billings, 2013).

As an action researcher, I intentionally altered my instruction in response to my problem of practice. Action research is “less a methodology than an orientation or stance toward the research process” (Herr & Anderson, 2005, p. 1). This alternative stance, which allows practitioners to borrow methods and insights from traditional research to resolve unique and localized problems, drove my efforts to integrate the principles of CRP into my classroom and effect positive change for my students and me.

Theoretical Framework

Principles of CRP and social reconstructionism guided this action research study, providing a foundation for creating a science curriculum that is more student-centered and purposeful. Such a curriculum recognizes diverse cultures and life experiences to make learning relevant for all students while offering equitable support for building higher-level academic skills. In addition to facilitating immediate support during classroom instruction, it equips students with world-class knowledge and skills that will follow them long after the conclusion of the study (South Carolina Education Oversight Committee, 2015).

CRP

Critical theory underpins CRP and thus laid a foundation for critical research with the goal of exposing repression, domination, and inequities to bring about social change (Efron & Ravid, 2013). Whereas critical theory enables scholars to analyze social differences between dominant and marginalized groups more broadly, the specific context of teaching was central to my study: presentation of content, how students engage with and make meaning of the

content, and various modes of feedback and assessment. Therefore, CRP was an appropriate lens for my action research because it framed my efforts to connect the inner workings of my classroom and the academic success of my students with their culture and identity (Gay, 2002, 2013, 2018; Ladson-Billings, 1995a, 1995b). Personalized learning links curriculum standards and student experiences, promoting deeper understanding that leads to academic success. Establishing these connections is not necessarily a problem for White students, who encounter a curriculum that celebrates White scientists, but could be a barrier to success for students of other races (Rawson & McCool, 2014). Thus, CRP promotes a more inclusive approach that seeks out the perspectives and contributions of all stakeholders. In this way, students become aware of alternative viewpoints and perspectives different from their own and begin to develop their cultural and critical consciousness.

CRP encompasses three primary tenets (Ladson-Billings, 1995a). First, teachers must believe all students can experience academic success. To reduce the racialized achievement gap, teachers must provide engaging opportunities for students of color that stimulate their intellectual growth and problem-solving ability. Second, CRP promotes developing or maintaining students' cultural competence—a congruent set of behaviors, beliefs, and attitudes that enable effective and respectful collaboration among diverse groups (Cross et al., 1989). Third, culturally relevant teachers believe that students must develop critical consciousness to challenge the unjust status quo.

More recent scholarship promotes the use of culturally sustaining pedagogy (CSP), an extension of CRP toward the goal of classrooms that foster and perpetuate linguistic, literate, and cultural pluralism as part of democratic education (Alim & Paris, 2017). At the onset of my research, my primary focus concerned the experience of African American students in my classroom. My search for change in instructional patterns led me to CRP as a model for translating my instructional practice in terms of students' cultural experiences (Irvine, 2009). When the demographic of participants deviated from this specific subset, I extended the asset-based nature of CRP and incorporated features of CSP by including the value of community languages, practices, and ways of life; connecting my curriculum to cultural histories and ideas; and providing access for student to consider nondominant cultural practices. The two approaches are similar and share a common background, yet their nuances afforded opportunity for further reflection, as I discuss in Chapter 5.

Social Reconstructionism

As CRP stimulates students' critical consciousness through critical examination of their beliefs, students may discover the need for social justice reform. Outlining how students can apply their learning to that end, social reconstructionism is an ideology that focuses on repairing the status quo by addressing social questions and injustices (Schiro, 2013). Achieving this ideal requires the "masses of humanity to critically analyze themselves in relation to their society, understand the ills of their society, develop a vision of a better world based on a conception of social justice, and actualize that vision" (Schiro, 2013,

p. 151). To achieve both vision and action (i.e., change), education is the key. Acknowledging that society is inherently unhealthy, social reconstructionist educators view school as a tool for solving social problems and advocate for student-centered curriculums that facilitate critically examining world events and controversial issues (Schiro, 2013). For example, opportunities for inquiry, dialogue, and sharing diverse perspectives allow students to consider real-world problems and develop new and better solutions (St. Norbert College, 2015).

Like CRP, a social reconstructionist approach was also appropriate for my action research because it offered a powerful pedagogical model. I wanted to shift my students and myself from the perspective of "knowledge as a product to knowing as a process" (Jones & Brader-Araje, 2002, p. 7). Aligned with CRP, social reconstructionism also provided a framework for developing students' critical and cultural consciousness, central to resolving my need for a more equitable classroom.

Purpose and Research Questions

The purpose of my critical action research was to create a more inclusive, critically conscious classroom. By analyzing my curriculum through the aforementioned lenses and attending to my students' experiences, I hoped to provide equitable learning opportunities and support diverse perspectives while sustaining high levels of rigor and academic success. My research aim also required me to challenge myself to be more reflective and critically conscious. My existing teaching habits and beliefs resulted, in part, from my unchallenged authority as a White male in the field of education. This narrow perspective did

not account for the interests, beliefs, and concerns of all students, especially students who do not look like me. Intentionally pursuing cultural diversity while designing lessons, I sought to advance my own cultural awareness and empathy toward my students—vital attributes for teaching in diverse classrooms.

To measure changes in my students and myself in response to the changes I made in my curriculum and pedagogy, I investigated the following research questions:

1. How do my students experience a more culturally and socially relevant science curriculum?
2. How does planning and implementing a culturally and socially relevant science curriculum impact my experiences as a teacher?

These questions align with my theoretical framework. Immersing my students in CRP could support their racial, ethnic, and gender identities, which, in turn, could promote the sense of belonging critical to academic success (Brown, 2004). Question 1 sought evidence of that anticipated outcome while—consistent with social reconstructionism—also documenting the extent to which my adapted classroom environment promoted students' thinking critically about social justice issues and advocating for change in their everyday communities. While Question 1 focused on the outward change in my classroom, Question 2 focused on the internal change in me. Addressing a complementary aspect of my multifaceted purpose, Question 2 captured evidence of my self-reflection as I addressed existing biases that shaped my instruction and worked toward developing my cultural competence and cultural awareness.

Overview of Methodology

As I explored participants' experiences with a more socially and culturally relevant curriculum, I was responsible for the design and implementation of the modified curriculum in two ways—as a researcher and as a classroom teacher (Herr & Anderson, 2005). Conducive to such a dual role, critical action research allows practitioners to explore and seek resolutions to context-dependent problems (Merriam & Tisdell, 2016). A specific iteration of action research, critical action research prompts participants to examine issues of race, class, gender, and power relations while considering ways to bring about meaningful change (Carpenter & Cooper, 2009). In this case, my students and I engaged in discourse that challenged our assumptions.

Herr and Anderson (2005) suggested action researchers should adopt a narrative style, which encourages deep reflection on the research process and findings. Similarly, Creswell and Creswell (2018) recommended qualitative methods for research related to social justice. A qualitative design was thus appropriate for this study to aid my understanding of student and teacher experiences—best expressed in words rather than numbers (Busetto et al., 2020; Merriam & Tisdell, 2016).

Mertler (2017) outlined four steps for action research: Identifying a focus area, collecting data, analyzing and interpreting data, and developing a plan of action. Having identified a problem in my classroom, I considered appropriate systems of collecting qualitative data that would allow me to design and assess an intervention. As I explain in Chapter 3, surveys, observations, reflection logs,

and a focus group provided richly descriptive data useful in determining the experiential outcomes of the changes I made in my classroom.

Positionality

My role in this study was multifaceted, given the context of my research—my own classroom. Therefore, as Chapter 3 elaborates, through all aspects of data collection and analysis, I reflected on how my positionality as a White man and my position relative to my participants influenced the study. As an insider-researcher, I examined "the outcomes of a program or actions in [my] own setting" (Herr & Anderson, 2005, p. 42). I had direct access to my students and the ability to implement instructional changes within the learning environment, prompting a need to consider potential biases related to my pedagogy and epistemological beliefs.

I have spent all 17 years of my teaching experience at my current high school; therefore, this one institution shaped my view of teaching in indelible ways. With over 90% of the faculty population and over 80% of the student population being White, the noticeable lack of diversity may explain my comfort with teacher-dominated pedagogy with little regard for diverse students. Being challenged to consider and reevaluate my instruction prompted my desire to gain a better understanding of my students to develop a more equitable learning environment. However, with little experience in engaging in CRP and operating from a social reconstructionist stance, I needed to monitor my own biases to ensure they did not interfere with my aim to create a classroom environment more conducive to critical discussion.

Beyond my race and gender, I needed to consider the influence of my expertise and training as a teacher. Numerous graduate-level science courses and professional development trainings had influenced my perceptions such that I tended to place a higher value on scientific principles over human experiences. For example, studies on the viability of nuclear energy as an alternative energy source dulled my sensitivity to the environmental and cultural impacts associated with the construction and accessibility of new nuclear power plants. Likewise, the overwhelming majority of my training through professional development opportunities focused on the standardization of content in lieu of student relationships. These one-shot sessions are often superficial in content and lack cohesive planning, rarely leading to improvements in student achievement (Yoon et al., 2007). As a result, I realized the majority of my educational training had done little to prepare me for implementing a culturally relevant curriculum.

An additional source of potential conflict was the power dynamic between my students and me—their teacher. AP students often value grades above all other indicators of learning or progress. If adapting my instruction made lessons more subjective, students may have felt pressured to skew their work to align with my perspectives for the sake of their grade (i.e., rather than being genuine).

Significance

If successful, my study promised to render my chemistry classroom a more transformative environment for my students and for me. Students' classroom experiences would be more meaningful, laying the foundations for academic success, developing greater cultural competence, and gaining

confidence in their ability to advocate for change on behalf of themselves and others. My intentional focus on all students' perspectives and experiences envisioned a more inclusive curriculum, vital for students who struggled to see themselves as scientists and who had yet to receive validation that they belong in my classroom. This pursuit of equity could lead to student empowerment and a better understanding of themselves and others, thereby inspiring students to maintain their cultural identity and integrity.

A second possible benefit of this study was the potential to guide other science teachers seeking more relevant approaches to their work. The review of literature in Chapter 2 presents the foundational aspects of CRP and social reconstructionism and ties them specifically to science education. Moreover, the research-based lesson plans I implemented as an intervention may inspire teachers to develop similar resources for their own classrooms.

Finally, this study was critical to my development as a teacher looking to foster a classroom environment that recognizes and celebrates the perspectives of students I have long overlooked in the design of my curriculum. By participating in discussions and listening to students share and discuss multiple perspectives, I gained a better understanding of the daily struggles diverse students face, allowing me to implement important changes and bring equity to my classroom.

CHAPTER 2

LITERATURE REVIEW

Beyond robust content knowledge, teachers need to cultivate deep understanding of their students and their students' cultures (Howard, 1999). When school populations become increasingly diverse, teachers must be prepared to restructure their classrooms accordingly (McFarland et al., 2019). However, many teachers are ill prepared to address the complicated web of cultural and racial diversity by using students' characteristics, perspectives, and experiences as conduits for teaching (Gallard et al., 2014; Gay, 2002; Johnson & Atwater, 2013; Lemons-Smith, 2013; Leonard, 2008; Lewis et al., 2002). Given the problem of practice introduced in Chapter 1, I included myself among such teachers and thus sought additional perspectives on how I might facilitate more culturally relevant and critically mindful lessons, chiefly by reviewing scholarship related to the lenses framing my research and resources that would support my aim to change my current practices specifically in a science education context. This literature review thus aligns with my research questions' focus on how my students and I experienced a new classroom approach.

Literature Review Methodology

This chapter surveys scholarly and credible peer-reviewed primary and secondary sources that explore the central topics of my study. The information I gained from this review provided historical context, a theoretical foundation, and

related themes with which to frame my action research. Using the University of South Carolina's online academic network, the Educational Resources Information Center, JSTOR, SAGE, Google Scholar, and my doctoral textbooks, along with such keywords as *culturally relevant pedagogy*, *social reconstructionism*, *culturally relevant teaching*, *critical race theory*, *constructivism*, and *cultural competence*, enhanced my understanding of my problem of practice as I prepared to resolve it.

Theoretical Framework

To aid my understanding of the framework I introduced in Chapter 1, I further examined historical and current perspectives of each component.

CRP

Ladson-Billings (2013) defined CRP as a "pedagogy of oppression, not unlike critical pedagogy but specifically committed to collective, not merely individual, empowerment" (p. 160). This definition is deeply rooted in the struggles African American students face at all levels by virtue of their social identities (Perry et al., 2003) and focuses on teaching students with regard to their identities, culture, and personal experience (Escudero, 2019). Gay (2002) expanded the scope of CRP by integrating specific methods of culturally responsive teaching. These techniques equip teachers to build better relationships with students, which supports students as they construct "a better understanding of themselves, others, and society" (Cullen, 2014, p. 25). Culturally responsive teaching assumes that situating academic knowledge and skills within students' lived experiences and frames of reference facilitates and

deepens learning by making lessons more personally meaningful, interesting, and appealing (Gay, 2002). Culturally responsive educators initiate positive changes on multiple levels, including instructional techniques, instructional materials, student–teacher relationships, classroom climate, and self-awareness (Gay, 2018). Aligned with CRP, culturally responsive teaching provides students with opportunities to think critically about the inequities in their own experiences and those of their peers.

Researchers have continued to reconstruct the definition and applications of CRP. Hammond (2017) challenged the systemic underdevelopment of African American students through a “watering-up” of a diverse curriculum to promote big-picture instructional equity. Contrary to “watering-down” the curriculum for low achieving students, Hammond’s “watering-up” approach is a challenge for teachers to build necessary scaffolding and skills that stretch and support students as they advance in their learning. Paris and Alim (2017) extended the conversation with the concept of CSP, which considers how learners’ identities and cultures evolve. CSP encourages curriculum that advances students’ cultural identities in real time while teaching math, reading, problem-solving, and civics (Caraballo et al., 2020).

Endorsing this need for a “remix” of the original theory to embrace a more dynamic view of culture, Ladson-Billings (2014) noted that CSP can use CRP as a framework and layer instructional shifts and other adaptations to ensure students are central to practice. In other words, these evolutions notwithstanding, CRP remained relevant to my research aims. These critical lenses are additive,

such that teachers need not abandon CRP even as they extend into CSP. Above all, educators can learn from marginalized students—not merely about them.

Lessons grounded in CRP prioritize representations of students' individual culture, identity, and personal experience (Gay, 2002, 2018; Ladson-Billings, 1995a, 1995b; 2001; Koss & Williams, 2018; Warren, 2017). Teachers who regularly consider these factors enable students to engage in authentic learning as valued members of the classroom (Howard, 1999; Paris & Alim, 2014, 2017). Such lessons serve two simultaneous purposes. First, they invite meaningful engagement from students whom curriculum writers have traditionally ignored. When students feel connected to the content, educators can attend to their academic needs and propel them toward excellence (García & Guerra, 2004; Ladson Billings, 1995b; Robinson & Biran, 2006). Second, CRP also broadens White students' education, improving their ability to embrace diversity, respect cultural and racial differences, and advocate for social justice reform (Pan, 2006).

Educators who aspire to CRP strive to improve their student–teacher relationships and their classroom climate (Brown, 2004; Gay, 2018; Irvine, 2012). Students should believe their teachers care for them, and teachers should make students feel visible, heard, valued, and important (Gay 2013; Parsons, 2005; Rychly & Graves, 2012; Tosolt, 2010; Valenzuela, 1999). Educators who build positive relationships with their students do so by affirming racial and cultural differences, understanding how learners construct knowledge, and knowing about the lives of the youth in their classrooms (Villegas & Lucas, 2002). Demonstrating knowledge of and support for students creates safe and secure

spaces to engage in civil, honest, and critical dialogue about sensitive issues (Cholewa et al., 2014; Delano-Oriaran & Parks, 2015) and allows students to express their individuality and perspectives without fear of backlash resulting in physical, emotional, or psychological harm (Holley & Steiner, 2005).

For students to make the most meaning of their classroom experiences, the curriculum must connect with their identity and their culture (Ladson-Billings, 1995b), hence the aim of my action research. Using CRP in the design of my study ensured I could answer my research questions authentically with appropriate data. More importantly, it facilitated my creation of a learning environment that instills greater interaction and relevance for the diverse group of students and the content that I teach.

Social Reconstructionism

The concept of social reconstruction, which emerged in the late 1800s (Ward, 1883, 1893), emphasized individuals' ability to influence social factors and suggested that education could lead to a more just and equitable world (Schiro, 2013). Dewey (1916, 1948) contributed to this ideology by describing the interconnectivity of education and social development. According to Riley (2006), Dewey's understanding of progressive education and the science of education contained the seeds of social reconstruction. For example, Dewey (1928) suggested that if social order requires a different quality and direction than the current position, schools should strive to educate for social change. Counts (1932a, 1932b) formalized this ideology by challenging a commonly held belief

that schools could solve all sorts of social problems. Instead, Counts suggested education was far broader than schooling (Riley, 2006).

Social and political reconstruction inspired many social movements from the 1930s to 1970s (Evans, 2007). One example is Myles Horton's Highlander Folk School, an adult education program established to promote social change through labor and civil rights movements. The school, which served factory, farm, and mineworkers in the mountains of Tennessee, reflected Horton's belief that overcoming social crises required educating the working (i.e., oppressed) class. In the 1940s, World War II interrupted such efforts, but Brameld (1956) revived interest in schools as sites for political and social change.

The ideology increased in popularity during the 1960s and 1970s as important social and political events—such as the civil rights movements, feminism, and protests of the Vietnam War—challenged dominant social perspectives (Schiro, 2013). In more recent decades, social reconstructionists have been concerned about corporate capitalism's efforts to regulate school reform via privatization and new accountability movements targeting teacher effectiveness, school efficiency, teacher education programs, and for-profit schools (Schiro, 2013). As curriculum development shifted from educators to businesses and politicians, social reconstructionists called for a reorientation of society based upon principles of equality and justice (Ayers & Ayers, 2011).

Counts (1932b) saw children as "bundles of potentialities which may be developed in manifold directions" (p. 15). Schools, therefore, have a responsibility to shape children as they begin to make meaning of their

experiences. By promoting critical thinking to transform “both social and personal consciousness to a higher realization of human solidarity” (White, 2005, p. 20), schools can be vehicles for reconstructing society through problem-based learning applied to real-life situations (Stern & Riley, 2002). In sum, curriculum should invite students to construct knowledge that addresses the real problems and concerns students face on local, societal, and global levels (Giroux, 2006).

Educators operating from this ideology take an invested position regarding the social, political, and moral values of the children they teach (Schiro, 2013), designing curriculum that helps students relate academic and personal goals to world, national, and local purposes (Cochran-Smith, 2004; Postman & Weingartner, 1969). Promoting collaboration and critical thinking through discussion and experiential learning, they encourage students to assimilate their experiences and construct knowledge symbolically by engaging mind—and body—in social interaction (McLaren & Giroux, 1997; Stern & Riley, 2002). Through lessons that cater to student interest, teachers offer opportunities for students to reflect, analyze, and reconstruct their understanding of society and the principles that shape them (Shoemaker, 2003). Students can then build from these experiences and their own interests as they continue to seek solutions to real-world problems.

Examples of these complex problems include racism, sexism, poverty, pollution, worker exploitation, climate change, population expansion, and energy crises (Schiro, 2013). I could easily integrate these issues into the current science standards. Thus, social reconstructionism, which encourages students to

consider their ways of thinking, feeling, and acting in response to social issues, readily aligned with CRP to constitute an appropriate framework for my study.

Historical Perspectives

Just as I explored the roots of my framework, I also reviewed historical perspectives to improve my understanding of the barriers marginalized students face. Researching the underpinnings of topics like racism, inequity, and underrepresentation in education proved valuable for my critical action research study. In addition to shaping the design of my modified curriculum, the knowledge I gained also bolstered my confidence in my ability to facilitate it.

Racism and its Effects in Educational Systems

Racism has been a factor in the United States since the country's inception, a practice inherited from settlers who carried over subdivisions of the White race based on different cultural backgrounds (Banks, 1995; Bonnett, 1998). This practice of identifying differences between individuals and assigning their worth based on race has plagued the nation's history and continues to manifest (Smedley & Smedley, 2005). Two historical implications of race include the identification and discrimination of Blacks and Native Americans. Harris (1993) commented on their interrelated marginalization:

> Although the systems of oppression of Blacks and Native Americans differed in form — the former involving the seizure and appropriation of labor, the latter entailing the seizure and appropriation of land — undergirding both was a racialized conception of property implanted by force and ratified by law. (p. 1715)

The practice reached a crescendo during the 18th century as the American colonies continued to exploit slave labor to keep up with the global demand for crops such as cotton and tobacco. The racial ideology of Whites as the standard class and Blacks as the substandard class was clearly established and has been protected and perpetuated in economic, educational, social, and cultural spheres (Turner & Parsons, 2014; Watkins, 2001).

The longstanding effects of this dichotomous classification manifest in education systems as the so-called achievement gap, a testament to pervasive racial and socioeconomic disparities in student achievement. Assessment and progress reports show significant discrepancies in the achievement of Black students compared to White students (Bowman et al., 2018; Carter & Welner, 2013), evident prior to children entering kindergarten and continuing to persist into their adult lives (Hanushek et al., 2022). The perpetuation and divergence of the achievement gap is exacerbated by curriculums and educational practices that do not represent the cultures of beleaguered individuals and thus result in intractable cognitive dissonance. Howard (1993) identified the stressful but necessary behavior of being a Black, Latinx, Hispanic, or Asian student:

> To be successful in mainstream institutions, people of color in the U.S. need to be bicultural and able to play by the rules of their own cultural community and able to play the game according to the rules established by the dominant culture. (p. 38)

Suppressing students' culture robs them of learning in schools where the content, instruction, and climate are exclusive in nature and serve as

impediments for success (Ladson-Billings & Tate, 1995). Thus, a more inclusive science curriculum in concert with culturally relevant teaching can decrease the achievement gap by promoting marginalized students' success.

In line with the evolution of CRP toward CSP, a more inclusive science curriculum benefits not only students of color, but also their White peers. Specifically, multicultural education should help White students understand, recognize, and combat racism (Banks, 1993), rather than exhibiting colorblindness and colormuteness (Castagno, 2008). In short, the way racialized privilege operates in society manifests in inequitable schooling with detrimental consequences for all learners.

A Need for Equity in the Curriculum

A common misconception is that scientific knowledge is value-free, and by extension, science education should also avoid any subjective biases and values, thus being completely objective (Sutrop, 2015). In reality, all scientific knowledge is socially constructed (Fuller, 1997), and thus marked by "the interest, motivations and aspirations both of the scientists that carry out such work and those who fund them" (Reiss, 2003, p. 3). Therefore, educators and students should examine incoming information for imbedded political and social influences—a first step in addressing social justice in science education.

Social justice is both a goal and a process, aiming for "full and equal participation for all groups in a society that is mutually shaped to meet their needs" (Bell, 1997, p. 3), while remaining "inclusive and affirming of human agency and human capacities for working collaboratively to create change" (p. 4).

This definition illuminated how I might bring about impactful and meaningful changes in my classroom, as did Hackman's (2005) suggestion that social justice education requires "an examination of systems of power and oppression combined with a prolonged emphasis on social change and student agency in and outside of the classroom" (p. 104). Because disempowerment, complacency, and hopelessness can thwart social progress, teachers may need to "move students from cynicism and despair to hope and possibility" (Hackman, 2005, p. 106), supplying tools for action and social change.

However, according to Hackman (2005), a "lack of self-reflection may prevent P–12 teachers from creating the kind of empowering and affirming classroom spaces that effectively support academic success for all students" (p. 107). Opportunities for self-reflection support educators and students, thus cultivating more social-justice-minded classrooms (hooks, 1994, 2003). White students can benefit from considering their previously undiscovered positions of White privilege (McIntosh, 2009), which then become sites for realignment, motivation, and enacting social change (Hackman, 2005). People of color can also profit from self-reflection on how internalized oppression may have affected their lives, their culture, and their communities.

Finally, Hackman (2005) emphasized awareness of multicultural group dynamics, which should shape the direction of class discussions and other activities. A teacher who fails to account for the classroom's group dynamics will be unable to address students' cultural needs and miss opportunities to serve them. Critical discussions are necessary regardless of the specific group

composition because “diversity and social justice issues affect all of our lives, and therefore should be an integral part of the classroom regardless of its make-up” (Hackman, 2005, p. 108).

An increasingly diverse science classroom like mine should provide learning opportunities that are relevant for all students. Meeting this expectation requires opportunities for students not only to access knowledge, but also to question, challenge, and reconstruct that knowledge in a way that leads to new understanding. As Moje (2007) argued, classrooms seeking equity must “offer possibilities for transformation, not only of the learner but also of the social and political contexts in which learning and other social action take place” (p. 4). Students must be aware that their actions not only directly impact themselves and their peers but also can have long-lasting repercussions on others outside of their immediate sphere. Taking up a topic of social justice in the science classroom can lead to explorations of social equity as students recognize their social influence on others and implications for taking action.

Underrepresentation in Science

The racial, social, and gender achievement gaps that have persisted over the past decade have coincided with disparate employment of African Americans in science-related professions compared to Whites (National Center for Education Statistics, 2019). The underrepresentation of African American students is multifaceted, reflecting both intrinsic and extrinsic factors (Carpi et al., 2017; Estrada et al., 2016; Estrada et al., 2018; Isik et al., 2018). Intrinsically, students’ academic mindset and motivation influence their participation in

science classes and pursuit of science-related professions (Rattan et al., 2015; Walton & Cohen, 2007). Research suggests one aspect of the academic mindset underrepresented groups question the most is their acceptance and belonging compared to their White peers (Ito & McPherson, 2018). Given whiteness as the social standard, spaces and discourses that are comfortable for White people may be sources of discomfort to people of color (DiAngelo & Sensoy, 2014; Leonardo & Porter, 2010). Consequently, students of color may not voluntarily enroll in science courses.

Another intrinsic factor connected to underrepresentation in science is the concept of a fixed or growth mindset (Kricorian et al., 2020). Dweck (1986) described a fixed mindset as the belief that one cannot change, while a growth mindset is malleable. In the same way a bodybuilder can target and strengthen muscle groups through exercise, students can flex various intellectual abilities through practice, targeted learning strategies, and assistance from others (Kricorian et al., 2020). Fostering students' growth mindsets can maximize learning and improve overall achievement, helping students of color feel more of a sense of belonging in science (Good et al., 2012).

Extrinsic influences also contribute to the inequitable distribution of students in science pathways. According to Falkenheim and Hale (2015), students of color in science and engineering pathways are more likely to come from backgrounds of poverty and low socioeconomic status as compared to their White peers. Such students often need to work full- and part-time jobs, limiting their ability to engage with the curriculum, faculty, or other opportunities integral

to science careers (Estrada et al., 2016). Moreover, non-White students may also be juggling the need to honor family obligations and backgrounds (Perreira et al., 2010; Plunkett & Bámaca-Gómez, 2003; Stewart et al., 2007; Tseng, 2004).

Underrepresentation in AP Classes

Another significant aspect of my context is the advanced nature of my classes. AP courses, which offer opportunities for academic rigor, are strong indicators of post-secondary success (Adelman, 2006). They prepare students for college-level coursework, increase their chances of admission, and promote future opportunities; however, minoritized students experience inequitable access to AP classes as evident in their disproportionate enrollment (Grissom & Redding, 2016; Patrick et al., 2020). Despite these long-discrepant data, gifted and talented programs continue to under-enroll marginalized groups (Donovan & Cross, 2002; Ford & Grantham, 2003).

Researchers have speculated on influences that may explain racial and ethnic disparities within gifted and accelerated programs, such as resource inequities, educator bias, and a lack of diverse educators. Funding gaps are particularly pronounced in schools that serve large populations of students of color (Morgan & Amerikaner, 2018), intensified by unjust distribution of district allocations (Roza et al., 2004). As a result, students of color are more likely to have underqualified and less effective teachers (Clotfelter et al., 2005; DeMonte & Hanna, 2014), thus limiting their access to and experiences in AP classes.

African Americans and other students of color also contend with the racial biases of those with the power to confer the title of gifted. Each state and school

may use a different determination of giftedness, but a common factor includes teacher recommendations and referrals (Donovan & Cross, 2002), which are subject to racial bias and systemic racism both implicitly and explicitly. Unjust decisions limit opportunities available to high-achieving students of color, denying them access to advanced curriculums (Kolluri, 2018).

A final and related limitation is a lack of teacher diversity. Students perceive teachers more favorably if they have the same racial and ethnic background (Wentzel, 2002), and Grissom and Redding (2016) found that African American students were more likely to gain access to gifted programs if they had a teacher of color, especially one they identified as a role model and who connected with their cultural needs and backgrounds. Educators of color can also serve as ambassadors and foster greater relationships with parents, ameliorating communication barriers that may hinder students' academic performance (Lareau & Horvat, 1999).

Ford (2015) suggested closing the achievement gap would require African American students to have equal footing and representation in gifted and accelerated programs. Access to these programs can lead to greater achievement and improved motivation for African American students, promoting a positive growth mindset (Hanson et al., 2016). These goals align with the goals of this study as a curriculum grounded in CRP embraces a multicultural approach that seeks to engage and support students of color. To enhance my understanding of multicultural education and improve the design of my curriculum, I sought additional research connected with these themes.

Related Research

The scholarship in this section closely aligns with my goals and the instructional practices I hoped to adopt. The nature of my critical action research study guided me to research the personal accounts of teachers who aligned themselves with CRP and culturally responsive teaching methods. These studies provided diverse perspectives, framed my understanding, and featured critical lenses that influenced the design of my study.

Through autoethnography, Lopez (2017) recounted her personal experiences with being a change agent and a culturally responsive educational leader in large, diverse, secondary schools. Rich descriptive details, including emotional accounts of her feelings and thoughts, invite readers to enter her world, walk in her shoes, and reflect on her lived experiences. Lopez also offered several insights for those interested in becoming culturally responsive leaders: developing consciousness of historical inequities, promoting inclusive activities throughout the school community, and engaging in reflective practices whereby educators critically examine the work they do (Beachum, 2011).

Lopez (2017) suggested traditional leadership methodologies, such as distributed leadership (Leithwood, 2001), do not adequately address schools' increasing diversity and complex social identities. Instead, she advocated for leadership that is socially and culturally just. This approach includes taking actions that bring about change within schools to ensure the curriculum is reflective of all learners and students, especially those whose experiences have traditionally been excluded (Beachum, 2011; Lopez, 2014). Additionally,

culturally responsive leaders should aim to establish a culture that values parental input and participation (Lopez, 2016), develop sociopolitical and critical consciousness of cultural norms and institutions (Ladson-Billings, 1995a, 1995b), and create experiences that are relevant to students (Gay, 2013, 2018).

Lopez (2017) used the Peruvian adage “little by little” to describe the knowledge researchers gain on the journey of becoming culturally responsive and socially just school leaders. Engaging in reflexivity and participating in training programs helps them “become cognizant of the resistance they will face [and] develop strategies to cope,” thereby acquiring “the agency to improve the environment in which they work” (Lopez, 2017, p. 28). I anticipated a similarly fluid, challenging, and ever-changing journey to make my classroom more socially and culturally just.

In contrast to traditional studies that measure academic success through performance assessments, Morales-Doyle (2017) conducted practitioner research that explored student experiences in response to a culturally relevant AP Chemistry class. The study included nine students in a small neighborhood public high school, two community members, and one parent. The author conducted a content analysis of student interview transcripts and used an embedded case study design to organize and map artifacts such as course binders, lab reports, and other class materials, yielding two significant findings for my research. First, the students embedded in social justice chemistry education successfully mastered the traditional science curriculum standards. Second, the students had opportunities to “move beyond academic achievement and position

themselves as transformative individuals" (p. 1055). Consistent with previous findings that justice-centered science pedagogy can effectively support traditional academic goals while also empowering students to advocate for a more just and equitable society, this study provided me with instructional strategies for organizing and presenting lessons for my students and validated the use of CRP and social reconstructionism in my AP Chemistry class.

Finally, Warren-Grice (2017) highlighted Black educators' use of CRP to support students of color in predominantly White suburban schools. Qualitative data collected through semi-structured interviews with five Black educators across four suburban high schools in the Midwestern United States documented their backgrounds, roles, and experiences with helping Black and Latino/a student achievement. Through portraiture, Warren-Grice shared participants' personal stories and captured their voices, relationships, and experiences. Results indicated "racial uplift," prioritizing both academic and racial advocacy. Academic advocacy manifested in mentorship, tutoring, student workshops, college tours, and cultural field trips. Racial advocacy entailed developing faculty and student awareness of and protective responses to mistreatment, neglect, and racism. This article, which illustrated the benefits of CRP through the perspectives of Black educators, expanded my awareness of how my position and cultural identity may limit my ability to support marginalized students.

Chapter Summary

In review, this chapter provided insights that guided and shaped my action research as I implemented CRP and addressed the need for social reform in my

AP Chemistry class. The next chapter elaborates on my plan to conduct a systematic investigation to meet the unique needs of my students. Although that aim was my top priority as an action researcher, this study may also add to the knowledge base described in this chapter and help other teachers design curriculum that yields more equitable and just classrooms and communities.

CHAPTER 3

METHODOLOGY

Through critical action research framed by principles of CRP and social reconstructionism, I sought to understand how my students and I experienced a transformed chemistry curriculum. CRP served as the focal lens in the design of my instructional units and guided adaptations to my instructional methods and pedagogy to align with the goals of this study. Social reconstructionism provided the model for reform and inspiration for change that I sought for my students and myself. Thus, they played important and complementary roles in this study. As the previous chapters explained, I intended to create a more inclusive classroom. Building on that foundation, this chapter describes my detailed research plan.

Research Design

Action research is a systematic, reflective approach to addressing areas of need within researchers' respective domains (Hine, 2013). For teachers, action research challenges their assumptions and classroom practices and incorporates components necessary for change: research, action, and reflection (Merriam & Tisdell, 2016). Critical action research in the classroom is characterized by continual reform in hopes of a new kind of school and a new society (Carson, 1990). Consistent with my problem of practice and aligned with CRP and social reconstruction, critical action research was an appropriate design for this study.

Qualitative designs are appropriate for identifying and explaining observed patterns, including the potentially invisible changes associated with personal experiences in response to changes in my classroom (Busetto et al., 2020). Qualitative research provides opportunities to describe, decode, and translate information (Van Maanen, 1979), allowing researchers to understand individuals' constructed experiences (Merriam & Tisdell, 2016). Due to the critical nature of my research, an authentic portrayal of participants' experiences was especially important (Patton, 2015). Thus, I collected several sources of qualitative data, inviting participants to express their feelings, concerns, and ideas related to their experiences with my curriculum. Surveys, classroom observations, reflection logs, and a focus group facilitated richly descriptive evaluations of my students' experiences, as well as my own (Merriam & Tisdell, 2016).

Role as a Teacher Researcher

Being a teacher researcher afforded me an opportunity to examine my curriculum and instructional approach for cultural relevance (Merriam & Tisdell, 2016). Although I have taught AP Chemistry for over 7 years, many of the lessons, activities, and laboratory experiments had not changed and reflected my monochromatic perspective. As I alluded in Chapter 1, I felt successful largely due to students' high scores on end-of-year assessments; however, a critical shift forced me to reevaluate my definition of success. An insider-researcher stance, considering my unique perspectives and understanding of my classroom and the relationships I had established with my students, supported the critical nature of my study (Herr & Anderson, 2005). As a reflective practitioner, I

immersed myself in data reflective of participant and my own experiences to uphold my goals of ensuring rigorous and high-quality instruction that is also ethical and relevant to students.

My distinct roles within this study reflected the two questions guiding my research. Consistent with my aim to ensure a more inclusive classroom and Question 1, I needed to actively engage in the learning in the classroom while taking an observer's perspective as I collected data on participant experiences. Additionally, consistent with my aim to critically consider my own beliefs and Question 2, I was a participant within this study as I considered how planning for and implementing lessons grounded in culturally relevant teaching challenged me as a White educator and shaped my lived experiences. Both of these roles supported the goals of this study and worked in tandem to facilitate my comprehensive understanding of the impact of a culturally rich curriculum on teacher and student experiences.

Setting and Participants

My critical action research occurred during the Fall 2022 semester in my AP Chemistry classroom—the site where the problem of practice emerged. After receiving institutional review board approval from the University of South Carolina, I submitted my request to my school district's Office of Assessment and Evaluation. A research review committee evaluated my proposal and determined it was ethical. After receiving their approval, I planned my study as outlined in Table 3.1, which illustrates the general timeline and topics of my modified curriculum and the data I collected during each phase.

Table 3.1 *Intervention Plan*

Unit	Topic	Data source(s)
Pre-intervention		pre survey
1	Leaders in STEM	observations, reflection logs
2	Flint Water Crisis	observations, reflection logs
3	Getting Electrons Excited	observations, reflection logs
4*	Color Chemistry	observations, reflection logs
5	Material Science	observations, reflection logs
Post-intervention		post survey, focus group

Note. In practice, I dropped Unit 4 from the study as I explain later in this chapter and Chapter 4.

My participants were students who chose to enroll in AP Chemistry for the 2022–2023 school year. Given my primary goal to analyze student experiences in response to a more culturally and socially relevant curriculum, I encouraged and invited all students to participate. Within the first week of the school year, I shared a brief presentation with students to explain the purpose of my study, identify the research questions, and outline the proposed units of study. As part of this presentation, I notified students their participation would be completely voluntary and in no way affect their grades. Following the presentation, students asked clarifying questions such as how assignments would be graded and how much extra work they would be expected to complete. After addressing their concerns, I disseminated an official invitation to participate and consent forms (Appendix A), which required the signature of both the student and legal guardian in advance of the intervention phase, in accordance with district guidelines.

I expected the critical nature of this study might elicit questions and concerns for parents and guardians, so I also mailed an official letter to the home address of each student to communicate with all stakeholders about the goals of my study (Appendix B). The letter explained the concept of CRP and informed participants and their families of their right to request access to nonconfidential materials used as part of the study. Additionally, the letter contained my email address and phone number to establish an open line of communication if questions or concerns developed throughout the study. I was both surprised and encouraged that all 16 students in the course volunteered to participate. Chapter 4 describes the participants in more detail.

Data Collection

I collected data through surveys, observations, reflection logs, and a focus group. These tools were appropriate for understanding students' experiences and my own, aligned with my research questions (Table 3.2). Collectively, they support the study's validity by spanning a spectrum of assignments and, through triangulation, lending trustworthiness to my findings (Merriam & Tisdell, 2016; Patton, 2015). Each tool also served a unique purpose, as this section outlines.

Table 3.2 *Data Collection Alignment*

Question	Instruments
1. How do my students experience a more culturally and socially relevant science curriculum?	surveys observations focus group student reflection logs
2. How does planning and implementing a culturally and socially relevant science curriculum impact my experiences as a teacher?	observations teacher reflection logs

Surveys

Surveys provide opportunities to assess students' opinions in response to new teaching methods and new curriculum materials (Efron & Ravid, 2013). Surveys can also collect large amounts of data to show trends in different stakeholders' views and opinions (Ivankova, 2015). Given my goal to measure the impact of a more culturally and socially relevant curriculum on student experiences, the use of surveys established reference points that allowed me as the researcher to evaluate changes in students' thoughts, opinions, and experiences. My extensive literature review and suggestions from Efron and Ravid (2013) aided me in the creation of questions related to students' experiences in previous science courses compared to my modified chemistry curriculum as well as the cultural, social, and personal relevance of science in their daily lives. Participants completed both the pre- and post-intervention survey via a Google Forms invitation on either a school-issued Chromebook or personal device during the appropriate designated window of time outside of normal classroom instruction hours. I transferred the responses to a Google Sheets document for further analysis.

Students received the pre-intervention survey (Appendix C) prior to the start of Unit 1. A majority of the questions required students to indicate the extent to which they agreed or disagreed with a provided prompt, followed by an open-ended prompt to facilitate clarification and interpretation (Ivankova, 2015). I sought to gather demographic information and establish a baseline for

comparison to evaluate student experiences in their previous science classes compared to the curriculum I implemented.

The post-intervention survey (Appendix D) consisted of similar questions and prompts, enabling me to detect and evaluate changes in student experiences as a result of experiencing the modified curriculum. Several additional questions allowed participants to consider the effectiveness of the modified curriculum and share their thoughts on how the lessons and activities in each unit could better suit the needs and interests of diverse student populations. The responses to these questions were sources of critical feedback to modify and improve the ongoing action research plan that will continue beyond the scope of this study. I also added questions to determine student interest in participating in a follow-up focus group.

Observations

Efron and Ravid (2013) pointed out that “most surveys measure respondents’ perceptions or attitudes, not what they actually do or how they behave” (p. 109). Additionally, surveys offer no way to determine if participants have been honest with their responses. Observations provide context such as nonverbal behaviors, gestures, and body language, facilitating more authentic interpretations of student behaviors and experiences (Efron & Ravid, 2013; Wragg, 2012). Observations were also appropriate for this study as a less intrusive way of collecting data to understand the behaviors and interactions of people in their natural setting (Ivankova, 2015).

Semistructured observations (Efron & Ravid, 2013) focused my attention on details that were relevant for answering my research questions, but they were flexible enough to capture unexpected encounters or unchallenged practices in my curriculum and pedagogy. I used an observation protocol form (Appendix E) to log descriptive and reflective notes detailing what I could "see, hear, and sense during the observation, and the thoughts, feelings, and understandings these observations provoke[d]" (Efron & Ravid, 2013, p. 88). The descriptive portion of the protocol recorded the physical setting in my classroom and described participants' actions and conversations. The reflective portion included preliminary interpretations and emerging insights.

During each unit of study, I was actively engaged in the facilitation of the lesson but particularly mindful of the happenings in the classroom and participants within it. Encouraged by Efron and Ravid (2013), I adopted a strategy of oscillating between broad and narrow views. Observations began with a sweep of the participants and the classroom environment. As needed, I narrowed my focus to identify specific behaviors, discussions, and interactions that were most relevant to my research questions. Occasionally, I expanded my perspective and reconsidered the broader picture for shifts in classroom dynamics and participant interactions.

Student Reflection Logs

The critical and reconstructive nature of my research depended upon authentic expressions of participant behaviors and experiences (Efron & Ravid, 2013). Reflection logs can increase students' awareness of their own beliefs,

values, and practices (Billings & Kowalski, 2006) while providing firsthand descriptions of participants' actions, experiences, and beliefs (Bogdan & Biklen, 2011). Following Efron and Ravid's (2013) suggestion to be purposeful in selecting useful and relevant questions, I chose semi-structured, open-ended prompts to highlight the overarching principles and transformative experiences students might have throughout the intervention phase of this study. Grounded in CRP, the questions elicited feedback on how the activities and lessons within each unit of study shaped the students' cultural and social development and shed light on the personal meaning of everyday events—central to understanding student experiences (Merriam & Tisdell, 2016).

Students completed reflection logs (Appendix F) at the conclusion of each unit. In addition to posing yes–no questions about the cultural, social, and personal relevance of the material in students' lives, the prompt also invited students to elaborate on their thoughts and opinions on the activities in the unit, yielding additional information for clarification and interpretation (Ivankova, 2015). Students used school-issued Chromebooks or personal devices to access the reflection logs on Google Forms shared only between the student and me. Reflection logs were confidential, but not anonymous, as I sought to study the transformation of student experiences and needed to track each student's experiences throughout the study.

Teacher Reflection Log

Schuessler et al. (2012) acknowledged the importance of thoughtful reflections when analyzing experiences through a critical lens. Answering my

second research question, related to my own experiences with the implementation of a modified curriculum, required a teacher reflection log (Appendix G). Similar to the design of the student reflection logs, I responded to several semi-structured, open-ended questions at the conclusion of each unit. The teacher reflection log allowed me to address two concerns relevant to my own experiences while designing and implementing a modified curriculum.

First, the reflection logs allowed me to consider specific challenges associated with each of the four units of study during the intervention period. CRP guided the intervention as a whole, yet each unit featured unique themes, activities, and lessons in an effort to create diverse and relevant learning opportunities for all students. To address this concern, I included questions that required me to reflect on specific design challenges, interactions between students, and my feelings during each unit of study. Second, the design of the teacher reflection logs allowed me to capture and evaluate my experiences throughout the intervention period. Specific questions prompted me to consider changes in my instructional pedagogy and personal growth. Due to the subjectivity of evaluating my own experiences, I also included questions that required me to monitor and consider my biases as a White male teacher throughout this study (Guillemin & Gillam, 2004).

When completing each entry, I adopted a phenomenological lens to consider my personal growth and transformation as a result of implementing a more culturally and socially rich curriculum (Merriam & Tisdell, 2016). As with the student logs, I used a Google Form and complied the responses in a Google

Sheet. Analysis of each individual reflection log as well as a global perspective throughout the entire research period allowed me to track personal experiences, success, and challenges as evidence of my own change.

Focus Group

Data resulting from surveys and observations, though valuable, may lack the necessary richness to trust and gauge how participants actually feel about a topic (Efron & Ravid, 2013). Because interviews establish open lines of communication necessary for in-depth analysis on participant experiences (Merriam & Tisdell, 2016), I anticipated making meaning of participants' perceptions, knowledge, opinions, experiences, and beliefs in one-on-one conversations (Efron & Ravid, 2013). However, true to the nature of qualitative action research (Merriam & Tisdell, 2016), my plans shifted in light of my emergent findings. Simultaneously collecting and analyzing data surfaced my participants' preference for sharing their experiences in small-group settings among peers compared to one-on-one interactions with me as their teacher. The small-group setting provided a safer space where participants shared their thoughts more openly and deeply. To accommodate this preference, I decided to alter my interview method by conducting a focus group.

A focus group is an interview on a topic with a group of people who have knowledge of the topic (Merriam & Tisdell, 2016). When participants share their view, hear the views of others, and refine their own views in light of what they have heard (Hennink, 2014), the sessions become "conversations with a purpose" (Dexter, 1970, p. 136). After verifying that my alteration did not impact

the review status of my study, I invited a subset of participants to partake in a small focus group with the goal of measuring the feelings and otherwise hidden experiences of my participants. I determined the subset based on survey and reflection log responses that warranted additional clarification or elaboration, congruent with my study's purpose. I aimed for a purposefully diverse sample of 4–6 individuals, recognizing participation would be limited by students' willingness (Patton, 2015). Chosen participants received an emailed invitation (Appendix H) explaining the details of the focus group, including the scheduled date, time, and location, as well as several structured interview questions for prior reflection. The session lasted approximately 45 minutes in accordance with student and researcher availability and took place in my classroom, a familiar setting that would make students more comfortable and was consistent with the nature of this study (Efron & Ravid, 2013).

I began the focus group by thanking the students for their participation and reminding them about their right to confidentiality, their right to withdraw without penalty, and my use of a recording device. I established co-constructive dialogue to afford everyone the opportunity to raise and pursue unanticipated items related to the study or seek clarification as needed (Efron & Ravid, 2013). The ability to ask follow-up questions that probe for details and encourage participants to deepen their responses is consistent with the aims of my research (Kvale & Brinkmann, 2009; Seidman, 2012).

I recorded the session on my iPhone and later transcribed it using the iRecord app. I listened to the recording and compared it to the transcription,

editing the transcription as necessary to correct any errors and ensure its accuracy. I then coded the transcription and sorted codes into common themes that aligned with my research questions.

Intervention Plan

As Table 3.1 illustrated, the intervention phase consisted of four units of investigation. I grounded the lessons and activities in CRP and ensured they complemented the traditional scope and sequence of the College Board AP Chemistry standards. The following sections elaborate on the activities and lessons in each unit to clarify their purpose within the context of the overall study.

Unit 1: Leaders in STEM

The intervention phase was concurrent with the start of the school year. My AP Chemistry class consisted of upperclassmen who had completed the prerequisite introductory chemistry course. However, students who had several semesters between the prerequisite course and AP Chemistry needed a review of basic chemistry skills and calculations, such as how to read the periodic table and how to determine the symbol, atomic number, and atomic mass of each element. In previous years, I began with a presentation that explored the history of the atom alongside a review of the aforementioned topics and highlighted several important discoveries that led to the currently accepted model of the atom: John Dalton’s first atomic theory, J. J. Thompson’s discovery of electrons, Ernest Rutherford’s gold foil experiment, and Niels Bohr’s proposal of energy levels. A critical examination of this activity reflected my problem of practice when I noticed that only White, male, European scientists were celebrated, which

contrasted with the diversity of students enrolled in my classes. Reflecting on this activity forced me to consider Ladson-Billings's (1994) finding that, "If classrooms do not use materials that portray diverse groups realistically, students are likely to develop, maintain, and strengthen the stereotypes and distortions in the traditional curriculum" (p. 18). By not portraying a realistic picture of the contributions of all members of the scientific community, I found myself guilty of Eisner's (1985) proposition that what we choose not to teach can be as significant as what we choose to teach.

In response to my critical reflections, I created the Leaders in STEM project to complement the history of the atom lessons and provide an opportunity for students to research and celebrate the accomplishments of underrepresented groups within the scientific community. This project began with a think, pair, share activity where students created a list of the most important scientists they could think of and included a description of why they were important. Students shared their individual list with other students and reflected on two questions:

1. Do you feel that you have something in common with the scientists on your list?
2. Are the scientists on your list representative of the global scientific community?

After discussing their reflections, students were tasked with identifying an individual from a traditionally underrepresented group within a STEM field and learning more about their significant contributions. Celebrating the work and

accomplishments of these individuals could provide my students with role models and inspire them to continue in STEM fields.

I gave students a list (Appendix I) of over 50 scientists, engineers, mathematicians, and other STEM professionals and asked them to focus their project on one individual. I encouraged students to investigate several people before making a final decision and extend their research beyond the list. Students had several days to complete this task and a worksheet that helped organize their discoveries including questions that prompted additional research regarding personal backgrounds and notable achievements in STEM fields. In addition to completing the worksheet, students were tasked to create a visual artifact for display in the classroom. The artifact was modeled after a periodic table square; however, the students substituted relevant information about the chosen individual in lieu of information about an element. The artifact was a focal point during each student's presentation of their chosen individual to the class, which included a review of personal details, notable accomplishments, and why the student admired or respected their chosen individual.

In the days leading up to their presentations, I dedicated time at the beginning of the class to showcasing and discussing diverse leaders in STEM fields, such as Neil deGrasse Tyson. Using information I collected during my own research, I created a poster to serve as a model for students' presentations. As another example, at a student's suggestion, we discussed Rosalind Franklin, a female scientist whose uncredited work was vital to the discovery of the double helix shape of DNA. I recalled the conflict surrounding the discovery, but could

not remember the exact details or the names of the scientists involved. I took the opportunity to conduct my own research and found a video (TED-Ed, 2016) that featured Franklin's work, which I shared with my students. The inclusion of this activity provided a timely opportunity to discuss gender inequities in professional careers, especially within the STEM field, and seemed to evoke strong responses in many of the female participants as Chapter 4 further illustrates.

The conclusion of this unit coincided with students' submitting a detailed report of their findings. These submissions included historical details, notable contributions in the STEM field, and the student's rationale for choosing the individual. Using this information, students created their posters, which served as visual displays during their classroom presentations.

Unit 2: Flint Water Crisis

Unit 2, which focused on solution-based chemistry, included activities and lessons to support students in their ability to identify mixtures and solutions, balance single replacement reactions, balance net ionic equations, and perform selective precipitation reactions. The storyline I chose for this unit was the water crisis in Flint, Michigan—the exposure of tens of thousands of residents to dangerous levels of lead in their drinking water. This human-made public health crisis ultimately led to the death of 12 people, affected countless others, and left long-standing impacts on the community and its residents (Kennedy et al., 2016). In addition to providing a relevant and real-world application of solution chemistry, the Flint water crisis provided a platform to discuss both social and environmental justice issues.

I introduced the topic as part of a think, pair, share activity, followed by a video overview of the event and related health concerns for the Flint citizens (Vox, 2016). I encouraged students to put themselves in the individuals' shoes and consider how lack of access to clean water would impact their daily lives. Students continued their investigation by reading an article that mentioned specific chemical reactions in the lead pipes around the city (Dingle, 2016). The author also discussed other chemical compounds and solution-based reactions that provided real-world connections to topics we covered in class, validating my choice to include the Flint water crisis to complement the AP curriculum.

To shift from a broad exploration of the event toward engineering a solution to the problem, I tasked students with using their knowledge of single replacement reactions and selective precipitation to design an experiment for removing dissolved lead ions from a sample of water. Students worked across several days in small groups to design a laboratory procedure that would precipitate the dissolved lead ions and filter out the solid product. These skills align with the College Board's requirements for what students should be able to accomplish—gravimetric analysis—as part of their laboratory investigations. After conducting their experimental procedures and discussing the validity of their designs as real-world solutions, students concluded the unit by discussing whether a similar water crisis could occur in their local community. By considering their own experiences, students could make a personal connection to the people of Flint and compare the inequities in their own lives and surrounding communities to those of the largely marginalized population in Flint.

Unit 3: Getting Electrons Excited

This unit of study coincided with an instructional transition into the first unit of study as outlined by the College Board, which specifies students' need to understand detailed models of atoms and consider the significance of electrons in chemical reactions and other chemical phenomena. Additionally, students are required to consider the relationship between the configuration of electrons within the electron cloud and the creation of light emissions. The history, use, and design of fireworks was the underlying theme for this unit, providing real-world applications of the concepts discussed in class—students could personally relate, having used fireworks to celebrate many national holidays, and the topic also provided opportunities to explore diverse cultural groups.

This unit began with a YouTube video (Wired, 2018) that featured a pyrotechnic expert explaining the art of fireworks. I then asked students to consider how fireworks related to the world of chemistry. An article on the science behind the construction and color of fireworks supported and enriched this discussion (De Antonis, 2010). Specifically, the article introduced students to how electronic transmissions between energy levels relate to the wavelength of light photons emitted. Students explored this relationship in greater detail through several laboratory investigations, including a virtual exercise with the principles of photospectroscopy and the emission spectrums of different elements on the periodic table. They also conducted a flame test: students heated small samples of various solutions in a Bunsen burner to discover what colors are associated with each element. Using the skills and principles learned in previous

investigations allowed students to identify the different solutions based on the colors of light emitted in the flame.

Shifting from exclusively scientific phenomena toward opportunities for students to make personal and cultural connections, I asked them to consider the purpose of fireworks and identify celebrations that traditionally feature fireworks. Students shared personal experiences and traditions related to New Year's Day and Fourth of July celebrations. Beyond these two holidays, I wanted students to consider global events, so I asked them to investigate several less developed countries (LDCs). Given that citizens of these countries likely lack access to fireworks, I asked students to pick one LDC, choose a holiday or event that is important to the citizens, and consider alternative ways that people celebrate.

This unit concluded with an opportunity for students to reflect on everything they had previously learned within the unit and design a specific firework that when exploded would display something personally significant or worthy to celebrate about their character. As part of the design, students were tasked to consider the specific chemicals necessary to produce their firework including the firework's color, shape, size, and packing pattern. Students illustrated a visual model of their firework display and used this as the focal point during their presentation to the class where they discussed features of their design and explained why the design was personally significant to them.

Unit 4: Color Chemistry

In my original research proposal, I intended Unit 4 to build upon what students had learned in the previous unit and continue the exploration of color

and its subjective interpretation. The activities I envisioned could help students discover that feelings and expressions related to colors are shaped by cultural and regional influences. For example, students would have investigated how various cultural identities and groups interpreted meaning from colors (e.g., red is a warning) and how their interpretations differed from one another. Students could specifically address how conflicts may arise based on how different cultural groups interpreted the same color. These activities would continue to showcase diversity in how students perceive the world around them and how personal biases shape their perceptions and understandings. However, I chose not to include this unit as part of my study, and in Chapter 4, I discuss why I felt the need to deviate from my initial design.

Unit 5: Material Science

Unit 5 coincided with an instructional shift into a unit of study outlined by the College Board on intermolecular forces and their influence on the physical properties of materials. Activities included in this unit supported student investigations and complemented the underlying theme of material science. As Chapter 4 elaborates, I constructed this unit in response to participants' feedback indicating a desire to see the personal relevance of chemical phenomena in their daily lives, which I therefore prioritized during class discussions.

Creating memorable laboratory experiences was a goal throughout this unit. I began with a hook activity akin to the cup game wherein someone scrambles multiple cups while asking their audience to track one particular cup of interest. Unbeknownst to students, I added a small amount of sodium

polyacrylate, a water-locking compound, to one of the cups before they arrived. At the start of class, students watched me pour water into one of the cups before scrambling them on my laboratory desk. Students were tasked to determine which of the cups contained the water, and I inverted each cup as they guessed. Students were shocked when I inverted the last cup and no water poured out. Students then launched into the laboratory exercise to investigate the properties of sodium polyacrylate. I followed the activity with a brief discussion about how diapers work and their impact on environmental sustainability.

Day 2 built upon the unique properties of materials when students made Oobleck, an example of a non-Newtonian fluid. This simple mixture of cornstarch and water creates a fluid that has different physical properties in response to surface pressure. The material flows when poured from a cup but cracks across the surface when pushed. Students used their personal experiences while creating and experimenting with Oobleck to better understand the roles of pressure and temperature on states of matter, standards required per the College Board when teaching phase diagrams and intermolecular forces.

The next laboratory investigation occurred after students read an article on the role of hydrogen bonding and the chemical processes associated with making candy (Husband, 2014). Building upon the connections in the article, groups of students engaged in making their own peanut brittle. The knowledge they gained from this experiment supported their understanding of intermolecular forces and their role in determining states of matter, while the memorable experience enhanced their personal connections to chemistry.

The final laboratory investigation in this sequence required students to adopt the position of an executive of a mining operation responsible for balancing the collection of minerals with landscape reclamation. This activity supported our discussion on the atomic structure and properties of alloys, mixtures of metals, in addition to providing an opportunity for students to consider environmental justice advocacy, a perspective noticeably lacking in previous units of study. I gave each group a chocolate muffin to represent their newly purchased plot of land and tasked them with developing a plan to extract all the precious minerals—the chocolate pieces—while honoring a promise to reclaim the land (i.e., restore the muffin back to its original form as much as possible). An accompanying worksheet and class discussion promoted critical investigation of mining operations and mining reclamation efforts.

At this point, my instructional focus shifted to preparing students for their eventual presentations at the conclusion of the unit. Students researched two unique materials, aerogel, the world's lightest solid (Veritasium, 2019), and graphene, a carbon-based compound (Tinnesand, 2012). Additionally, students read an article featuring adhesive polymers (Heltzel, 2020). Each of these investigations encouraged students to consider how the interactions between molecules connected to real-world applications and uses of each material, a theme that students' presentations emphasized.

To foster personal connections to the content, I encouraged students to investigate a material that was relevant to a career they were interested in pursuing after high school or a hobby or activity they enjoyed. As part of their

presentation, I encouraged students to consider the design of the material and establish a connection between its physical properties and practical application. I provided several website links to guide their investigations while allowing the autonomy to select any material of interest.

Students concluded this unit by investigating the difference in polarity between permanent and washable markers, followed by an activity where students tie-dyed shirts. I encouraged students to consider why the dyes interacted with the shirts and differences in intermolecular forces of the dyes that allowed them to permanently affix to the shirts. Following the investigation, students kept the shirts as a thank-you gift for their participation in the study.

Data Analysis

Aligning my research with the strategies provided by Bogdan and Biklen (2011) allowed me to be strategic in the design of my study to narrow the scope and focus on specific and measurable goals. Because my research questions were targeted and relevant to action research in my classroom, I was able to collect an abundance of qualitative data central to my investigation and problem of practice. The analysis phase of my study yielded ample connections between the implementation of a modified chemistry curriculum and student and teacher experiences, and answering my research questions affirmed my use of new strategies and systems to ensure my classroom is more culturally and socially relevant long after the conclusion of this research.

A goal during the data collection period was to saturate myself with information relevant to the context of my problem of practice and research

questions (Merriam & Tisdell, 2016). Saturation occurs when analysis of the collected data does not reveal any new discoveries or insights relevant to the study. Saturation was a goal of this study; however, the timeline of my intervention plan and my inexperience in conducting research limited the amount and quality of data. To optimize my circumstances and minimize limitations, I followed Merriam and Tisdell's recommendation of simultaneously collecting and analyzing the data. In addition to effectively managing the time allocated for my research, this strategy addressed the emergent nature of qualitative studies. The simultaneous blend of collecting and analyzing data allowed me to discover reoccurring themes and categories as they appeared and informed the instructional design of upcoming lessons.

Preparation for Analysis

Before effective analysis could occur, organizing the data to facilitate interpretation was important. I stored all documents electronically in password-protected folders, keeping hard copies in a secure location on site. To protect participants' confidentiality, I gave them the option to choose a pseudonym at the start of the research period and stored all data using these identities.

Participants completed surveys and reflections using Google Forms. Linking student responses to a Google Sheet allowed me to categorize and code participant responses for each question. In this way, I could easily analyze group responses to a specific question or I could analyze the collective responses of a particular individual across multiple units of study. I also transcribed and stored the observation protocols and teacher reflection logs as Google documents.

Organizing documents in this way allowed me to consider the specific details of day-to-day interactions between me and my students while discovering and tracking longitudinal trends that emerged throughout the research period. Likewise, I stored the transcript of the focus group on a Google document. A text-based version of the conversation ensured an accurate record of participant responses. Qualitative analysis is often integrated and recursive, so organizing the collected data allowed me to revisit these records as new understandings and reoccurring patterns began to emerge (Merriam & Tisdell, 2016).

Categorizing and Coding Data

Constructing categories and deriving meaning from qualitative research is susceptible to subjective interpretations; however, being subjective does not mean qualitative research is not trustworthy or valid (Marshall & Rossman, 2011). The extensive literature review related to this study and my theoretical framework provided a sound foundation for my interpretations and lends authenticity to my conclusions. To increase the validity of my findings, I used multiple data sources including surveys, classroom observations, reflection logs, and interviews to provide an authentic and accurate representation of student experiences (Merriam & Tisdell, 2016). Triangulating multiple sources allowed me to cross-check findings for evidence of patterns. A final form of validity comes from having a diverse population of participants, each with their own unique and diverse perspectives. Having multiple participants allowed me to consider whether individual responses were consistent with the feelings of the entire group or unique to the student. In this way, I was able to compile evidence that is not

limited to a singular perspective but authentic to the shared experiences of all students in my classroom.

Answering the second research question proved to be challenging as I was only able to consider my own perspective and my own experience. Consequently, I needed to consider my positionality and how it shapes my understandings. To help in this endeavor, specific questions in the teacher reflection log allowed me to periodically reflect on my biases and purposefully consider how they influenced my interpretations.

To reach my goal of saturation (Merriam & Tisdell, 2016), I used necessary tools, procedures, and strategies to categorize and code data and form meaningful interpretations (Efron & Ravid, 2013; Merriam & Tisdell, 2016). Data analysis began with a reflective review of my research questions (Appendix J) in which I attempted to establish several themes that I anticipated would emerge. The themes I discovered in this exercise served as an initial guide for grouping data, but evolved and expanded during subsequent analysis.

With these themes established, I began with an extensive review of the data to identify and sort repeating trends in a process referred to as coding, what Merriam and Tisdell (2016) described as “having a conversation with the data—asking questions of it [and] making comments to it” (p. 204). Saldaña (2016) recommended applying “a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language based on visual data” (p. 4). Following similar suggestions outlined by Bogdan and Biklen (2011), I grouped reoccurring themes together based on

responses that shared significant events, behaviors, perspectives, and relationships throughout the study.

While coding, I remained open to emerging categories (Merriam & Tisdell, 2016), making notes of my observations when responses did not easily fall into one of the predetermined categories. Coding data in this way allowed for a recursive review over several months of time to ensure saturation. With this assurance, I felt confident in moving forward with my analysis. After coding was complete, I analyzed each of the categories individually and began to synthesize and interpret the information to understand how the collective data related to my research questions (Miles & Huberman, 1994). Further refinement of my categories was necessary to include how the context, frequency, sequence, cause and effect, and rationality of events shaped my study, which I ultimately used to answer my research questions (Merriam & Tisdell, 2016).

Validity

As this chapter has demonstrated, I took several explicit steps to address my biases and ensure an ethical approach in both the instructional design of my modified curriculum and interpretation of data. Additionally, I sought the expertise of critical colleagues as a means of supporting the validity of my study. I engaged in regular discourse with my chair, an accomplished teacher educator in the fields of action research and critical studies, throughout the dissertation process. Furthermore, I had the pleasure of completing the Ed.D. program alongside my wife as she simultaneously conducted her own action research study. Our shared experience and ability to peer review was compounded as we both currently

teach at the same school, the site of this research study. Therefore, her perspectives and knowledge of the culture and climate of our school proved valuable, and her imprint is evident throughout this study.

I also engaged in a unique form of respondent validation to ensure my findings were accurate representations of my participants' experiences: I invited all participants to attend my dissertation defense (Merriam & Tisdell, 2016), and seven accepted. Thus, they had an opportunity to voice any disagreement with the data presented. As my participants were intimately connected with the study, their confirmation of my findings ensured authenticity and a valid interpretation of their thoughts and experiences.

Chapter Summary

This chapter shows that my research plan was systematic in its design and aligned to the framework guiding this study. A clear outline of the methods used to collect and analyze data ensured the accuracy and authenticity of my interpretations of student and personal experiences. Typical of action research, the discovery of themes, categories, and findings unfolded in various stages throughout the study. Likewise, the focus of my analysis evolved in response to unique challenges and experiences during each phase. Chapter 4 elaborates on these discoveries and how I used them to answer my research questions.

CHAPTER 4

FINDINGS

As previous chapters alluded, the purpose of this study was to evaluate student and teacher experiences with more culturally and socially relevant lessons and activities in a modified AP Chemistry course. Within the College Board guidelines, I designed four units to foster personal and cultural connections to real-world events and consideration of the diversity within and beyond the classroom. Surveys, observations, reflection journals, and a focus group yielded an abundance of rich qualitative data, which I exhaustively reviewed and coded for evidence of participant experiences. Reflecting on reoccurring themes surfaced insights related to the following research questions:

1. How do my students experience a more culturally and socially relevant science curriculum?
2. How does planning and implementing a culturally and socially relevant science curriculum impact my experiences as a teacher?

After describing my participants and providing additional context related to my intervention, this chapter presents my analysis of the data collected by each research tool and my findings relevant to each question.

Participants

I used the school's web-based student information program to collect background information on my students. Of the 16 participants, five (31.3%) were

male and 11 (69.7%) were female. Moreover, 12 students (75%) were listed as juniors or 11th-grade students, whereas four (25%) were seniors or 12th-grade students. Based on responses to the pre-intervention survey (Appendix C), 14 students (87.5%) identified as White, one identified as Hispanic/Latina(o), and one identified as Asian and White. This racial breakdown was significant, given my initial aim to support African American students. The lack of diversity in my sample prompted a shift in my pedagogical approach during the study and pushed me toward CSP, which I discuss further in Chapter 5.

Also of note is the high percentage of female students—unusual across my 17 years as a teacher, including 7 with AP classes. Because AP Chemistry classes at my school typically have significantly more male than female students, having over a 2:1 female to male ratio prompted me to reevaluate the design of my units. As the study progressed, I prioritized the voices, perspectives, and contributions of female students and endeavored to consider gender equity in the design of my curriculum—especially as a means of supporting female students in their pursuit of STEM majors and careers. In Chapter 5, I reflect on these discoveries and modifications to my curriculum.

Intervention

As Chapter 3 detailed, the intervention phase centered on four thematic units designed to address the lack of culturally and socially relevant themes in a traditional AP Chemistry course. Of note, I changed the topics of these units in the middle of the intervention phase as a result of student feedback. Consistent with my intentions to collect and analyze data concurrently as suggested by

Merriam and Tisdell (2016), I discovered some emerging patterns in student responses at the conclusion of Unit 3 that prompted me to alter my initial plans.

One of the primary goals of Unit 3 was to expose students to different cultures and invite them to consider how their experiences and perceptions might differ from those of their classmates. The initial goal of Unit 4 was to continue to build upon these ideas while investigating the relationship between Chemistry and color. Some of the planned activities included an investigation into colorblindness and how rods and cones help human eyes determine color; an article on the chemical compounds used to create artificial dyes in food products (Rohrig, 2015); a project wherein each student would research how different cultures interpret an assigned color; and a final project wherein students would design a chemistry superhero or villain using only three colors, each conveying some special meaning about their character.

Before finalizing the activities and lessons for the Color Chemistry unit, I reflected on student responses to the Unit 3 Reflection Log. Noticing several negative responses made me question the design of my lessons. One student responded that Unit 3 was “extremely boring,” and a different student described it as their “least favorite unit so far.” My initial analysis of the Unit 3 Reflection Log indicated a lack of meaningful connections with the content and more negative experiences compared to the previous units. Another concern going into Unit 4 was the scope and sequence of topics suggested by the College Board. The recommended unit coinciding with Unit 4 centered on students’ learning how to draw Lewis dot diagrams representing the bonding between atoms in a molecule

and learning about the polarity of chemical bonds and molecules. From my experience as a veteran teacher, I felt aligning the recommended topics with opportunities for students to make personal, cultural, and real-world connections would be difficult. I wanted each unit of study in the intervention period to be as relevant as possible and avoid the misconception that I was assigning busywork.

Based on this analysis, I deviated from my initial plan to teach all four units consecutively by taking a break after Unit 3. During this time, I designed Unit 5, which I hoped would be more conducive to personal and cultural connections. The new unit also aligned better with the College Board scope and sequence, which emphasized intermolecular forces and their role in solids, liquids, and gases. As the rest of the chapter illustrates, this decision supported the goals of this action research study and proved to be meaningful for participants.

Presentation of Findings

Multiple data collection tools contributed to my overall conclusions regarding how my students and I experienced the modified curriculum. Due to the overlap in my use of the tools, this presentation of findings follows chronological order to enhance readability. However, subsections focus on specific tools as needed.

Pre-intervention Phase

The pre-intervention survey consisted of one demographic question, one question related to how participants defined and interpreted the word culture, and seven category-based questions where participants indicated the extent to which they agreed or disagreed with the prompt (Appendix C). As I explained in

Chapter 3, each of the seven questions had a corresponding open-ended prompt to aid my interpretation of student responses (Ivankova, 2015). Grounding my study in CRP, I was interested in students' understanding of culture, especially to see if their views aligned with my research aim. Students' definitions of culture also helped me learn more about their cultural identities, which in turn guided the design of lessons and activities in each unit. Specifically, I identified three distinct themes related to how students defined culture.

The most common description, evident in five responses (31%), included references to personal beliefs, traditions, and ideals. For example, Charlotte stated, "Culture is the law, behavior, art, beliefs, or anything that makes up the identity of a particular group." A second theme was that culture depended on or related to one's surroundings and environment. Three students expressed this idea, including Jessica, who stated, "Culture is the effect that your surroundings, home, and people in your life have on the way you live." Three students also illustrated the third theme: a direct correlation to an individual's community. Sydney, for example, defined culture as "the traditions, ideals, language, and knowledge of a distinct community."

I was surprised by students' thorough and thoughtful responses. I had predicted they would associate the word culture with "cancel culture" or have shallower definitions, but nearly all students demonstrated deep understanding. Further illuminating these themes, Table 4.1 presents results for the category-based questions, followed by a brief analysis of each question along with students' open responses.

Table 4.1 *Pre-Intervention Survey Results*

Question	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
1) Different genders, races, and cultures were included in topics, lessons, and activities discussed in my previous science classes.	3	18.8	2	12.5	3	18.8	8	50.0	0	0
2) It is important for students to consider the different cultures, perspectives, and personal experiences of other students.	11	68.8	3	18.8	1	6.3	1	6.3	0	0
3) It is important for teachers to consider the different cultures, perspectives, and personal experiences of other students.	10	62.5	5	31.3	1	6.3	0	0	0	0
4) I feel that my culture, perspective, and personal experience was considered in previous science classes.	2	12.5	3	18.8	6	37.5	5	31.3	0	0
5) Topics, lessons, and activities in previous science classes were relevant to my personal experiences.	0	0	3	18.8	5	31.3	8	50.0	0	0
6) Topics, lessons, and activities in previous science classes addressed problems in society today.	2	12.5	3	18.8	4	25.0	7	43.8	0	0
7) Topics, lessons, and activities in previous science classes empowered me to advocate for change.	0	0	6	37.5	1	6.3	7	43.8	2	12.5

As Table 4.1 and Figure 4.1 show, three students strongly agreed that their previous science classes included different genders, races, and cultures, but their open-ended responses indicated a potential problem in the wording of the question. I wanted to determine if underrepresented groups were included and discussed as part of the instructional design in students' previous science classes. However, several students appeared to interpret the question as referring to teachers' allowing underrepresented groups to participate in class activities. For example, Aurora stated, "All of my previous science teachers were very inclusive towards everyone, I have never seen any of my teachers treat a person of a different gender, race, or culture being any differently."

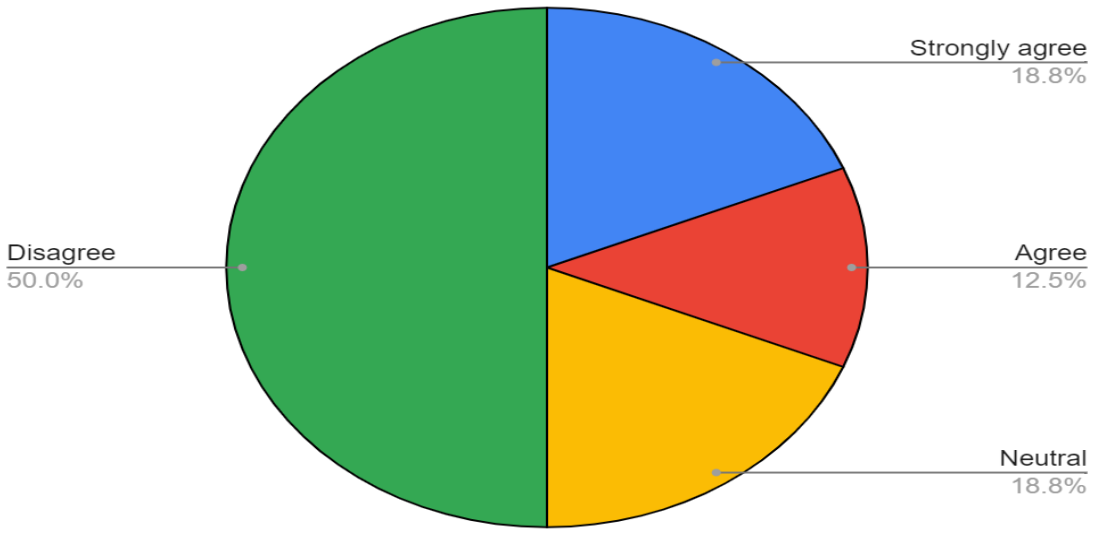

Figure 4.1 *Pre-Intervention Responses to Question 1*

Half the participants (*n* = 8) disagreed with this statement. Many students who chose this response noted that their previous science classes focused more on teaching concepts and ideas rather than teaching about people. For instance, Eliza stated, "In my past classes, genders, races, and cultures were never

brought up because we were learning about science related topics, such as molecular mass, mitosis, and other topics." The responses to this question suggested a curriculum grounded in culturally and socially relevant material would be a new experience for the majority of participants.

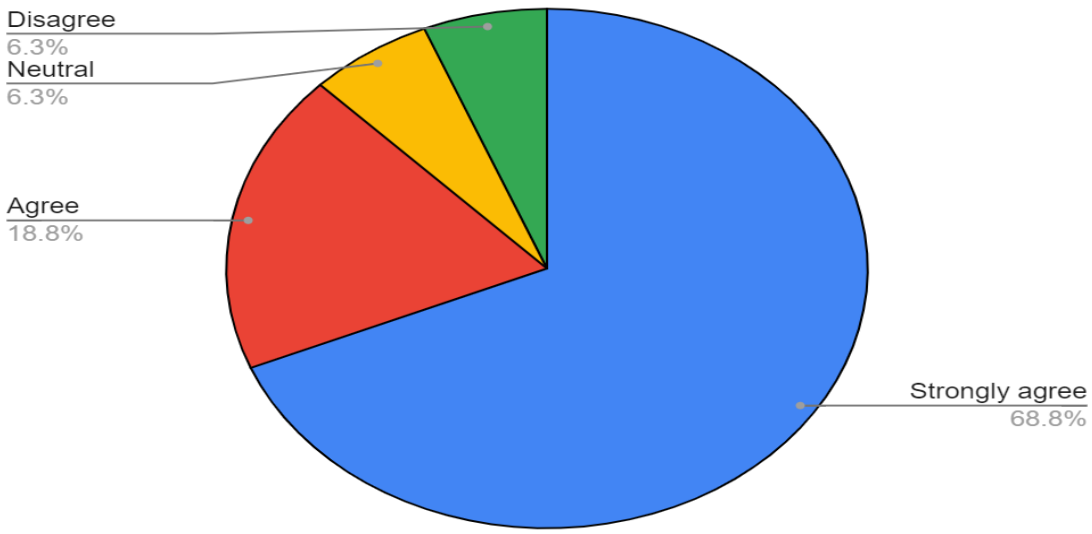

Figure 4.2 *Pre-Intervention Responses to Question 2*

As illustrated in Figure 4.2, 87.5% of participants (*n* = 14) either agreed or strongly agreed that considering other students' cultures, perspectives, and personal experiences is important. Many open responses emphasized understanding and noted the value of considering different perspectives when solving problems and interacting with diverse populations. Another common theme was a link to empathy, which three students identified. As Susan stated, "understanding someone's culture and background . . . can make us as human beings way more empathetic and reasonable." Such responses were particularly interesting as I had not expected so many participants to either agree or strongly agree. My prior experiences as a high school educator led me to believe students

were more concerned with their own experiences and feelings, yet a common theme of discovery throughout this study was that my students are much more culturally aware than I anticipated. Participants continuously impressed me their awareness of cultural differences and empathy toward others.

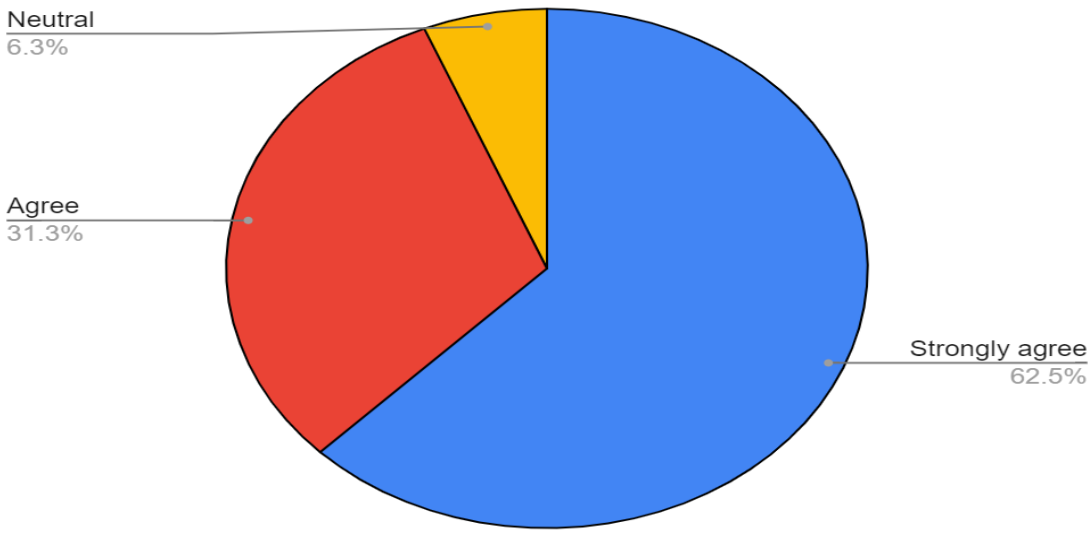

Figure 4.3 *Pre-Intervention Responses to Question 3*

Regarding Question 3, 93.8% of participants (*n* = 15) either agreed or strongly agreed that teachers' consideration of students' cultures, perspectives, and personal experiences is important (Figure 4.3). Their open-ended responses primarily noted benefits of teachers' cultural awareness. As Stevie stated,

> It's especially important for teachers to consider different experiences of students because it helps include them more in conversations. Not considering the students' experiences may hinder their learning as they aren't as connected to the material as they could be.

Although teachers can be uncomfortable discussing cultural ideas for fear of backlash (Frankenberg, 1993; McIntyre, 1997; Morrison, 1992; Weis & Fine,

1993), facilitating conversations centered on race and culture can normalize the practice, creating opportunities to strengthen relationships with students.

Another important theme in the responses to Question 3 was a need for equity and respect in the classroom. Aurora exemplified these values by stating,

> I think that everyone being treated equally in a class by a teacher is one of the most important parts of a great class. A student feeling included is much different than a student not being included. It is so important for the teacher to consider the differences of other students, because they should treat every single student with the same ounce of respect and personality as they treat another.

Comparing the results from this question measuring the importance of teachers' cultural awareness to the results from the previous question measuring the importance of students' cultural awareness surfaced an interesting observation. A majority of students (n = 10) indicated the constructs were equally important. However, three students prioritized their peers' consideration of other students' perspectives over teachers'. Conversely, three students indicated teachers' cultural awareness was more important than that of their peers. Nevertheless, nearly all responses indicated that students and teachers should be mindful of cultural differences and personal experiences in class.

Question 4, which measured whether participants' previous science classes considered their culture, perspective, and personal experience attracted an array of results (Figure 4.4), but two common themes emerged in the open responses. Several students acknowledged that their White identity was

ingrained in teachers' normative practices. As Susan stated, "I think my culture is assumed, which is usually right as I am a blonde woman, providing not much room for error. However, I am not sure if my culture was exactly considered." In addition to reiterating my underestimation of participants' acute awareness of cultural differences, Susan's response also highlights the need for White students to engage in multicultural learning to better understand the hidden barriers and experiences of traditionally marginalized students.

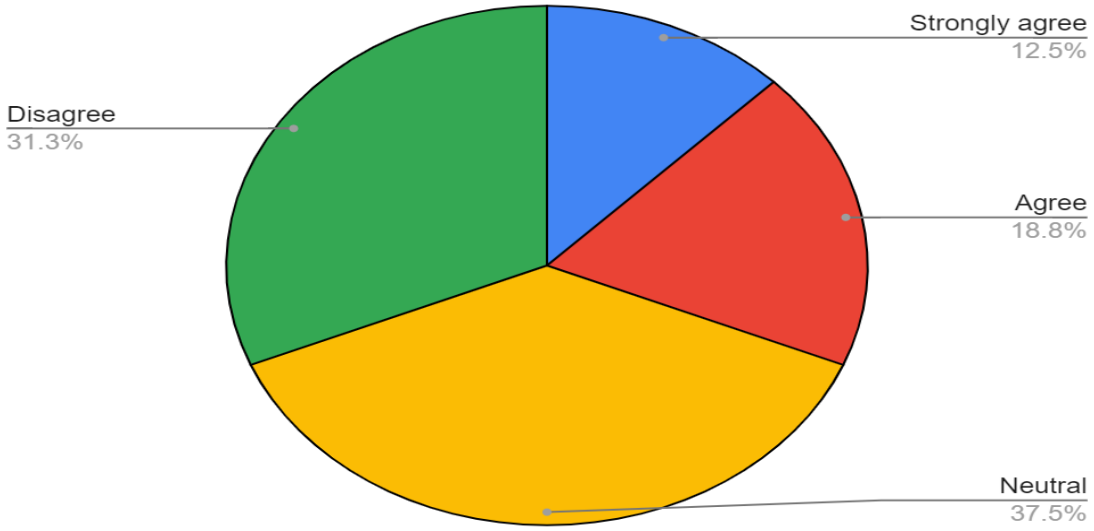

Figure 4.4 *Pre-Intervention Responses to Question 4*

Another theme in the open responses to Question 4 was students' acknowledgment that science classes align with objective pursuits: learning factual knowledge and scientific truths. Sydney shared, "I neither agree, nor disagree with this statement because science is based on facts and in a class where everything is based off of numbers and clear observations, I do not believe it's important to consider someone's culture." Despite being a student of color, Malcolm also promoted the common view of one-size-fits-all teaching, qualifying

the lack of evidence that his “culture as a Hispanic was considered in previous science classes” by stating, “But I don’t believe it was needed, I was present in the class to absorb knowledge. My ethnic background didn’t matter as I was there to learn.” Malcom’s belief that students’ backgrounds are irrelevant suggests their experiences also lack value, reinforcing the need for this study. When educators enact CRP, they combat the belief that classrooms are where students simply “absorb knowledge.” Teachers who invest in culturally and personally relevant lessons draw upon student experiences so learning is an active and participatory process.

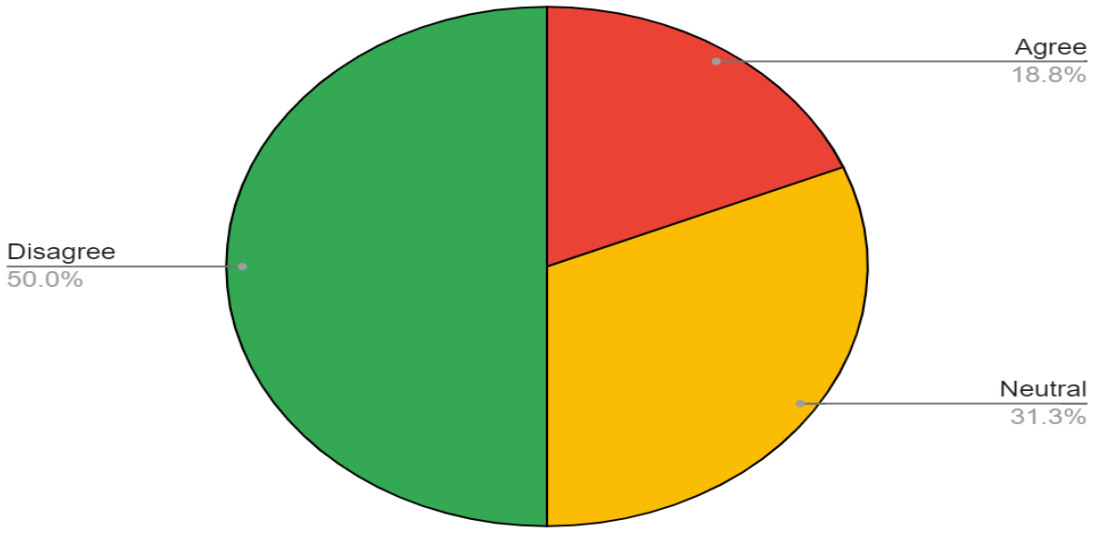

Figure 4.5 *Pre-Intervention Responses to Question 5*

As evidenced by Figure 4.5, 50% of participants (*n* = 8) indicated that topics, lessons, and activities in their previous science classes were not relevant to their personal experiences. A common theme in their open-ended responses was their perception that science classes were more objective than other courses. As Romeo stated, “I’ve always felt that there was a separation of

science classes and personal experience compared to English and personal experience." Such responses indicate a low level of personally meaningful connections between classroom discussion and their own experiences. Several responses alluded to a possible explanation. Participants indicated difficulty in making personal connections in science classes due to a broader instructional scope intended for mass audiences. Stevie explained,

> A lot of activities or lessons in previous science classes used things from popular culture to help relate science to the student. I wouldn't say that the lessons were very relevant to personal experiences, but teachers usually try to present topics in a way that most of their students would be able to relate to or understand.

Participants who agreed with the statement provided very loose connections between scientific content and personal experiences, such as when Hayden wrote, "I feel like chemistry and biology are everywhere in our lives, so in a way, every lesson related to all of us." I considered these responses as I designed the modified curriculum, knowing from my literature review that culturally and socially relevant instruction must cater to students' unique perspectives and reflect their lived experiences, in contrast to a curriculum written for the masses (Gay, 2002, 2013, 2018; Ladson-Billings, 1995a, 1995b).

Based on the open-ended responses to Question 6, the distribution of ratings in Figure 4.6 seems to reflect students' individual experiences in previous classes. The students who agreed with the statement noted coursework that specifically addressed issues like global warming, climate change, and ocean

pollution. I noted that many of these students had taken either Marine Science or Environmental Science as elective courses.

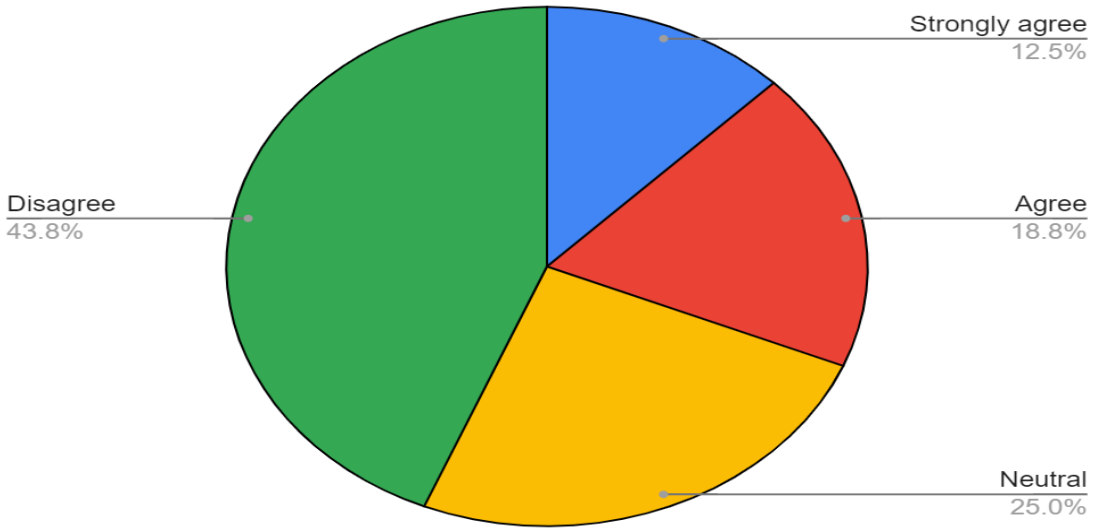

Figure 4.6 *Pre-Intervention Responses to Question 6*

Students who disagreed felt science courses should focus on objective truths; investigating social issues was either irrelevant or unaddressed by their previous teachers. For example, Nathan's prior classes "were designed to teach content that was as general and applicable to any scenario, school, political situation in any nation, etc." Charlotte's response also caught my attention:

> Nothing I really learned in science classes so far has been life changing for me or addressed the issues that are currently in society. Even something such as global warming, that you would think would be addressed in science classes because it relates to the weather units taught in middle school, was not taught from my experience.

Teachers like me may shy away from more culturally relevant curriculum due to the perceived difficulty of maintaining alignment with course standards and pace,

yet Charlotte's response underscores the need to scaffold science content around real-world scenarios that are important to students. The statement thus affirmed my goal of documenting my experiences in the study, too. I saw potential for helping other teachers overcome this perception and providing insights on how to accomplish cultural relevance even in an AP classroom.

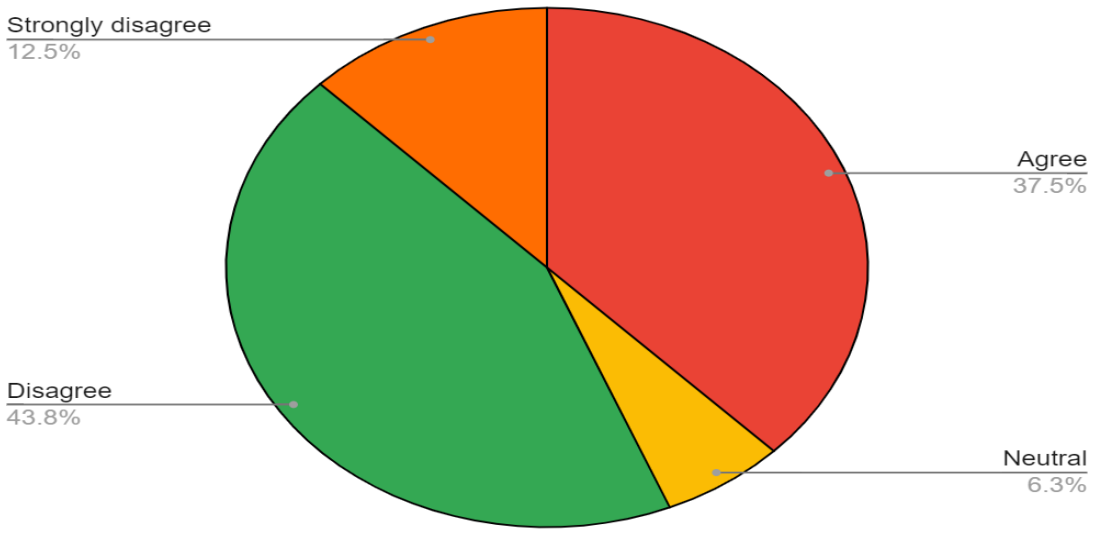

Figure 4.7 *Pre-Intervention Responses to Question 7*

As indicated by Figure 4.7, 56.3% of participants (*n* = 9) either disagreed or strongly disagreed that the topics, lessons, and activities in their previous sciences classes empowered them to advocate for change. Many indicated a lack of opportunity to consider other perspectives, which seemed to stifle their ability or even desire to advocate for change. As Stevie admitted, "I have never felt the need to advocate for change in a science class because we never discussed anything that needed to change. Lessons are always just about the material and not anything more." Such responses reinforced my resolve to equip students to advocate for change.

In contrast, 37.5% of students (*n* = 6) agreed with this statement, two of whom, in their open responses, connected their ability to advocate on others' behalf to their experiences in classes with an intentional focus on environmental justice. The other students who agreed associated the meaning of change with their personal growth, such as feeling inspired to challenge themselves to reach their personal goals (Susan) or wanting to change their major as a result of their interest in a particular science course (Dr. Doris). As Sydney shared, "I have definitely been empowered by my science classes in the past to pursue a career in STEM, but not necessarily empowered to advocate for change in the world." The array of responses could indicate a flaw with how I phrased this question or a disconnect between advocacy opportunities and traditional curriculums.

Overall, participants' responses to the open-ended prompts on the pre-intervention survey indicated several interesting discoveries. First, I realized the participants were more culturally aware than I thought they would be. They addressed the value of alternative perspectives and noted the influence of cultural biases in classroom settings and instructional practices. However, their responses also highlighted a lack of opportunities to reflect on how cultural differences impact the daily lives of high school students. Further, they reported the pursuit of purely objective concepts and facts as central in their previous science coursework. This discovery suggested the possibility of conflict with my intentions to infuse my curriculum with more culturally and socially relevant material. I continued to examine and build upon these themes as I proceeded to the intervention phase.

Intervention Phase

Consistent with my intention to present my findings in chronological order, this section addresses each unit of the intervention phase in a specific sequence—both to enhance readability and account for my use of multiple, overlapping data collection tools. First, I provide a brief reminder of the specific topics and big ideas in each unit along with my intended goals. Next, I highlight notable events captured by my observation protocols concurrent with instruction. I then move to analysis of participants' open-ended responses captured by the student reflection logs completed at the conclusion of each unit. Finally, each subsection addresses the unit as a whole through analysis of my own responses to open-ended questions in the teacher reflection log.

Unit 1: Leaders in STEM

As discussed in Chapter 3, this unit coincided with the beginning of the school year and included a review of material covered in prerequisite classes. Therefore, I anticipated few opportunities for personally meaningful connections. Instead, my goal for this unit was to introduce students to CRP teaching practices and provide opportunities for participants to recognize and reflect on cultural differences. Unit 1 was the shortest of the four units, spanning 4 days of instruction and culminating in the Leaders in STEM project and presentations.

Unit 1 Observations. I completed three separate observations during Unit 1. First, I collected data related to my initial presentation of the study when I sought students' participation. The remaining two observations occurred during the introduction and presentation of the Leaders in STEM project.

Given the importance of first impressions, I was both curious and anxious as to how my students would react to the invitation to participate in this research study. I was also very nervous that the critical nature of this research would spark debate and conflict related to instructional time. During this observation, I focused on student expressions, student questions, and student engagement.

I previewed the nature of my research with students the day before the official presentation to convey the importance of my study and share the intended goal. I wanted to prime students to understand why my presentation differed from other class presentations (i.e., lectures). During the presentation, I shared my research questions and was honest about my intentions to improve my instruction to better suit the needs of a diverse student population. I observed that the class as a whole seemed engaged and even excited by the prospect that the content would be more relevant to their daily lives. Confirming my observation, all 16 students chose to participate. One student transferred out of my class shortly after this presentation due to a schedule conflict but indicated a desire to take the class next year out of curiosity about how the results of this study would impact the future curriculum.

The second observation coincided with the introduction of and requirements for the Leaders in STEM project. I sought to observe student interest in the project and determine if students recognized the lack of underrepresented scientists in traditional science curriculums. Consistent with my plan in Chapter 3, students helped me construct a list of well-known scientists on the board, and I asked the class to consider the individuals' names. After

students observed that White males constituted the overwhelming majority of the list, I asked them to reflect on their observation alongside the initial prompt's emphasis on fame. They associated money and access with the listed scientists, and one student even acknowledged that the White male scientists had more privilege—a notable insight in a majority-White classroom. This response and the discussion that followed this activity convinced me that my participants were more culturally aware than I initially thought they would be.

The third and final observation in this unit coincided with students' presentations of their projects. Congruent with my goal of providing opportunities for students to recognize and reflect on cultural differences, I evaluated two components of students' posters and presentations: whether they (a) celebrated underrepresented individuals for their accomplishments in STEM fields and (b) connected their personal experiences to the experiences of their chosen STEM leader. Using a template I had provided earlier in the unit, all 16 students produced high-quality posters with relevant information and historical context that celebrated the work and accomplishments of their chosen STEM leader. Figure 4.8 is one such example that I obtained permission to share. Other notable posters featured Kalpana Chawla, the first woman of Indian origin to enter space; Saint Elmo Brady, the first African American to obtain a PhD in Chemistry in the United States; and Ynes Mexia, a Mexican-American botanist who discovered over 500 new species of plants. Each of these posters included relevant images and details to illustrate the real-life experiences and challenges each leader faced while pioneering paths for future scientists to follow.

Marie Maynard Daly

During a time when only two percent of African American women in America had college degrees, Marie Maynard Daly worked extremely hard to become the very first Black woman to earn a Ph.D. in chemistry. She was born on April 16, 1921 and beginning at an early age, Daly showed obvious signs of interest in science as her father studied chemistry and she had the same ambition. Daly earned her bachelor's and master's degrees from Queens College and New York University, respectively. In 1947, Marie Maynard Daly became the first African American woman to be awarded her PhD in chemistry for her research on how compounds produced in the body participate in and affect digestion. Marie had many contributions to STEM, but her most significant ones included he structure of pyrimidines and purines in DNA and he relationship between clogged arteries and high cholesterol, which increased our understanding of how diet affects the health of the heart and the circulatory system.

MmD

4.16.1921 - 10.28.2003

Figure 4.8 *Leaders in STEM Poster*

The rubric prompted students to discuss what they admired or respected about their chosen leader, and I listened for comments related to cultural or personal relevance to categorize each presentation as exhibiting strong, weak, or no connections. Strong connections highlighted explicit similarities between the student's and leader's experiences. Weak connections acknowledged cultural differences without going further. I observed strong connections among 75% of students (*n* = 12), whereas 18.8% (*n* = 3) demonstrated weak connections, and one presentation made no connection. Of the 12 strong presentations, 10 made cultural connections and two had personal connections. Therefore, I believe this activity succeeded in bringing attention to underrepresentation in STEM fields and providing opportunities to recognize and reflect on cultural differences.

Among the students who made deeper connections, Edward, inspired by his chosen scientist Edwin Land, went above and beyond by bringing in a collection of cameras, including one of the first Polaroid cameras ever manufactured, which he used to take a picture of our class. This strong personal connection was encouraging, demonstrating that the curriculum was personally relevant to his daily life. Another interesting theme that emerged during presentations was the connection between female students and the female leaders they chose to research. Nearly all female students shared feelings of being empowered or inspired by their chosen female leaders.

I noticed these feelings were true regardless of the race of the chosen leader. This observation—that White students were inspired by underrepresented groups—was striking. This culturally centered activity allowed students to find

value through their shared experiences and bring awareness to discrepancies related to the global scientific community today versus common portrayals in educational publications related to scientific discoveries.

Another interesting observation was that female students presented clearer evidence of deeper connections with their chosen STEM leaders compared to male students. This evidence might suggest that many of the female participants are interested in pursuing STEM careers and may already be aware of the systemic difficulties women face in STEM fields. Their awareness may have enabled them to make stronger personal connections.

Unit 1 Student Reflection Log. Following the Leaders in STEM project, students reflected on Unit 1. In addition to inviting their general thoughts (Questions 1–2) and extended responses to specific prompts (Questions 4, 6, 8, and 10), I posed yes–no questions related to cultural and personal relevance (Questions 3, 5, 7, and 9). Table 4.2 presents the results of the latter.

Table 4.2 *Unit 1 Student Reflection Log Responses*

Question	Yes		No	
	n	*%*	*n*	*%*
3) Was there anything during this unit's activities and lessons that you felt was personally meaningful or relevant to you?	9	56.3	7	43.8
5) Was there anything during this unit's activities and lessons that encouraged you to consider the perspectives of others?	12	75.0	4	25.0
7) Was there anything in this unit's activities and lessons that encouraged you to consider social inequities or advocate for social justice?	12	75.0	4	25.0
9) Was there anything in this unit's activities and lesson that improved your understanding of the Chemistry concepts being taught?	8	50.0	8	50.0

When asked to provide their general thoughts on the activities and lessons in Unit 1, 50% of students (*n* = 8) responded that they enjoyed researching and learning about diversity in STEM fields. Specifically, students appreciated learning about scientists from different cultures; however, two of these students also felt the unit activities did not connect to the chemical concepts and ideas we reviewed in class. Sydney, for example, stated, “I liked researching all the different scientists and listening to other students present their research, however I felt our time and energy could’ve been spent on other, more useful things related to the content we’ll be tested on.” Responses like Sydney’s validated one of my concerns related to instructional time. In my experience, AP students tend to believe that any time not devoted to content is busywork. I hoped to change this misconception throughout the intervention period. By exploring more culturally and socially relevant topics, I hoped to promote a positive classroom climate that improves student relations as well as provide opportunities to make connections that enrich their understanding of the course content.

Question 3 in the reflection log asked students to consider if the activities and lessons featured in this unit felt personally meaningful or relevant. As illustrated in Table 4.2, 43.8% of participants (*n* = 7) responded “no,” which I expected due to the limitations of Unit 1’s introductory nature. Concurrent with the first full week of class, the unit required spending time in class on building relationships with students and establishing classroom routines. Regardless of the reason, many students seemed to miss out on the opportunity to establish a meaningful connection as part of the Leaders in STEM project, a goal of Unit 1.

For those students who did indicate that the lessons and activities connected with their personal experiences, two notable themes emerged.

First, several students made specific personal connections to the experiences of the marginalized scientists we discussed. Jeremiah's response was particularly interesting: "I understand how it feels to be judged based on just your physical appearance, just like how these scientists were." Likewise, three of the 16 participants (18.8%) acknowledged a strong connection to the leaders' frustrations and struggles. A second theme that emerged was female empowerment, consistent with my observations of students' presentations. Nearly all female participants chose to research a female leader and identified a strong connection with being female and pursuing a STEM career. Susan stated, "I feel as if the biography project related to my personal experiences as I was able to learn about women in STEM and how they also changed science, not just generic white men." Susan's response spurred me to consider opportunities for gender equity in the design of my modified curriculum.

In response to Question 5, 75% of participants (*n* = 12) indicated the topics and activities in Unit 1 encouraged them to consider others' perspectives. I intended to help them discover and celebrate the accomplishments of underrepresented groups in STEM fields, so I was encouraged to see that a large majority of students achieved this goal. Nearly all the participants who answered affirmatively acknowledged that the stories and struggles featured throughout the unit and in students' presentations helped them consider alternative viewpoints, cultures, and backgrounds. Based on their responses to

this question, students seemed to value the presentation aspect of the project more than the research portion of the project. Listening to the presentations afforded students the opportunity to hear many different stories, which provided opportunities for students to make meaningful connections to diverse groups.

As displayed in Table 4.2, 75% of students (*n* = 12) also felt the lessons and activities in Unit 1 encouraged them to consider social inequalities and injustices. Two responses stood out. Charlotte stated,

> The person I chose to research for my presentation faced discrimination and prejudice but she still became extremely successful. Her story made me wonder how many people out there have been stopped from making important contributions to society because of social inequities.

Similarly, Aurora stated, “I was surprised to hear about the hardships people who weren’t straight white men endured. It really opened my eyes and I felt bad that the world had to work that way and sometimes still does.” These responses and several others indicated students’ growing empathy—exceeding my vision to expose students to diverse perspectives and leaders. I was excited that so many of the participants deeply considered the significance and application of the unit’s lessons and activities.

Noted in the final question of Table 4.2, 50% of students (*n* = 8) indicated the Unit 1 activities and lessons helped them understand chemistry concepts. Concurrent with the beginning of school, Unit 1 did not offer many opportunities to connect to principles of chemistry. Most students who responded that this unit improved their understanding made connections to various review lessons and

activities rather than the Leaders in STEM project. Newtron stated, “There simply was not anything that broadened my understanding to current AP Chemistry.” I expected this lack of connection due to the scope and sequence of chemistry content at the beginning of the year while recognizing an opportunity for improvement—building on the Leaders in STEM project’s strong focus and intended cultural connections with components that align better with improving student mastery of introductory chemistry topics.

Unit 1 Teacher Reflection Log. Analysis of my own reflections highlighted my initial fear of trying something new and worry of how students would respond. I noted specific changes to my traditional pedagogy as I “designed features that would allow students to personalize their reports” and strategically emphasized the significance of all genders, races, and cultures in STEM disciplines. These observations provide evidence of my efforts to combat my initial problem of practice by broadening my perspective and giving students a more realistic picture of the global scientific community, especially to support their future pursuits in STEM careers.

My fear subsided in later responses, where I recorded my impression that Unit 1 succeeded. I enjoyed listening to students’ presentations—more than I expected to. In addition to recounting their enjoyment and pride when making personal connections, I also documented my belief that discussing other underrepresented scientists prior to the presentations made students comfortable with the nature of the project and enabled them to present with confidence. Despite the overall success of the unit, as mentioned earlier, I reflected on how

the lessons and activities could have connected better with the history of the atom timeline and that changing the order of the topics could improve alignment.

My response to Question 6, evaluating aspects of my teaching that I wanted to improve or be more conscious of, led me to a discovery about my own character and habits as a classroom teacher. I noted, “I need to improve on how I conduct my think, pair, share time. I want to encourage students to interact, but I think I need to do better about letting students control the discussion.” Several times during follow-up discussions, I found myself discussing how the information discovered from activities might affect student experiences instead of inviting students to share their own reflections and ideas. I found myself talking at my students instead of inviting them to share their thoughts with the group. This discovery was an important turning point for my transition from sage-on-the-stage to guide-on-the-side pedagogy (King, 1993). I became more aware of my approach and tried to improve during future classroom discussions.

Unit 2: Flint Water Crisis

As discussed in Chapter 3, Unit 2 covered social and environmental injustices associated with the polluted water of Flint, Michigan. This unit reflected CRP as it provided numerous opportunities for students to make meaningful cultural and personal connections. Additionally, it featured the strongest connections to social justice and one of the few opportunities for participants to advocate on behalf of others. Challenging my White and predominantly affluent students to consider the perspectives and lived experiences of marginalized individuals was an explicit goal. The stark differences between my students and

the Flint citizens provided opportunities for discussions of race, politics, and culture while staying true to the AP curriculum. Unit 2 spanned 5 days of instruction and culminated with the Lead in the Water laboratory investigation.

Unit 2 Observations. I completed four observations during Unit 2. The first two coincided with our initial investigation of the Flint water crisis and captured students' reactions and discoveries. The remaining observations documented students' experiences during the Lead in the Water laboratory investigation and whole-group discussion.

During the first two observations, I noted my efforts to help students make personal connections. Because the Flint population differs considerably from the students I traditionally teach, I worried the class would lose interest without a meaningful connection. However, my observation notes suggested most students identified and empathized with the citizens of Flint. I noted, "I believe the video was a good introduction. It gave students some details and prompted several follow up questions that we will revisit during future activities."

These observations also captured evidence of my intentions to alternate throughout this unit between a broad, global perspective and a specific, individual focus. Day 1 began with a factual news account (Vox, 2016), whereas beginning Day 2 with a think-pair-share activity allowed students to consider how the polluted water affected Flint citizens' daily lives. This alternating approach was valuable as students observed how small details intertwined to impact bigger problems. I observed students' investment in this topic and noted participants did not shy away from asking critical questions, such as, "How could the governor do

that to their people?" Their attention to the underlying themes of social injustice again reflected their cultural awareness and the success of my unit design.

The next observation occurred during the Lead in the Water investigation that required students to develop their own experimental procedures based on solubility rules and net ionic equations we discussed in previous lessons. The problem-based investigation modeled the contaminated drinking water in Flint and intimately situated students in the context of the crisis. Specifically, I sought to capture students' planning during the open-ended investigation.

Given no procedure for completing the laboratory objectives, students indicated they were nervous yet excited. Groups spent time brainstorming ideas and used whiteboards to document a list of required materials as well as their initial plans (Figure 4.9). The whiteboards were useful for organizing and refining their thoughts. Moreover, I noted students' high levels of engagement and excitement, especially when we traveled to the chemical supply room where students were able to pick out the materials they needed for their investigations.

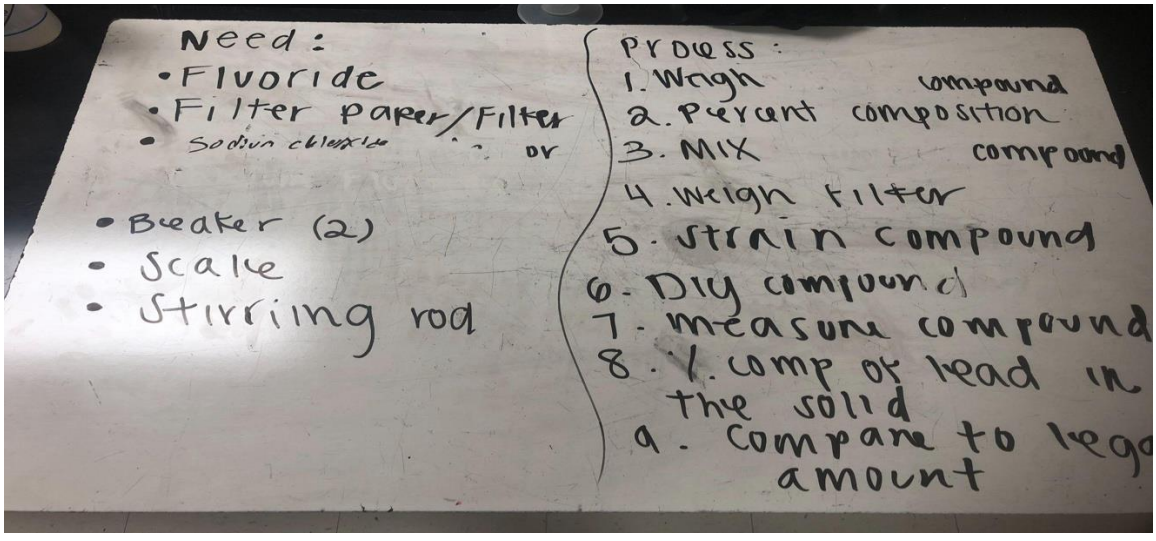

Figure 4.9 *Student Whiteboard*

The final observation captured students' responses to a documentary featuring children from Flint (60 Minutes, 2021) and overall reflections on Unit 2. The most notable observations were in response to my question of whether a similar water crisis could occur in our community. Students mentioned times when their neighborhoods participated in boil water advisories but acknowledged a long-standing crisis would be unlikely. When prompted, they connected the privileges of their largely White and affluent communities with the power to enact change, whereas the low SES of Flint made citizens more vulnerable.

Two points of interest emerged during our discussion, highlighting student awareness of outsiders who advocated on behalf of the citizens of Flint. First, students seemed troubled that the marginalized community had been ignored for so long, their concerns taken more seriously only after an external investigation by Virginia Tech faculty. Second, students noted the ethical dilemma Dr. Hanna-Attisha faced as she broke protocol when she chose to publish her findings on the toxicity of lead in children's blood levels before undergoing peer review. Students agreed with her actions, reasoning doing what was right for others was more important than following the academic process.

Unit 2 Student Reflection Logs. The high levels of student engagement and meaningful discussion I observed throughout the unit resonated in students' reflection log entries. Following the Lead in the Water activity, students completed an entry associated with the topics, activities, and lessons in Unit 2, using the same format of yes–no questions and prompts as in Unit 1. Responses to the yes–no questions appear in Table 4.3.

Table 4.3 *Unit 2 Student Reflection Log Responses*

Question	Yes		No	
	n	%	*n*	%
3) Was there anything during this unit's activities and lessons that you felt was personally meaningful or relevant to you?	9	56.3	7	43.7
5) Was there anything during this unit's activities and lessons that encouraged you to consider the perspectives of others?	15	93.8	1	6.2
7) Was there anything in this unit's activities and lessons that encouraged you to consider social inequities or advocate for social justice?	15	93.8	1	6.2
9) Was there anything in this unit's activities and lesson that improved your understanding of the Chemistry concepts being taught?	15	93.8	1	6.2

A majority of students responded positively to Unit 2. Three main themes emerged in their descriptions of how the activities and lessons connected with their personal experiences. First, students indicated their enjoyment by using words like "fun" (Jessica & Susan) and "engaging" (Mr. President). These responses support similar findings from my observations. I was encouraged that students could have fun while also being challenged: This unit was their first exposure to AP-level work, which can be overwhelming. Additionally, this unit featured complex critical themes that challenged students to consider diverse perspectives in contrast of their own experiences. To see that many students had an enjoyable experience in spite of these challenges was encouraging.

The second theme I discovered was students' appreciation of connections between the lessons and activities and real-world problems. Five of the 16 students addressed such connections, including Aurora, who stated, "I think that learning about the Flint Michigan water crisis and experimenting on it was really

interesting. I like that we connected chemistry to real life because I never really did that in my last chemistry class." Aurora's response is particularly interesting because of the comparison to previous courses. One of my goals for the modified curriculum was to establish more meaningful connections between course concepts and students' personal experiences, so I appreciated that at least one student recognized a difference between the modified curriculum and a traditional chemistry curriculum.

A third and final theme acknowledged the differences between the Lead in the Water laboratory experiment compared to traditional labs in previous science classes. Five of the 16 students preferred using hands-on, inductive reasoning skills and navigating the experimental design process. Edward, for example, stated, "We spent a lot of time on Flint. The lab was pretty fun, as we had to do it ourselves." This finding is noteworthy as it provided insight into student preferences and shaped the design of future laboratory investigations.

As evidenced by responses to Question 3 in Table 4.3, 56.3% of participants (n = 9) answered affirmatively that the activities and lessons were personally meaningful and relevant. Five of the nine openly empathized with the citizens of Flint. These encouraging results validated my choice of videos to emphasize personal perspectives and testimonies. The responses also indicate students took advantage of an opportunity to consider and adopt an alternative perspective. The students who stated that the activities were not personally meaningful indicated a very literal interpretation of the question with responses such as "I have never dealt with lead in the water so I cannot relate" and "It

wasn't exactly meaningful to me because I don't have unclean drinking water." Because this unit featured the strongest connections to social justice and a need for social reconstruction, I hoped all students would find a meaningful connection, yet I was not surprised some students struggled. This unit may have been their first opportunity to consider complicated social topics in a science curriculum.

Table 4.3 also highlights the 93.8% of participants (*n* = 15) who affirmed in response to Question 5 that the activities and lessons encouraged them to consider others' perspectives, an explicit goal of Unit 2. As cited by several students, the documentary-style videos clearly helped them to connect with the lived experiences and hardships of the citizens of Flint. Nathan stated, "The Flint Michigan Lead Lab and accompanying videos, gave me insight into the hardships that the people of Flint faced not having had access to water and how they had to struggle hard to get it fixed." As intended, the problem-based laboratory investigation provided students with the opportunity to step into the context of the situation and make meaningful connections. Doing so would have been difficult without the time to be so immersed in the problem.

Moreover, 93.8% of participants (*n* = 15) responded that the activities and lessons in this unit encouraged them to consider social inequities or advocate for social justice. The one student who responded no to Question 7 nevertheless acknowledged their interest in social justice and their prior knowledge of the problems in Flint in their explanation. Given this unit's clear connection to social justice, I was encouraged that essentially all students were able to recognize the injustices experienced by citizens of Flint. Malcolm's response to this question

was particularly powerful: “The fact that someone had to illegally go through multiple medical records of other children to get results hurts me. No one should have to prove through illegal means that a problem exists.” Another significant response came from Hayden, who stated, “The people of Flint deserved better and their situation was handled so poorly because of their social and economic class.” Such responses suggest most students had an authentic experience where they were able to consider their own positions and status compared to individuals who were marginalized and see significant discrepancies.

I expected one goal for the modified curriculum—to provide opportunities for students to advocate on behalf of marginalized groups—would be particularly challenging. Because I felt weak in this capacity myself, I was especially ill-equipped to develop this skill in my students. Thus, I was excited that four of 16 students specifically addressed a desire to advocate for the people of Flint when explaining their responses to Question 7. For example, Sydney stated, “Hearing about the people of Flint and their hardships, I was very motivated to advocate for them and for justice towards those who were greatly impacted by the poisonous water.” Although three other students acknowledged a desire to advocate, only Stevie seemed to consider what advocating on behalf of the citizens of Flint would actually look like. Stevie’s response detailed how time was a valuable resource and could serve members of the surrounding community. Stevie thus helped me consider how to develop this unit in the future—with opportunities for my students to serve marginalized individuals in the immediate community instead of being geographically disconnected from the problem.

Finally, as indicated in Table 4.3, 93.8% of participants (*n* = 15) responded affirmatively to Question 9. That this unit's activities and lessons improved their understanding of chemistry validated my effort to align with the College Board standards. Solubility and precipitation reactions are critical to understanding what went wrong in Flint. Nine students specified the laboratory exercises as important in further developing their understanding of the concepts. Students indicated the real-world application of the Lead in the Water lab was engaging and gave them a clearer understanding of what was actually happening as precipitation reactions occurred. One enthusiastic response came from Stevie:

> The lesson tied really well with the things we were learning. My favorite thing in particular was when we had to design our own lab to get lead out of water. It was maybe the best thing I have ever done and it was so rewarding and exciting. This lab also helped me see how there isn't this one perfect solution to the Flint water crisis.

Such responses suggest students' engagement and understanding relate to their ability to construct their own knowledge. Providing similar opportunities in future units may help students make personal and relevant connections to the content.

Each reflection log included a final open-ended question prompt that allowed students to provide additional comments. Unit 2 was the only unit that elicited enough responses to connect to a common theme: students' resounding desire to do more laboratory investigations like the Lead in the Water activity. In their view, the hands-on approach and problem-solving aspects of the lab created a "fun and educational" learning opportunity grounded in worldwide

problems. That Stevie, for example, would “love to see [activities like this] in more classes” supports the idea that culturally and socially relevant activities and lessons are multidisciplinary. Connecting to social justice issues like the Flint water crisis can enable teachers to engage in cross-curricular lesson planning to support learning across multiple subjects. Additionally, students acknowledged that the lab improved their application of chemistry topics such as solubility, selective precipitation, and net ionic equations.

Unit 2 Teacher Reflection Log. My own reflections from Unit 2 captured my confidence that “this unit will be the best unit in terms of connectivity.” The perceived benefits of activities and lessons led me to consider how effective my entire course could be if aligned to culturally and socially relevant themes. Forthcoming sections elaborate on this idea and discovery of additional themes.

This log also documented an increase in my confidence, which I associated with our positive classroom environment built on supportive relationships and opportunities to speak freely without fear of judgment or consequences. I also reflected on the effectiveness of the unit design and sequence of activities and noted a shift in my pedagogy: “alternating between global and individual perspectives kept students engaged as each day brought new opportunities for discovery.” To devote more instructional time to situating students in the context of the problem, I grounded the bell-work activities in culturally relevant themes instead of reviewing chemistry concepts. I noted my mixed feelings about substituting opportunities to review material outlined by College Board with opportunities to further our critical investigation, yet students

clearly demonstrated mastery of chemistry concepts and skills in their end-of-unit examination. This discovery was significant, providing evidence that my modified curriculum was successful in preparing students for their AP exam while fostering meaningful connections to culturally and socially relevant material.

As a participant researcher, I noted my shared experiences with students fostered my growth and advanced my cultural awareness. Specifically, my log entry described how a discussion with participants helped me discover a privilege I had not previously considered. As a White male, I have the privilege of assuming a majority of government decisions are in my best interest, especially in local settings. Observing how government officials hid the truth about the quality of water and acted in ways that purposely jeopardized Flint citizens' health and well-being was shocking. This experience helped me understand why traditionally marginalized groups may not trust government officials. Feeling empowered and encouraged by my efforts to teach a more culturally and socially relevant curriculum, I shifted my focus to Unit 3.

Unit 3: Exciting Electrons

Preparing students for their AP exam had always been important to me, hence my dutiful attention to College Board outlines and instructional sequences. Integrating culturally and socially relevant activities into a unit more heavily influenced by these guides posed a challenge. As noted in Chapter 3, Unit 3 featured the study of electron configuration and shifts in electron positions during the creation of light particles referred to photons. Given the unit's more abstract nature, connecting to a theme that was both meaningful and relevant to students'

lived experiences was especially important, and I felt studying fireworks would provide opportunities to infuse cultural themes and strengthen students' awareness of other cultures and practices. Unit 3 spanned 6 class periods and culminated in student presentations of their firework project.

Unit 3 Observations. I completed three observations during Unit 3. The first coincided with students' investigation of their unique Chinese zodiac symbol based on the year, month, and day of their birth. This activity tied to a previous discussion of holidays that feature fireworks, when my students and I discovered we did not know much about the Chinese New Year.

The activity began with a YouTube video (TED-Ed, 2017) on the history of the Chinese zodiac. Unique to other videos from the intervention period, it emphasized Chinese pronunciations and gave explicit descriptions of Chinese symbols and writing. I felt this attention to detail lent authenticity, an important component in a more culturally relevant curriculum. After viewing the video, students completed a web quest activity to discover characteristics of their astrological signs. In turn, students shared their discoveries and reflected on whether the personality traits assigned to their animal were accurate.

My observations of this activity yielded two discoveries. First, this activity marked my growth as a critically mindful educator. Upon discovery that my students and I lacked knowledge about the Chinese New Year, I devoted class time to learning about Chinese culture. This shift in my pedagogy shows that I prioritized a culturally relevant lesson over purely academic content. Second, this activity proved meaningful for participants. As noted in my observation, "This

think, pair, share activity had the most [student] engagement so far." Students seemed to enjoy sharing their animals, although some were slightly offended to be called a horse or a pig. Finding they had similar animals as other students forged personal connections between peers, and the open classroom discussion allowed students to share anecdotes and personality traits, supporting my goal to establish a supportive classroom environment. Their reflection logs echoed many of these sentiments. However, with limited attention to Chemistry content, I wondered if students would consider the activity a waste of time or busywork. Reflecting on these feelings, I noted, "Even if they feel this way, I feel like the personal and cultural gains justified this activity."

The second observation occurred as students researched holiday traditions in LDCs. As described in Chapter 3, I wanted students to consider other cultures while making connections to a country's development rating. I intentionally collaborated with an instructor in a different discipline, blending content pertinent to chemistry and social science to promote student engagement with real-world circumstances. Indeed, my observation notes show students were "interested and engaged throughout the activity." Given the opportunity to share how their selected country celebrates holidays, many students voiced alternatives to fireworks, including "eating food, spending time with loved ones, religious practices, decorations, and wearing costumes." Exploration of cultural connections and exposure to different customs and traditions made this activity valuable, in my view.

The last observation occurred during student presentations at the end of the unit. As discussed in Chapter 3, I encouraged students to reflect on everything they learned throughout the unit and choose a firework design that would display something personally significant about their character. Similar to how I assessed other presentations, I considered the depth of students' personal and cultural connections as they explained their firework design (i.e., the overall shape and colors) and identified relevant chemical compounds.

My observation captured one of the highlights of the entire intervention period. Two students chose designs that celebrated their culture. Susan's firework, in the form of a babushka, honored her Russian family and heritage. Stevie chose a Ukrainian trident to celebrate their birth country and honor family residing in Ukraine. Given the ongoing war between Russia and Ukraine, I was nervous that the politicalized drama of the situation would bleed into students' interactions, so I was proud of the class for not pitting the two students against one another or making culturally insensitive statements. I wrote,

> I may draw attention to this tomorrow and acknowledge that we can celebrate both of these [perspectives] regardless of the current war between the two countries. I want to affirm both students that it's okay to be proud of their heritages and cultures, and they should not be judged themselves based on the current circumstances.

As noted, the next class period, I thanked all students for their contributions and specifically affirmed and thanked both of these students for their meaningful presentations. I followed with an invitation to consider other world circumstances

that might pit individuals against one another and if those were significant in daily interactions with classmates. Overall, I believe this activity was successful and supported the overarching goals of this study to engage in more culturally relevant activities and develop personally meaningful relationships.

Unit 3 Student Reflection Logs. Following the firework project, students reflected on Unit 3. Their entries followed the same procedure as in Unit 1 and 2. Results for the yes–no questions appear in Table 4.4.

Table 4.4 *Unit 3 Student Reflection Log Responses*

Question	Yes		No	
	n	%	*n*	%
3) Was there anything during this unit's activities and lessons that you felt was personally meaningful or relevant to you?	9	56.3	7	43.7
5) Was there anything during this unit's activities and lessons that encouraged you to consider the perspectives of others?	11	68.8	5	31.2
7) Was there anything in this unit's activities and lessons that encouraged you to consider social inequities or advocate for social justice?	4	25.0	12	75.0
9) Was there anything in this unit's activities and lesson that improved your understanding of the Chemistry concepts being taught?	12	75.0	4	25.0

Nine students indicated they enjoyed the lessons, based on their open-ended responses. Several such students elaborated on learning about Chinese culture, which "was cool" as well as personally relevant for one student. Students also recognized how studying fireworks involved real-world application of course content, which made the lessons more interesting. Stevie stated,

> I liked the connection to fireworks when we were talking about light and emissions. I liked seeing the real world connections to what we were

learning, and I liked how it went more in depth than just mentioning fireworks use certain compounds to emit specific wavelengths. Because we explored it a little more deeply, I will remember it easier.

This response is noteworthy because of the connection between the personal relevance of the lesson and the ability to remember the content. Although most students enjoyed the unit, four of the 16 specifically stated that they did not enjoy certain aspects, including one for whom the activities “felt like busy work.”

Beyond mere enjoyment, 56.3% of participants (*n* = 9) felt the and lessons related to or connected with their personal experiences (Table 4.4). However, these students’ explanations primarily cited personal use of fireworks to celebrate holidays and special events. Consistent with previous discussion, many students acknowledged that their connections centered on the relevancy of fireworks instead of connecting personally with the material discussed in class. Aurora’s response represents this idea: “Not really meaningful, but relevant. Now whenever I watch fireworks, I’ll know what chemicals are producing which color, and all that happens to get them into the sky.”

A common response of the five participants who stated that this unit did not connect with their personal experiences was their failure to connect with a cultural identity different from their own. Hayden’s response is a good example: “We learned about Chinese New Year, but since that’s not my culture it didn’t feel particularly meaningful to me specifically.” Exposing students to new cultures can increase their cultural awareness, yet students like Hayden disconnected when the topics, activities, and lessons did not align with their personal and cultural

identities. Such responses played a significant role in my decision to take a break during Unit 4 while planning for meaningful connections in Unit 5.

In response to Question 5, 68.8% of participants (*n* = 11) indicated the unit encouraged them to consider others' perspectives. Given my concern about integrating more culturally and socially relevant aspects with standards focused on atomic structure, that nearly three quarters of the students felt this way was a huge win for me. Of these 11 responses, a common theme was the LDC activity. Eliza's response exemplifies these sentiments: "Learning about other country's holidays encouraged me to consider other country's beliefs and holidays that they celebrate." Another common theme was connecting to Chinese culture. Students noted that investigating the Chinese zodiac symbols and watching videos of Chinese New Year celebrations broadened their worldview. Charlotte's response is representative: "The activities encouraged me to consider the perspective of others, because it made me realize how cultures and traditions vary from not just culture to culture but from person to person as well."

As one of the two students whose cultural heritage came up during the firework presentation, Susan had a particularly interesting response to this question: "I loved seeing others' firework projects, especially when making a connection with [other] students. Though she may be Ukrainian and I am Russian we were still able to connect and respect each other's cultures." This response validated my inclusion of culturally relevant themes. Again, I was proud of students' ability to value one another despite the political strains that could have divided and alienated them.

As evident in Table 4.4, 25% of participants (*n* = 4) indicated the Unit 3 activities and lessons encouraged them to consider social inequities or advocate for social justice. A common theme in their explanations was a connection to the investigation of how LDCs celebrate holidays and significant cultural events. This activity helped students consider alternative perspectives, but they noted the lack of opportunities to advocate for social justice. These results are not surprising; admittedly, the design of this unit did not feature the same critically mindful investigation as the previous unit. Many students acknowledged this contrast in their responses, stating that the activities and lessons did not encourage them to consider inequalities among different groups, nor did it evoke a desire to advocate for social justice. Mr. President's perspective on the focus of this unit, that "It was more about our ideas and not analyzing others," is an accurate sentiment and representation of the goals and overarching themes of this unit, which aligned more with exposure to diverse cultural groups and considering cultural differences as opposed to a social injustice. These findings prompted me to consider how to improve the design of future units to be more inclusive of opportunities to advocate for social justice.

Finally, in response to Question 9, 75% of participants (*n* = 12) indicated the unit improved their understanding of chemistry concepts. A common theme in their explanations was the importance of having visual models for the concepts discussed in class. Several responses indicated the study of fireworks and their colors helped them make strong connections to the chemical structures and properties of different elements. Sydney's response provides one such example:

> Considering how fireworks take on energy as they go up into the sky and only emit light once they explode helped me understand how electrons take on energy as they go up and only emit light once they start to go down energy levels.

Such responses affirmed my decision to study fireworks as an accompaniment to Unit 3. Analysis of the construction and use of fireworks afforded students opportunities to connect their lived experiences to a less abstract phenomenon and aligned with a specific goal of Unit 3.

Reflecting an alternative view in response to Question 9, Stevie confided, "I'll be honest, although it was a cool week to learn about fireworks, I don't think that it particularly improved my understanding of Chemistry." Stevie continued,

> I would have understood it just as well if we had only done regular lessons and didn't dive as deep into fireworks as we did. That being said, I still think the activity was valuable in its own way. Things don't always have to improve understanding. I think it was enough that it gave us a real life example of light emissions.

Stevie's response was noteworthy for several reasons. First, it highlights my challenge of identifying culturally and socially relevant themes that would be meaningful in a chemistry classroom. Reflecting on such responses led to my decision to rethink Unit 4 because I did not want another unit where students felt they did not improve their understanding of chemistry. Second, Stevie's response demonstrates that a culturally and socially relevant curriculum can be valuable even when students believe it does not directly improve their understanding of

the content. These feelings align with my vision of the importance of cultural, social, and personal connections that support, encourage, and facilitate a sense of belonging in the classroom.

Unit 3 Teacher Reflection Log. Analysis of my reflection log surfaced an important transition. I wrote, “This unit was interesting because I felt like the inclusion of more culturally and personally relevant lessons came much easier and was more natural than it was in previous units.” This feeling indicates growth as I became more accustomed to implementing the modified curriculum. Being more comfortable, in turn, allowed me to modify lessons more spontaneously to cater to specific discoveries and interests. For example, when our bell-work activity on Chinese zodiac animals prompted students’ questions and my own desire to learn more, I extended the topic into the following day when students discovered their symbols. This impromptu activity lacked strict connection to chemistry content yet contributed to a fun and engaging environment through student interaction. I realized my pedagogy needs to be directive but flexible enough to accommodate the unplanned and unique student experiences.

The reflection log also notes the relationships I developed with students. Unit 3 took place approximately 9 weeks into the semester, a significant amount of time for us to become comfortable with one another. More than comfort, the personally relevant themes throughout the intervention period provided opportunities for students to connect with other classmates and facilitated a positive and supportive classroom environment. As a result, I felt empowered while implementing new lessons and activities without fear of repercussion.

A final theme was the unit's alignment with my goal of implementing more culturally and socially relevant themes. I stated,

> This unit was definitely shy on social reconstruction and cultural connections where students are able to advocate on behalf of others. I am not quite sure how that could have been accomplished with the theme I chose, but I am aware that this is not something I am featuring as much as I would like to.

As previously discussed, the cumulative Unit 3 data shaped my decision to implement Unit 5 in lieu of Unit 4.

Unit 5: Material Science

Pausing between Unit 3 and Unit 5 allowed me to consider how to enhance students' meaningful connections with chemistry content. I selected intermolecular forces and their physical properties as the primary focus for Unit 5 and identified several real-world applications to demonstrate the everyday relevance of this topic. Unit 5 spanned 8 instructional periods, more than any other intervention unit, and culminated with the material science presentation.

Unit 5 Observations. I completed four observations during Unit 5, coinciding with laboratory investigations to capture students' reactions. Student engagement was a common theme across the hands-on activities. In the first entry, I noted the importance of planning a "hook" activity. Transferring "straight from [students'] observation of the cup demonstration into an exploration of the compound," the class connected their intrigue and desire to solve a problem with information collected during the investigation. I saw a similar relationship when

discussing non-Newtonian fluids. I noted, “the hands-on learning experience allowed students to discover the properties of these fluids” and kept all students engaged in the activity.

When making peanut brittle, I noted the activity was a good use of class time as “students had a memorable and personally engaging laboratory experiment.” Likewise, during the muffin mining activity, I noted, “The hands on nature of this lab made it a great success. Having the visual model in front of them made it real and kept them focused.” Observing each group’s attempts to keep their muffins intact was both enjoyable and relevant. Many of the students’ reflection logs confirmed these observations.

Unit 5 Student Reflection Logs. Students struggled to make meaningful connections in Unit 3. Thus, I was curious about how students would relate to the content and activities in Unit 5. Log entries followed the same procedures as in earlier units, and Table 4.5 displays the yes–no results.

Table 4.5 *Unit 5 Student Reflection Log Responses*

Question	Yes		No	
	n	*%*	*n*	*%*
3) Was there anything during this unit’s activities and lessons that you felt was personally meaningful or relevant to you?	11	68.8	5	31.2
5) Was there anything during this unit’s activities and lessons that encouraged you to consider the perspectives of others?	6	37.5	10	62.5
7) Was there anything in this unit’s activities and lessons that encouraged you to consider social inequities or advocate for social justice?	3	18.8	13	81.2
9) Was there anything in this unit’s activities and lesson that improved your understanding of the Chemistry concepts being taught?	15	93.8	1	6.2

In response to Questions 1 and 2, 69% of students (*n* = 11) indicated the activities in Unit 5 were either “fun” or “enjoyable,” echoing my observation notes. Discussion of hands-on experiences was a common theme. Malcolm’s response is representative: “The activities and lessons completed this week were entertaining, informative, and immersive.” Nathan’s response, “I believe [the activities] were very educational and informative, but not as culturally relevant as past activities,” is also noteworthy because it echoed my own feelings about this unit, as I discuss later in the chapter.

Regarding Question 3, 69% of students (*n* = 11) indicated the activities and lessons were personally meaningful. Three themes emerged in their explanations. First, students found meaning in the muffin mining activity. Several noted the activity helped them become more aware of humanity’s impact on their surroundings. These statements validated my decision to include this activity, but Sydney’s response inspired me to improve it in the future: “The muffin mining activity was personally relevant to me because I am an advocate for protecting the environment.” Helping students become more aware of cultural—and in this case, environmental—justice issues is a great first step, but this activity could further my goal of equipping students to advocate for change.

A second theme I detected was a personal connection to the material science presentation. One student noted their appreciation of the “wonderful” opportunity to share their passion for their chosen material with other students. For other students, researching a material connected to a career they intended to study made the activity more fun and engaging. As Stevie stated,

> The material science project is pretty meaningful to me personally. I'm doing my presentation on this self-healing gel that uses carbon dioxide in the air and sunlight to photosynthesize, grow, and harden. I want to go into computer science in the future, and I think this material has a lot of potential in fixing cracks on phone screens and things like that. It was interesting to learn about it and I'm excited to see what happens with it in the future.

Comments such as Stevie's support the design of this unit as I intended to provide opportunities for meaningful connections to students' potential careers, which many students alluded to as part of their presentations.

The third and final theme was a personal connection to the tie-dye activity. Many students made note of this activity as their favorite for a variety of reasons and shared specific personal connections, including reminiscing about their time at summer camps (Charlotte) and their affinity for art (Eliza). Overall, student responses indicated that this unit provided many opportunities to make connections that were personally meaningful and relevant.

In response to Question 5, 38% of students (*n* = 6) indicated the Unit 5 activities and lessons encouraged them to consider other perspectives. All referenced the muffin mining activity as a catalyst, falling into one of two categories: three students made personal connections with citizens in proximity to mining operations, and three students made personal connections to environmental justice and the impact mining has on the environment. Charlotte's response is a good example of the first category:

> The mining muffin activity and the video that went with it encouraged me to consider other people. The video demonstrated how water sources for towns and communities have been affected because of mining excavation that has not been cleaned up, this made me think about the perspectives of others.

Malcolm's response exemplifies the second category:

> The muffin mining experiment helped me understand the world around us in terms of resources. I always want more and more goods to make life easier/better. However, I never think about where the materials for these goods come from or how they are obtained. It made me feel a little more self-conscious of the products I buy.

In contrast, students who responded that this unit did not encourage them to consider the perspectives of others noted how the unit focused more on materials than people (Dr. Doris), on simple ideas rather than big-picture problems (Romeo), or activities not grounded in culture (Mr. President).

Students shared similar feelings in response to Question 7, concerning social inequities and advocating for social justice, as only 19% of students (n = 3) answered affirmatively. I was disappointed in these results because I believed the muffin mining activity would prompt consideration of environmental justice and the perspectives of individuals impacted by mining operations, yet only a few students made those connections. As Charlotte said, "The muffin mining activity made me consider the environmental impacts from mining excavations." However, the College Board curriculum, namely the focus on intermolecular

forces and their application to solids and liquids, might explain this unit's weaker thematic connection to social justice.

Indeed, in response to Question 9, 94% of students (*n* = 15) indicated the activities and lessons improved their understanding of related chemistry concepts. This result indicates this unit was the most effective in improving students' understanding of the material. Students' explanations further validated the unit design as conducive to making meaningful connections with the content.

Specifically, students indicated the importance of hands-on activities. For example, Aurora stated, "The project with permanent markers and 'magic' markers helped a lot with my understanding on how polar and nonpolar substances react with polar and nonpolar solutions. It was helpful to have a real visual of the reactions." Likewise, Edward valued the laboratory activities, stating, "The chromatography lab was the most beneficial in terms of what I learned. The 'like dissolves like' concept was cemented in my mind through that lab."

Several students indicated the activities helped them visualize chemical phenomena and principles from my lectures. Hayden wrote, "The labs are always fun, and live demonstrations help me to understand the processes that are occurring. I liked tie dying and making Oobleck because we got to be messy." Whereas most laboratory experiments in my AP Chemistry class are precise, accurate, and organized, these activities were memorable to students because of their lack of order. Students may remember the mess of the Oobleck, our uncertainty of how the peanut brittle would turn out, and the stained lab tables after tie-dying shirts in years to come.

An interesting theme in several responses was a direct reference to the *ChemMatters* articles featured in this unit. Although we read such articles in two other units, students had yet to indicate their value. As Nathan stated, “The graphene activity was significantly helpful for my understanding of intermolecular forces, specifically network covalent solids that use covalent bonding to form through carbon’s make up of graphene.” These comments validated my use of the articles as hooks to capture student attention, provide relevant visuals to improve understanding, and demonstrate real-world applications of content.

Unit 5 Teacher Reflection Log. Analysis of my Unit 5 refection log indicates mixed feelings. I noted, “I initially felt pretty good about everything in this unit, but after a more critical analysis, I feel that I did not do a great job of providing opportunities for students to make cultural and social connections.” Nevertheless, there were several positive takeaways.

First, I noted my excitement about the laboratory experiments. The sodium polyacrylate demonstration, muffin mining activity, and peanut brittle lab were all new to me. At the same time, I noted, “It feels like we are flying the airplane while it is being built.” These experiences stretched me as an educator as I sought to anticipate students’ challenges during experiments while attending to my overarching goals. As a result, I felt like I did not have all the answers, which inspired me to become more flexible and focus less on my usual routine.

I made another interesting observation when I reflected on my positionality and biases during this unit. I noted:

> I do not believe that me or my students were out of our comfort zones as much, which made this unit feel more “normal”. I need to be careful not to associate “normal” with “good”. A more culturally and socially relevant curriculum would likely make my experiences more challenging, but these challenges are important to ensure diverse populations still feel connected to my classroom.

I intended for all units to reflect my critical lens; however, my positionality and instructional habits may have limited the design of Unit 5. Additionally, I noted that integrating culturally and socially relevant activities with the topic of intermolecular forces was more challenging as compared to previous topics. These feelings could explain why the activities were more content-heavy.

Post-intervention Phase

As I shifted from the mixed results of Unit 5 to the post-intervention phase, I continued to reflect on students’ ability to make culturally and socially relevant connections. Noting this area for improvement and my role in making such progress happen, I considered what real-world topics would better align with course content and how activities could adopt a more critical lens. Follow-up data from the post-intervention survey and focus group session reinforced and extended these reflections.

Post-intervention Survey

As on the pre-intervention survey, I asked students to define culture, expecting to see changes as a result of the intervention. Two themes emerged in their post-intervention responses, both evident in Newtron’s response:

> I would define culture as a group of individuals that share one or many beliefs about something that bring those people together in order to have similar interactions, values, beliefs, and many more things that can relate them to others in that specific group or others around the world.

In other words, some students associated culture and community, explaining their view that community shapes culture by influencing people's "way of life" through shared "experiences, ideas, and feelings." A second theme that emerged was a connection between culture and beliefs, echoing student responses on the initial survey. Students cited beliefs about art, holidays, religion, food, clothing, dialect, and customs.

Comparing student responses from the pre and post surveys surfaced an interesting observation: more students connected culture to community after the intervention (n = 9) versus before (n = 5). This finding likely reflects my influence, given my own interpretation of the word culture as largely inspired by an individual's community. I likely projected this idea to students during our conversations and by choosing activities and lessons centered on community problems and a broad focus of marginalized groups (e.g., the Flint water crisis). Nevertheless, responses on both surveys indicated students' awareness of the complexity in defining and understanding one's culture.

Table 4.6 presents results for the same category-based questions that appeared on the initial survey, followed by a brief analysis of each question reflecting on differences between pre and post survey data.

Table 4.6 *Post-Intervention Survey Results*

Question	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
1) Different genders, races, and cultures were included in the topics, lessons, and activities discussed in this class.	7	43.8	7	43.8	1	6.3	1	6.3	0	0
4) I feel that my culture, perspective, and personal experience were considered in this class.	4	25.0	9	56.3	2	12.5	1	6.3	0	0
5) Topics, lessons, and activities in this class were relevant to my personal experiences.	2	12.5	9	56.3	2	12.5	3	18.8	0	0
6) Topics, lessons, and activities in this class addressed problems in society today.	6	37.5	8	50.0	2	12.5	0	0	0	0
7) Topics, lessons, and activities in this class empowered me to advocate for change.	2	12.5	7	43.8	4	25.0	1	6.3	2	12.5

As Figure 4.10 shows, in response to Question 1, 87.5% of students (*n* = 14) either strongly agreed or agreed that the topics, lessons, and activities discussed in our class included gender, race, and culture. On the pre-intervention survey, only 31.3% of students (*n* = 5) indicated such inclusion in previous science courses. This increase was encouraging, validating my intentional modification of the curriculum to include culturally and socially relevant themes.

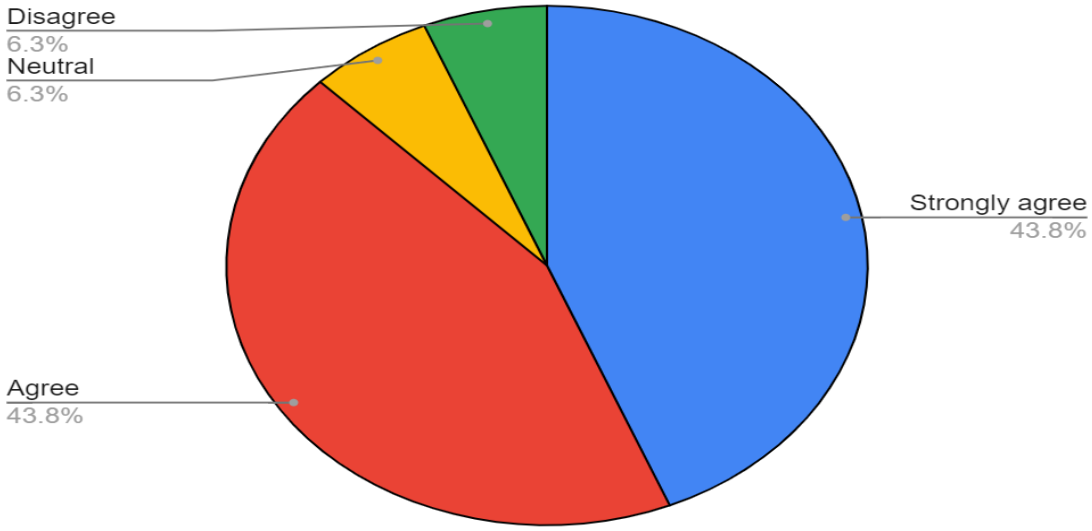

Figure 4.10 *Post-Intervention Responses to Question 1*

Analyzing the explanations of students who either strongly agreed or agreed with this statement yielded two primary themes. First was the importance of classroom discussions, as 37.5% of students (*n* = 6) highlighted numerous in-class references to differences in race, gender, religion, traditions, and culture. These responses reflect the success of my intention to foster open discourse throughout each unit of study. I believe these large-group discussions created a supportive environment where students could share insights, ask questions, and

engage in critical thinking, an endeavor to not just think deeply, but be more critically minded (Haymarket Books, 2020).

The second theme that emerged was the relevance of the classroom activities and laboratory experiments. Four students (25%) indicated these lessons helped them connect with the world and were inclusive of different cultures, races, and genders. These responses also reflect my intentional design and critical evaluation of each activity. Practicing CRP helped me integrate culturally and socially relevant themes into preexisting lessons while maintaining a focus on College Board standards. Eliza's response provided evidence that I accomplished these goals: "Each week, our class learned about the uniqueness of other countries, including what they believed and celebrated to highlight the contrasting genders, races, and cultures that make up pieces of our world." However, Newtron's response provided an alternative perspective:

> Although some races were not completely incorporated, the majority of both genders and cultures shined throughout the lessons including many older generations that elaborated on the struggles of women when they had to fight for their own positions as well as other races.

Newtron thus reminded me that my goal of creating a culturally relevant classroom is still a work in progress. With more practice, time, and training, I hope to improve the instructional design of the curriculum.

In response to Question 4, 81.3% of students (*n* = 13) either strongly agreed or agreed that their culture, perspective, and personal experiences were considered in class (Figure 4.11). On the initial survey, only 31.3% of students (*n*

= 5) indicated the same regarding their previous science classes. Students cited specific activities that facilitated personal connections, such as designing their own firework and investigating their Chinese zodiac symbol.

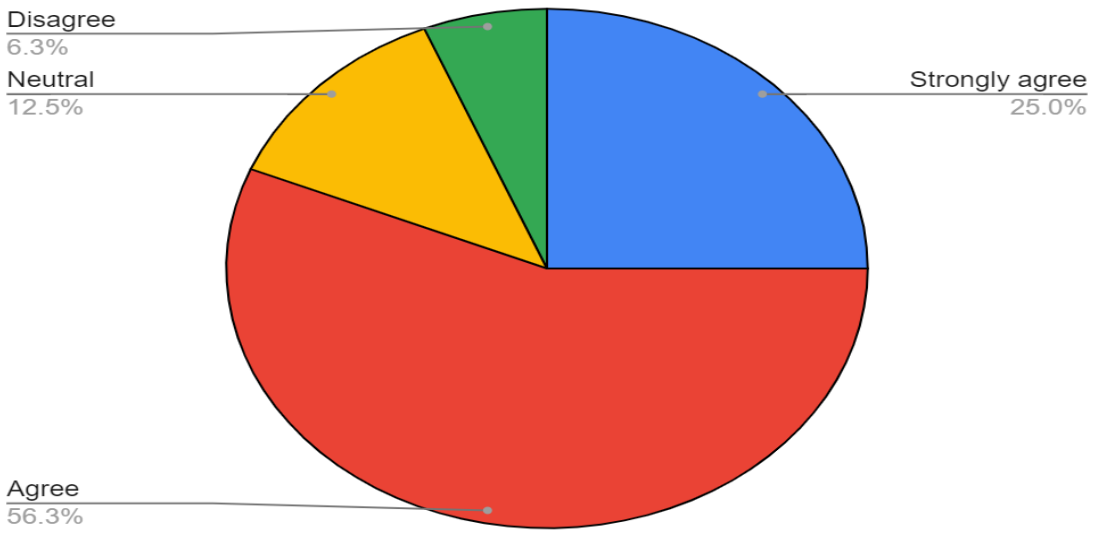

Figure 4.11 *Post-Intervention Responses to Question 4*

Another theme was the positive, supportive environment in which students shared their experiences with one another. Stevie saw such opportunities in "each activity, especially projects or presentations," and noticed,

> It was really up to the student if they were comfortable enough to reveal that part of themselves to the entire class, and if they weren't, they didn't have to. Any time anyone did talk about themselves, though, it was always a positive conversation which was nice to participate in.

Stevie's encouraging response serves as evidence that I established a more culturally relevant classroom environment.

In contrast, 18.8% of students (*n* = 3) were either neutral or disagreed that my class included their culture, perspectives, and personal experiences. Two

responses speak to White students' experiences with a culturally diverse curriculum. One student stated, "I feel like by nature as a white guy my culture will always be considered." Another responded, "I have a more broad and American culture, which was already present in the material in this class, and the culture targeted in this class was to be more inclusive of more specific and diverse cultures." These honest answers to the prompt convey an awareness that I used critical lenses in the design and implementation of class activities.

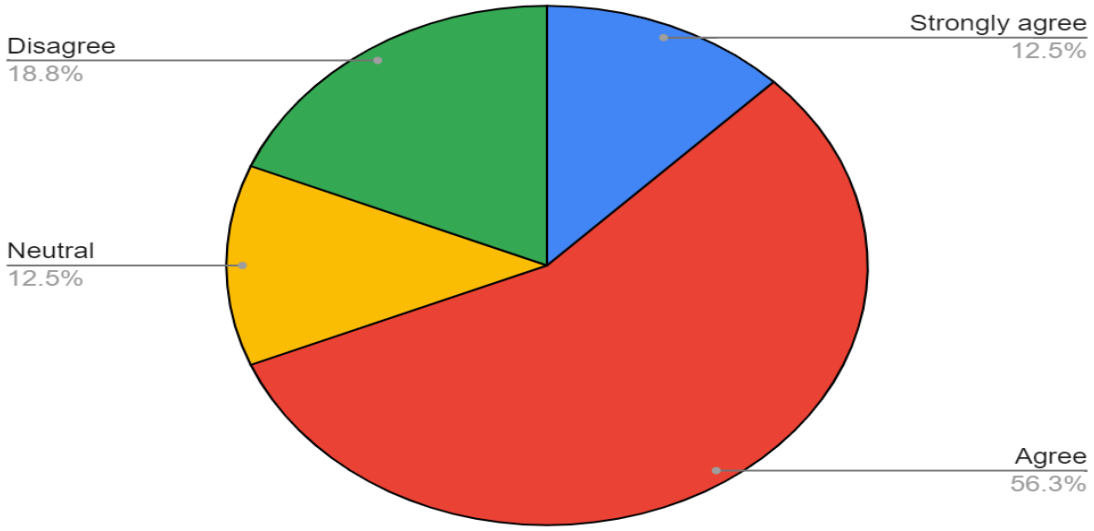

Figure 4.12 *Post-Intervention Responses to Question 5*

In response to Question 5, about the personal relevance of the class, 68.8% (*n* = 11) of students indicated they either agreed or strongly agreed (Figure 4.12). This result was an increase compared to the pre-intervention survey, which found 18.8% of students (*n* = 5) indicated similar sentiments about previous science classes. Again, students pointed to specific opportunities for relevant connections, as in Eliza's response:

> Many topics/lessons related to me on a personal level unlike my other classes in school, which made coming to class and learning more interesting, as I enjoyed learning new material while also feeling personally connected to the materials being taught.

Eliza's comment highlights how making relevant connections can excite students.

Jeremiah's response was also noteworthy, as it indicated a potential flaw in my phrasing of the survey question:

> My personal experiences were not in the scope of the cultural activities planned for class, as they were targeted to be more specific as compared to my more broad experiences, such as the Flint Michigan Water Crisis, which is way out of scope to my experiences. However, the point of these activities was for us to consider other cultures, not to relate to our own broad cultures that we have already accepted, so no harm is done in these developments.

Jeremiah helped me realize the prompt assumes an outsider perspective that contradicts the White identity of most student participants. Altering the prompt would align with the sentiment of Jeremiah's response and more appropriately measure participants' abilities to connect with different cultures.

As for Question 6, Figure 4.13 shows that 87.5% of students (n = 14) indicated they either agreed or strongly agreed that topics, lessons, and activities pertained to current social problems. On the initial survey, only 25% (n = 4) indicated the same regarding their previous science classes. Their open-ended responses mentioned several activities that contributed to this increase.

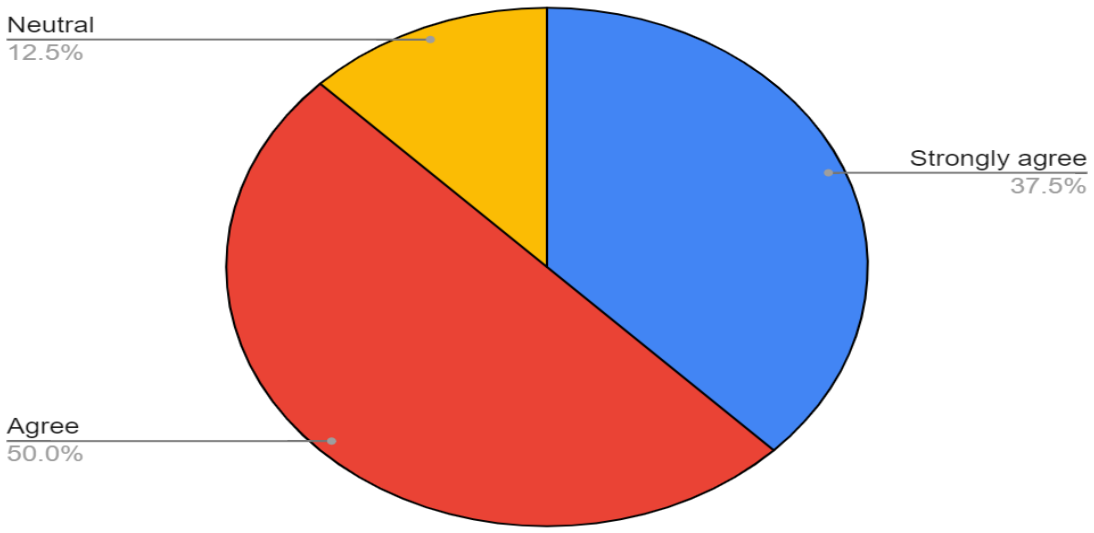

Figure 4.13 *Post-Intervention Responses to Question 6*

Many students cited the Flint water crisis. Because Unit 2 had the strongest connection to social justice advocacy, it specifically aligned with the nature of this question. Susan captured the personal significance of this activity by stating, “The Flint Michigan crisis taught me the needs for activism in low income regions and how due to their lack of wealth they are treated less than and put in dangerous situations.” This activity provided the framework for students to consider that many social inequities are complicated and multifaceted, extending beyond the scope of their own lives. Feedback from students also indicated the activity helped them consider how contaminated water problems would be handled differently in their own communities.

The muffin mining activity, which also addressed a current social problem, featured prominently in students’ responses. They acknowledged the importance of environmental justice and how mining operations threaten the sustainability of certain regions. For example, Romeo stated, “The sustainability lab was the best

lab to show how our treatment of the environment cannot be so easily fixed." Romeo aptly connected present-day human actions to long-term consequences.

Malcolm's response also stood out to me. It featured aspects from Unit 1 to highlight problems experienced by female and other marginalized scientists. Discussing how White males stole ideas from these scientists allowed students to consider and discuss social inequalities related to gender and class.

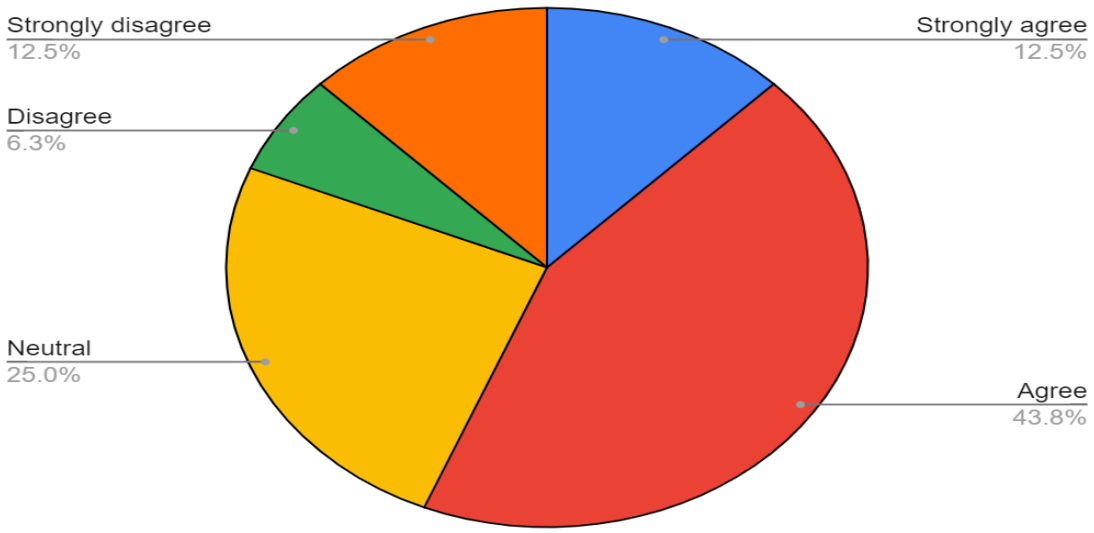

Figure 4.14 *Post-Intervention Responses to Question 7*

In response to Question 7, as Figure 4.14 shows, 56.3% of students (*n* = 9) answered affirmatively, an increase from the 37.5% of students (*n* = 5) who indicated on the initial survey that topics, lessons, and activities in their previous science classes empowered them to advocate for change. This discovery was encouraging but indicates an area for improvement in the future. First, students who agreed with this statement offered a variety of explanations. Charlotte noted, "a lot of activities opened my eyes to issues going on in society today, making me want to help better our society." Jeremiah had a similar awakening, stating, "It

certainly made me think about social issues that I hadn't previously given much thought to. I realize the world needs a lot of help." Jessica's response also captures a desire to advocate for change: "Many of these problems occurred because people didn't care or didn't know, I think fighting for change should be something everyone should do."

Although a majority of students agreed with this statement, a significant number felt otherwise, including two students who strongly disagreed. For example, Stevie's response highlights a limitation of the intervention:

> One topic got close to making me feel empowered to advocate for change, and that was the Flint, Michigan study. What a perfectly designed lesson plan. It really resonated with me by making me consider societal issues. A similar water crisis could happen in my own community, and what would people do? It did prompt me to seek out some more volunteering opportunities, but I don't think I would classify that as advocating for change. Most other activities also failed to make the connection to societal issues, which really doomed them with this question.

Other students who responded they were neutral or disagreed with this statement also cited a lack of opportunities or motivation to advocate for change. Reflecting on my own experiences, I agree that several units lacked the necessary components to increase students' desire to advocate for change and the opportunity to put advocacy into action.

The goal of Question 8 was to capture student perceptions as directly related to one of my research questions. When asked, point-blank, if I succeeded

in creating and teaching a more culturally and socially relevant chemistry class, all 16 students responded affirmatively. This result was encouraging, and students elaborated on my intentional inclusion of diverse topics and cultural groups, which deviated from their prior experiences in science classes. Sydney stated, “All of our activities were thought out to address different cultural and social aspects. These topics were never addressed to me in previous chemistry classes, making this class significantly different.” Similarly, Charlotte described me as “extremely successful in creating a class that was more culturally and socially relevant” and reported learning “more about the current issues in society and how to help them in [my] class, than all [other] courses combined.” A final encouraging note came from Mr. President, who stated, “The class was much more engaging and exciting than any other class I have been in.”

Students also noted the benefits of learning from the modified curriculum. Stevie, for example, spoke to the scope and sequence:

> Even if an activity wasn’t perfect, it sparked up conversation in the classroom, which is the most important thing. Students got to know each other better, and it made the classroom culture more inclusive. The activities were always attempting to be socially relevant, and that’s enough for a kid to take and run with it.

Like Stevie, Malcolm also complimented my instruction, stating that I “was able to dive into different socially relevant topics that connected with [students]” and added that I made them “more appreciative towards social, class, and environmental issues.” Similarly, Jeremiah wrote, “I actually learned concepts in

chemistry and then was able to see them applied in real life situations which I feel like my previous classes have not been able to do."

The open-ended prompt in Question 9 allowed participants to address limitations in my intervention and offer critical feedback for improvement. Additionally, this question helped me consider my positionality within this study to address personal biases that influenced my design and instruction. Several themes emerged from student responses to this question.

Three students suggested lessons and activities should feature more diverse populations. Specifically, students highlighted a lack of South American and Middle Eastern representation. These suggestions are valid as the inclusion of current events and issues relevant to other countries would provide more opportunities for students to consider the experiences of diverse populations. Jeremiah's suggestion in particular prompted reflection on my positionality:

> I think it could focus more on things [students] deal with on a daily basis that are familiar to us because we did learn about recent stuff but not all of it was super relevant to me as a high schooler.

I was grateful for this feedback as I had not previously considered the experiences of high school students in other countries and how their experiences would be similar or different compared to U.S. students.

Question 10 sought direct feedback from student participants to help me answer my first research question related to how students experienced learning from a modified curriculum. Figure 4.15 displays their responses. That each participant chose a different word to encapsulate their experience is a testament

to the complex nature of this research and how individuals' perceptions and knowledge uniquely shape their experiences.

curious	**engaging**	**improved**	**done-well**
relevant	**memorable**	**exciting**	**mind-altering**
intrigued	**fun**	**insightful**	**ignorant**
informative	**immersive**	**begrudgingly**	**chill**

Figure 4.15 *Student Reactions to the Modified Curriculum*

Most participants' words conveyed appreciation for the modified curriculum (e.g., improved, exciting, engaging), while a couple reflected feelings of discomfort or resistance (e.g., ignorant, begrudgingly). This outcome is not surprising; curriculum that addresses cultural and social differences can challenge preconceived notions and perceptions of student identities and potentially move them outside their comfort zone. Nevertheless, a majority of students evidently benefited from the modified curriculum.

Focus Group Analysis

As discussed in Chapter 3, conducting a focus group provided additional insight into students' experiences. I invited six students to attend based on their willingness in response to Question 12 on the post-intervention survey and used a semi-structured protocol (Appendix H). Due to scheduling conflicts, only four students were able to participate in the session: Edward, Jessica, Susan, and Mr. President. Analyzing the transcript of our conversation yielded three themes as well as important feedback for improvement.

The first theme I discovered was the significance of student voice and choice during classroom activities, especially related to student presentations. Students noted their appreciation of activities that allowed them to express themselves and their perspectives. As Edward shared,

> I loved every single [activity] because they were relevant in all fronts to me because, you know, I can do whatever I want. I took every presentation and ran with it. I just loved all those assignments. I think probably that's the best way to be personally relevant, because it's a blank canvas.

Edward's statement showcases his excitement to share personally relevant material with his peers and reminded me of the joy I feel as a teacher when I share my passion for learning with my students.

Further discussion surfaced appreciation for diverse perspectives during presentations. When students presented individually, the class had multiple opportunities to connect with the theme of each unit. Additionally, they recalled feeling empowered when peers validated their contributions. In other words, students were part of something bigger than themselves. As Jessica stated, "When students get to pick exactly what they're researching, or like what they're doing, I think we could bring in more cultures. So, maybe it's not always on [Mr. Sox] to provide that cultural equity."

The second theme that emerged was students' ability to apply culturally and socially relevant themes. The Flint water crisis was particularly significant to Susan, as "It brought to [her] eye, like corruptness in the world." She continued, "I didn't think it would happen for providing clean water. And we all know that, like,

money runs the world, but [it] was definitely an eye opener that people of lower classes can't advocate for themselves." Edward also felt strongly about the Flint study "considering other people's perspectives" was so impactful and brought the socioeconomic angle of the crisis to the fore. Jessica adopted a culturally relevant lens while considering problems in other classes:

> I am taking medical courses where it shows examples of a certain rash or disease, and we only see it on White or like white-colored skin. So it's really hard, like, how would people of color tell whether they have this disease or not if all the models are not people of color?

These comments indicated students were able to apply my lessons in other domains. Consistent with CRP, their learning was not limited to the four walls of the classroom. Rather, Edward shared a revelation in response to Unit 1: "So, the world isn't just old White guys?" A culturally and socially relevant curriculum fostered a more inclusive perspective.

I noted one final theme: although some activities failed to immerse the class in other cultures, students nevertheless acknowledged my effort to demonstrate CRP. Edward noted:

> I never felt particularly immersed. I mean, I felt immersed in, you know, intermolecular forces and gas laws and all that . . . but I didn't really feel like I was learning too much about other cultures.

My other data collection instruments also detected this theme; however, the focus group session enabled students to express sentiments of encouragement and appreciation for my work in progress. For example, Jessica admitted some

activities “were definitely more effective than others,” while adding, “but honestly . . . I think you do way better than other teachers do. I mean, you’re setting the pathway. It’s like . . . no one’s done this before, [so you are trying to] see what’s good and what’s bad.” Mr. President also contextualized my modified curriculum by referring to other teachers: “I feel like this could advance academia. What you learn here and what people get from your paper, they can use that in their own classrooms.” Similarly, Susan voiced appreciation for teachers who are invested in their teaching: “I feel like a connection to education makes it resonate more with you. So that’s why we take, like, our favorite classes because that resonates more with us.” Such responses demonstrate the potential ripple effect of CRP.

Participants also offered suggestions for enhancing the modified course. Citing my emphasis on Asian cultures during Unit 2, they recommended aligning instruction with “the backgrounds of other cultures” to facilitate relevant connections with diverse student populations. Additionally, they encouraged me to elaborate on historical significance. Edward explained:

> You could, like, go into the history of the topics that you’re teaching. Staring a slideshow as, like, this is how this concept came to be could go into the history of the topics that you’re teaching [and] would be more culturally inclusive.

Chapter 5 describes my vision for applying these suggestions in future units.

Overall Analysis

Looking across the data elicited several themes pertaining to my research questions. Question 1 asked how my students experience a more culturally and

socially relevant science curriculum. The ultimate success of the intervention depended on students' perception of the curriculum's personal significance. My efforts to measure their experiences revealed five discoveries.

First, my curriculum surfaced participants' belief that teachers and students should consider cultural differences in their day-to-day interactions. Student responses to Questions 2 and 3 on the pre survey, observations, student reflection logs, and the post survey captured these feelings. This discovery supports the use of CRP in all classes. Students expect teachers to consider their perspectives and find meaningful ways to make the content relevant, regardless of cultural differences. As Aurora shared on the pre survey,

> Everyone being treated equally in a class by the teacher is one of the most important parts of a great class. A student *feeling* included is much different than a student being included. It is so important for the teacher to consider the differences of other students, because they should treat every single student with the same ounce of respect as they treat another.

Aurora linked a student's inclusion in a class to its value. When teachers adopt inclusive mindsets, they establish safe, supportive classrooms where students can thrive academically and further develop their cultural competencies.

Second, the modified curriculum supported students' understanding of chemistry. This finding was particularly important to me because I had feared students would perceive the change in pedagogy as a disruption of their normal learning practices. Student reflection logs, observation notes, post survey responses, and the focus group transcript prove otherwise. Reflecting on the

relationship between class activities completed and chemistry concepts, Mr. President noted, “The activities were fun and engaging. [They] didn’t take too much time to complete and solidified my understanding.” Likewise, students’ cumulative responses to Question 9 in their reflection logs suggest the activities and lessons in each unit improved their understanding of chemistry (Table 4.7).

Table 4.7 *Student Reflection Log Responses to Question 9*

Unit	Topic	Yes		No	
		n	*%*	*n*	*%*
1	Leaders in STEM	8	50.0	8	50.0
2	Flint Water Crisis	15	93.8	1	6.2
3	Getting Electrons Excited	12	75.0	4	25.0
5	Material Science	15	93.8	1	6.2

The deviation in Unit 1 is likely a result of its introductory nature and short timeline. Responses in Units 2, 3, and 5 indicate the success of the modified curriculum through students’ confidence in their chemistry knowledge. In accordance with my instructional design, lessons highlighted the real-world significance of content, which enhanced their understanding of the material.

I gave students numerous opportunities to discuss positive and negative aspects of each unit, yet none of the participants indicated their instruction suffered as a result of the modified curriculum. Considering the advanced level of the course and typical academic mindset of students in my community, I believe this outcome is a significant achievement. It provides further evidence of the

value of CRP and my ability to infuse the academic curriculum with meaningful experiences for students of diverse backgrounds.

Third, I discovered students were engaged during culturally and socially relevant lessons. Evidence of engagement was consistent across responses to Question 1 in their reflection logs and in my observation notes throughout the intervention period. Students described lessons as fun, interactive, interesting, and relevant, echoing numerous records from my observations. For example, during the web quest activity on firework alternatives in LDCs, I noted, “Students were interested and engaged throughout the activity. When asked to share what they found, many students took the opportunity to share what they had learned.”

Participants’ engagement extended beyond activities. Discourse prior to activities set the tone for the activities themselves. For example, the initial sodium polyacrylate demonstration during Unit 5 captured students’ interest in a way they could further develop after transitioning to the laboratory. Similarly, the *ChemMatters* articles facilitated engagement. Jessica noted, “I really liked the articles that you gave us because it allowed us to first [consider] how we would perceive it, and then it would give the perspective of someone else and how it affected them in their situations.” Such responses affirm my intentional use of articles, think-pair-share discussions, and demonstrations to engage students at the onset of lessons and lay foundations for future discoveries.

Fourth, I discovered improved relationships among students, based on evidence from my observations, student reflection logs, teacher reflection logs, and the focus group. During the focus group, Susan reflected on the Unit 2

presentation: “When I shared my traditions, [classmates] were genuinely interested and willing to learn, not disrespectful even with their differences of culture.” Respect for classmates’ perspectives was also evidence across student reflection logs. Isabella’s response during Unit 1 was a good example.

> I considered the perspectives of others when I was doing a lab with my partners. We were stuck on something within the lab and I had to consider the perspective my partner had on the problem versus my perspective, which were two different perspectives.

Improved relationships among students proved to be an asset during laboratory investigations, notably the Lead in the Water activity. As I noted in my observations at the onset of the lesson, “students seemed nervous, but excited.” The complex nature of this lab required students to brainstorm testable conditions and share ideas in a supportive yet critical setting. Each lab group succeeded in having such dialogue, and I noted, “all students were engaged and communicating well while developing procedures.”

A final discovery related to Research Question 1 was how aligning my instruction to CRP impacted students’ immediate and long-term perspectives, as evident in student reflection logs, post survey responses, and the focus group transcript. Students’ reflections on Question 1 and 3 convey the modified curriculum’s influence on their thinking. In Unit 1, stories of underrepresented scientists “opened [Aurora’s] eyes to a lot of hardships,” and Unit 2 had a similar effect. Aurora “could only imagine the feeling of citizens in Flint,” thinking, “I would’ve felt so uncomfortable and unsafe, along with feeling like the government

in control of my town cares more about money than my health. Let alone if I had children." Studying the Flint water crisis also moved Jeremiah, who voiced a desire to "make sure everyone has equal access to clean resources, not just affluent communities." In Unit 3, Sydney acknowledged, "Learning about the cultural significance of fireworks and celebrations associated with fireworks really made me think about how others live." Likewise, the activities encouraged Nathan to "consider other people's perspectives and how they celebrate holidays." In the final unit, the muffin mining activity made Malcolm resolve to be a more conscious consumer. Thus, throughout the intervention period, participants indicated changes in their worldview in response to the curriculum.

Students' grasp of chemistry was vital for passing the exam at the end of the semester, yet instruction grounded in CRP promoted equity and unity—lessons I want students to remember long after they finish my course. During the focus group session, Jessica gave me hope by commenting,

> The more you do this, the more people are going to want to take your classes, and the more people will be immersed in this. And then maybe, they'll become teachers and they'll do the same thing. So it will spread.

Jessica's comment highlights the exponential influence teachers have. I was encouraged by the notion that cultural lessons in my classroom could inspire students to be agents of change in their own spheres of influence.

Indeed, Research Question 1 was intimately connected to Question 2: How does planning and implementing a culturally and socially relevant science curriculum impact my experiences as a teacher? Enrolling in an Ed.D. program

challenged me to consider my own beliefs and their influence on my teaching practices. Such introspection permeated this study as I considered the strengths and weaknesses of my modified curriculum. Analysis of observation notes, teacher reflection logs, and the focus group transcript yielded three discoveries related to my experiences as a teacher.

First, just as open and supportive relationships were important to student experiences, meaningful relationships with students were important to my own experience. Reflecting on Unit 1, I wrote, “I was nervous to try something new and interested to see if students would buy into the plan for this week.” Deviating from my traditional pedagogy prompted fear of backlash from students and parents and concern that I was unable to facilitate culturally and socially relevant experiences. By Unit 2, I reflected,

> I was thankful to observe a lot of engagement and buy in from students. I think that I am getting better at having open ended conversations with my students. I was nervous at the start, but I feel like I have trusting relationships with my students where I can speak freely and I have a classroom environment where they can speak freely.

In other words, my fears subsided when I realized students were having fun and appreciated making personal connections.

Positive relationships with students empowered and encouraged me to keep going even when things did not go exactly as planned. I noted in Unit 5,

> There have been a lot of distractions in this unit, especially since I had to modify Unit 4. While difficult and not particularly enjoyable, it did give me

> practice in being more flexible and catering to the specific needs of what was happening in class and my students.

Despite my insecurities, participants eagerly engaged in activities and regularly asked how the study was progressing, even inquiring as to what I was learning. I do not believe I would have been as motivated or successful if participants had not been genuinely interested in the outcomes of my research.

In my years as an educator, I have had the pleasure of teaching many students; however, I experienced a unique bond of not only friendship but also respect with this particular group of students. As I noted in review of the pre-intervention survey results, participants were more culturally aware than I expected, which I would not have known unless students shared their experiences with me. The modified curriculum invited us to share personal experiences, which yielded new discoveries. The more I learned about my students, the more I understood their backgrounds and insights, which made me a better teacher.

Second, I discovered that implementing the modified curriculum became easier over time. My reflection on Unit 3 exemplifies this discovery:

> This week was interesting because I felt like the inclusion of more cultural and personally relevant lessons came much easier and was more natural than in previous units. I was able to do more impromptu lessons and was able to add a lesson on the fly when I needed to extent the unit due to changes in the schedule and pace of the class.

As I became acquainted with CRP and implemented multiple critically mindful lessons, this feeling overcame my prior belief that activities needed to check off every box possible. Expecting every lesson to foster cultural, social, and personal connections while simultaneously encouraging students to advocate for social and environmental justice was an impossible goal, and I soon realized the need to relax such strict criteria. By Unit 3, I reflected,

> The most challenging thing [for me] in this unit was finding a theme that allowed for personal, social, and chemical connections. We are covering atomic structure in class and sometimes the material we are covering doesn't lend itself easily to student connections. I think I did a good job sticking to a theme for this unit and while I didn't have everything fully fleshed out for the week when I started, I was able to add some lessons that blended nicely!

This response captures my transformation and the need to modify instruction based on student experiences.

Flexibility was central to my instructional design because I could not predict exactly which topics and events would be meaningful. This discovery was important for me—and likely for other teachers—as it demonstrates perfection is not required for improvement. I believe I succeeded in my goal to improve my pedagogy through strategic lesson planning, open-minded reflection, and trial-and-error implementation. Each activity yielded new knowledge and experience, which informed my design and execution of the next activity. In this way, I grew as an educator and my ability to facilitate critically mindful lessons improved.

Finally, implementing the modified curriculum made me increasingly aware of cultural biases in my own instruction. This discovery emerged from analysis of my teacher reflection logs. At the completion of each unit, I challenged myself to consider how my positionality and biases influenced my instructional design and interpretations of the unit. In Unit 1, I noted the strong relationships female participants formed when researching and presenting on underrepresented scientists as “not something that I expected to come out of this unit of study.” As a White male, I had not considered the importance of empowering my female students. My positionality also played a role during Unit 2, when facilitating discussion was a unique challenge. I reflected,

> I was aware of my outsider position relative to the Flint crisis and tried to ensure that I spoke about how ‘I think’ I would feel, and elaborate on how my everyday circumstances are different from the people in Flint.

In this way, I aimed to limit assumptions during classroom discussions while inviting students to share their own feelings and experiences.

These revelations continue to impact my everyday practices. Small, practical steps—including diverse names in practice problems, writing question prompts in less formal language, and choosing ethnically diverse Barbie dolls for a bungee jump lab in physics—emerged from my reflections. Collectively, they demonstrate progress in my journey to become a better teacher.

Summary

Chapter 4 presented my findings from this action research study exploring the impact of a more culturally and socially relevant curriculum on student and

teacher experiences. An exhaustive review of data from surveys, reflection logs, observations, and a focus group yielded multiple discoveries about my students and myself. These discoveries largely affirm my use of CRP in AP Chemistry. Answering the research questions advanced my knowledge and use of CRP; however, results also revealed areas for improvement. Chapter 5 elaborates on these findings and offers suggestions for improvements.

CHAPTER 5

IMPLICATIONS

Through action research, I sought to improve my practice by grounding my AP Chemistry curriculum in culturally and socially relevant topics. Analysis of data collected before, during, and after the intervention period yielded evidence of positive experiences overall, suggesting the modified curriculum was beneficial to both students and teacher. To further explore the significance of my study, I reflect on my findings and their connections to preexisting literature, offer recommendations for fellow and future practitioners, articulate plans for future implementation, critically reflect on my methodology, and suggest avenues for additional research.

Reflection on Existing Literature

Cross-analysis of my literature review with my own discoveries revealed two themes consistent with the scholarship framing this study. First, my study affirmed the significance of positive and supportive relationships among students and between students and their teachers in culturally mindful classrooms. Educators who aspire to CRP prioritize content as well as classroom climate (Brown, 2004; Gay, 2002; Irvine, 2012). As noted in Chapter 4, meaningful relationships were evident in both student and teacher experiences in my study, demonstrating how culturally responsive classrooms consider and value students (Gay, 2013, 2018; Parsons, 2005; Rychly & Graves, 2012; Tosolt, 2010). From

the onset, I aimed to facilitate lessons in which students could reflect on their own understanding in contrast with the experiences of their classmates. Because CRP embraces the intrapersonal aspects of students' characteristics that make them unique, thereby personalizing learning experiences (Ladson-Billings, 1995a, 1995b, 2001, 2013), I not only encouraged students to reflect, but also to engage in dialogue that supported the discoveries made during critical reflection.

Students' reflection logs document ample evidence of such reflection throughout the intervention period and convey participants' comfort with sharing perspectives and experiences due to their peers' accepting attitudes. Such improved classroom climates and student relationships are associated with culturally responsive educators (Gay, 2018). Delano-Oriaran and Parks (2015) noted civil, honest, and critical discourse is only possible if students have evidence they are supported and known. Consistent with hooks (1994, 2003), open discourse at the onset and conclusion of activities created opportunities for students to speak freely, ask questions, and be heard.

Specifically, student presentations at the conclusion of units supported this initiative and served as platforms for student affirmation for their work. The consistent and regular implementation of these activities normalized the reflective process and helped facilitate a positive classroom environment. The more we shared and discussed, the more positive our classroom climate became, and vice versa. This positive feedback loop resulted in meaningful relationships built on trust and understanding. The benefits of these positive relationships are innumerable and were a significant reason why I felt comfortable completing my

modified curriculum. Listening to and learning from students provided opportunities to recognize cultural and personal differences and gain insights into their daily lives (Villegas & Lucas, 2002). In the end, I felt as if our classroom became a family—one that may bicker at times, but with invariably strong bonds.

The second theme that emerged from placing my findings in conversation with existing literature was culturally relevant lessons' impact on student learning. As indicated by student responses in Figure 4.15, not everyone had an overall positive experience; however, observations and reflections throughout the intervention period note consistent student engagement. I can attest from prior experience that AP students are not necessarily inclined to participate or complete their work, yet I believe my participants were engaged because they found purpose in the modified curriculum. When lessons represent learners' culture, identity, and personal experiences, students connect (García & Guerra, 2004; Gay; 2002, 2013, 2018; Robinson & Biran, 2006) and experience authentic learning as valued members in the classroom (Ladson Billings, 1995a, 1995b, 2001, 2013; Paris & Alim, 2014, 2017).

The critical nature of my culturally relevant lessons empowered students to consider diverse perspectives and the value that comes with a more holistic perspective on both past and present challenges. Consistent with social reconstructionism, participants applied their experiences to world, national, and local purposes (Cochran-Smith, 2004). Additionally, the curriculum encouraged them to take action and speak out on behalf of their beliefs. As demonstrated in observations and reflection logs in Unit 2, critically mindful lessons and activities

promoted both discussion and experiential learning, which encouraged students to assimilate their experiences and construct new knowledge (McLaren & Giroux, 1997; Stern & Riley, 2002). In this way, students reconstructed their understanding of society and the principles shaping them as they sought solutions to real-world problems (Shoemaker, 2003). Broadening the scope and sequence of my class encouraged White students to embrace diversity, respect cultural differences, and advocate for social justice reform (Pan, 2006). Advocating for social justice is both a goal and a process (Bell, 1997). Thus, I hope students continue to apply the lessons they learned in my classroom to combat prolonged social injustices as empowered agents of change.

Recommendations for Practice

My problem of practice for this qualitative action research study surfaced when I realized a lack of diverse teaching practices at odds with increasing student diversity (National Center for Education Statistics, 2019). Answers to Research Question 2 regarding my experiences while implementing my modified curriculum relay the importance of meaningful relationships with students, increased confidence with repetition, and increased awareness of cultural biases in my normative practices. These insights may prove valuable for teachers considering the adoption of more critical and cultural mindsets. Therefore, my recommendations for practice center on the use of more culturally relevant teaching practices in science.

First, practitioners should consider problem-solving approaches while implementing culturally relevant lessons. A problem-based approach enables

students to investigate real, open-ended problems; formulate questions; and develop solutions to authentic challenging situations (Allen et al., 2011; Torp & Sage, 2002). Inviting students to solve meaningful problems supports critical thinking and student engagement, both necessary for challenging injustice and inequity (Ladson-Billings, 2001). This instructional approach not only identifies meaningful examples for students, but also encourages them to devise meaningful solutions for change. This outcome was most evident in Unit 2, during our investigation of the Flint water crisis. As noted in both student and teacher reflections, the problem-based unit proved most successful at immersing students in culturally relevant and responsive pedagogy.

Second, I recommend normalizing the use of student presentations. When designing my modified curriculum, I was unsure if the time dedicated for presentations would be valuable; however, my observations and students' responses suggest incorporating presentations might be the most worthwhile change I implemented. Students' reflection log entries and post survey responses emphasized how they valued having freedom and choice regarding the topic and design of their presentations. Presentations also afforded students the opportunity to self-reflect and include personally meaningful features. In this way, assignments become more relevant, useful, and engaging. Indeed, students leading presentations were not the only beneficiaries. Evidence from student reflection log entries and the focus group conversation suggests audience members acquired new insights and learned from the diverse collection of presentations and presenters. As demonstrated by the Leaders in STEM project,

exposure to diverse perspectives and experiences increased multicultural awareness and encouraged self-reflection (Banks, 2004).

Third, I recommend expanding my use of culturally relevant lessons by integrating a STEAM-centered design that features multilayered thinking combining the best of arts and technical elements. When used intentionally, art can anchor students in the design process, promoting a more holistic and valuable approach to learning (Gess, 2017). Research further suggests a STEAM framework and design supports deeper critical thinking and opportunities to explore personally relevant connections among materials, design, society, and the environment (Perignat & Katz-Buonincontro, 2019; Sochacka & Walther, 2016). Such diverse instructional strategies could strengthen personal and cultural connections in science disciplines. As evident in my students' fireworks projects in Unit 2, when given the opportunity, students openly shared personally meaningful and culturally significant aspects of their identities. In conjunction with my earlier recommendation for presentations in science classrooms, this approach promotes student choice and provides a platform that supports meaningful classroom relationships that affirm student work and contributions.

My final recommendation is for curriculum designers and district leaders responsible for approving curriculum. The outcomes of this study should encourage pursuit and adoption of culturally relevant curriculums. The value-added nature of CRP leverages students' strengths to make learning more relevant and effective, working to reverse patterns of underachievement for students of color (Gay, 2013; Ladson-Billings, 1995a, 1995b, 2001). As Muñiz

(2019) suggested, all states already incorporate some aspects of culturally responsive teaching; however, the majority have yet to provide a model clear or comprehensive enough to support teachers who are eager to strengthen and further develop their practices. Supporting the adoption of culturally responsive teaching is a major investment and a foundational step that district and state leaders can take to bolster teacher preparation and development. Not only would such efforts provide teachers with guidance on the necessary skills and mindsets to be culturally responsive in their careers, they would also affirm teachers' choosing to adopt culturally responsive teaching practices in their classrooms.

Implementation Plan

Consistent with the principles of action research (Merriam & Tisdell, 2016), the knowledge I gained through this study will inform my continued pursuit of a more culturally and socially relevant AP Chemistry curriculum. The conclusion of this study marks a step, if not significant leap, in my effort to improve my pedagogy by adopting a culturally responsive mindset. Reflecting on my recommendations for practice yielded several ways to heed my own advice and continue to advance my curriculum.

First, I intend to apply the lessons learned when creating a modified AP Chemistry curriculum toward a modified AP Physics curriculum. I began teaching AP Physics in 2020, and although my background in the subject was limited, I eagerly stepped into the role to challenge myself and learn something new. Now in my third year with the course, I continue to experience challenges as well as daily opportunities to learn. Not surprisingly, the problem of practice that inspired

this study is also apparent in my Physics curriculum, which thus merits closer examination. The field's heavy emphasis on mathematical calculations may seem culture-neutral, yet the growth I experienced as an action researcher has inspired me to creatively infuse culturally relevant practices in AP Physics so more students can benefit.

As indicated earlier in this chapter, I believe a STEAM instructional approach can reinforce teachers' efforts to adopt more culturally relevant practices as students further develop problem-solving skills, creative and computational thinking, as well as collaboration and communication with their peers. In my case, a hands-on modeling approach could be effective. By describing, explaining, and predicting physical creations, models can foster students' learning (Satterthwait, 2010). Tasking students to showcase their understanding of content through literature, song, paint, or other media may stimulate personal connections and make increasingly abstract topics such as atomic theory and molecular geometry more accessible. I have yet to determine where such lessons would fit in my existing curriculum but remain open to new possibilities, mindful of the value of flexibility during my intervention.

A final component of my implementation plan reflects my evolving understanding of how to modify my curriculum. When designing my intervention, I based the lessons and activities on four strategic elements: cultural connections, personal connections, social justice connections, and content connections. These four cornerstones framed the design of each unit and the activities and lessons within them (Figure 5.1). However, as noted in Chapter 4,

my execution of and growing comfort with culturally relevant lessons convinced me that grounding my practice in all four simultaneously is not always feasible or necessary. My Unit 3 observations captured the challenge of "get[ting] all four of these themes in one activity," and I proposed, "Perhaps it's okay to just include 1 or 2 and try to alternate their use." I will consider this sentiment as I continue to improve the lessons featured in this study and in the creation of new ones.

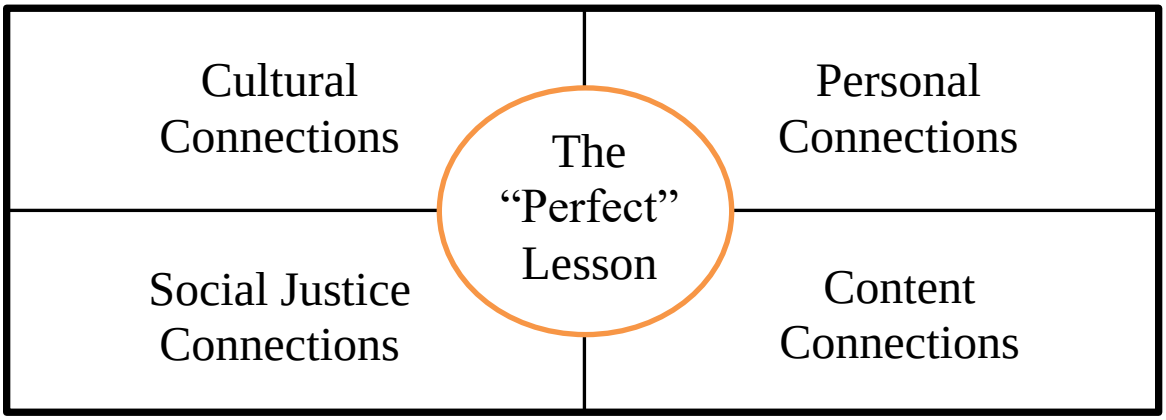

Figure 5.1 *Expected Relationship of Themes*

Recognizing the importance of each theme, I aim to find as many opportunities for overlap as possible. At minimum, I will strive to address each theme at least once during each unit of study. Similar to the confidence I experienced after completing multiple culturally relevant lessons, I believe students' ability to fully unlock the potential of a culturally rich curriculum requires multiple exposures so they become familiar with the process and mindset.

Reflection on Methodology

The final step in action research is reflection (Mertler, 2017). Despite my best intentions, this study included unique challenges and limitations that warrant further discussion. First, as I alluded in earlier chapters, reflecting on my

framework suggested a way to adjust it. I chose CRP to support this study for its "ability to link principles of learning with deep understanding of (and appreciation for) culture" (Ladson-Billings, 2014, p. 77). However, Ladson-Billings acknowledged that scholarship, like culture, is fluid, generating new ways to define and interpret culture. Specifically, Ladson-Billings endorsed the shift from CRP to CSP—highlighting the need for critical revisions without nullifying CRP. Instead, Ladson-Billings (2014) explained,

> Such revisions do not imply that the original was deficient; rather, they speak to the changing and evolving needs of dynamic systems. Remixing is vital to innovation in art, science, and pedagogy, and it is crucial that we are willing to remix what we created and/or inherited. (p. 76)

Viewing CRP as an earlier rendition of CSP, I expect such a revision of CSP in the future as more research yields new discoveries. For now, Ladson-Billings's embrace of CSP encourages me to consider how CSP might improve the design and execution of this research study.

CSP pushes students to "consider critical perspectives on policies and practices that may have a direct impact on the[ir] lives and communities" (Ladson-Billings, 2014, p. 78). Identifying a limitation of CRP, Paris (2012) highlighted the benefits of CSP as an alternative that is "more than responsive of or relevant to the cultural experiences and practices of young people" by actually "sustaining the cultural and linguistic competence of their communities while simultaneously offering access to dominant cultural competence" (p. 95). This explanation of CSP and emphasis on multiculturalism resonates with me.

In fact, I believe my intent to address the lack of equal representation in my curriculum and my desire to reform my instructional practices align with the goals of CSP. Conducting additional research squarely grounded in CSP will be part of my ongoing work to improve future learning cycles in my classroom; however, I do not believe this study suffered greatly from centering a different framework. CRP and social reconstructionism more than adequately supported my efforts to diversify my curriculum and foster opportunities to critique and question dominant power structures.

At the same time, my reflections also revealed some specific limitations, such as several instances when students seemingly misinterpreted my survey questions and reflection prompts. These misunderstandings limited my analysis of students' responses. Additional guidance and practice writing qualitative question stems—in student-friendly language yet aligned with my research aims—would improve my study.

Moreover, this study was also subject to limitations consistent with the nature of action research. First, the study setting prevents direct replicability in other classrooms. I designed the intervention specifically for my AP Chemistry class, and the 16 participants—a relatively small sample—do not represent the experiences of students in other settings. Yet, these limitations also nod to the benefits of action research, which enables teachers to plan investigations based on their specific concerns and unique areas of influence (Efron & Ravid, 2013).

A final methodological limitation was a lack of outside perspectives during the implementation of my intervention and analysis of data. Despite my best

intentions, I could not eliminate the influence of my biases and my narrow, largely inexperienced perspective, as evident in students' critiques and suggestions for improvements during the focus group as well as my limited understandings of students' responses. Reflection log prompts that encouraged me to consider my positionality could only go so far without critical outside perspectives. Nevertheless, I adhered to principles of action research: I improved my practice and fostered my professional growth by seeking to understand my students, solve problems, and develop new skills (Efron & Ravid, 2013).

Recommendations for Future Research

Additional research is needed to understand how students and teachers experience culturally mindful curriculum. My study suggests both populations benefit. However, more generalizable research could advance the field's understanding of this phenomenon. For example, given the flexibility of CRP and CSP for use in any domain, extending the approach I personalized for the attitudes, skills, and mindsets of my students to a neighboring classroom at my school might yield different yet illuminating results. Likewise, similar studies in other locations, school communities, and grade levels could yield new discoveries that bolster the field's understanding and support the work of the next generation of teachers.

These benefits are not and should not be limited to science classrooms. As illustrated in Chapter 4, the LDCs web quest activity that students found particularly meaningful resulted from collaboration with a colleague in social studies. Students' responses suggest the interdisciplinary aspect enhanced their

ability to form real-world connections. Every content area has something unique to offer in terms of incorporating diverse cultures. Despite some participants' initial belief that the objective nature of chemistry precluded culturally relevant material and instruction, my intervention helped them see otherwise.

In addition to illuminating student and teacher experiences in other disciplines, enlisting a wider range of students would surface greater insight into multicultural instruction. Further, if every course in a student's schedule exhibited culturally relevant teaching, exploring whether student experiences shifted due to it being a more normative learning approach would be interesting. Either way, such studies could improve teachers' ability to craft lessons that are appropriate for diverse audiences and build upon the strengths of multiple perspectives.

As noted, this study also made me more aware of female students' needs. Despite my focus on understanding student experiences, I overlooked gender equity in the initial design of my modified curriculum. Likely a result of my own privilege, I had not given much attention to how female students might respond to the overrepresentation of male scientists or struggle to make meaningful connections with content. Student presentations during Unit 1 highlighted significant barriers for women in STEM fields, such as peer relations, ingrained gendered practices, and lack of representation that can limit women's interest, achievement, and persistence (Dasgupta & Stout, 2014). Educators like me who desire more equitable classrooms should conduct action research in this direction. In my case, units on kinetics, equilibrium, and buffer chemistry afford opportunities to explore connections to the medical field, conducive to

showcasing contributions of female role models. I plan to consider this area of personal growth in greater detail as I continue to modify my curriculum.

Conclusion

This study gave me a deeper understanding of equity, yet I am still learning about my position of power as a White male educator. Even as my status may constrain my ability to identify inequity, I have a responsibility to use my privilege to bring about greater equity. These efforts start in my classroom, but I believe my influence extends further. As I shared in Chapter 1, my past success as an educator largely depended on traditional measures of student achievement. My journey to become a better educator has challenged me to shift that paradigm toward a broader view of what students can accomplish—from a data-driven mindset to a learner-driven mindset.

Certainly, AP scores are concrete measures of student success, but my experiences have shown me they should not be the only factor. Each lesson is an opportunity for rich, relevant, and authentic learning. I must remove barriers for students and push myself to find their strengths, rather than classifying them by their limitations. I want students to feel their contributions are vital to the success of our class and school as a whole. As this study demonstrated, I can offer my students supports that make content more meaningful and relevant to their personal experiences. I continue to charge myself to improve my classroom and invite fellow educators to do the same. Simply put, students are the heart of our work, but how often is our work the hearts of our students?

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APPENDIX A

LETTER OF INVITATION TO PARTICIPATE

Dear students,

This letter serves as a formal invitation to participate in a research study conducted as part of my work in the University of South Carolina's Doctor of Education program in Curriculum Studies.

The purpose of this study is to explore student experiences in AP Chemistry when taught from the lens of culturally relevant pedagogy. Culturally relevant pedagogy focuses on instruction that connects students' personal identity, culture, and experiences with content already embedded within the curriculum. (Escudero, 2019, Gay 2002, Ladson-Billings, 1995). Connecting the information discussed in class with personal and real-world applications can work to propel individuals toward academic excellence (García & Guerra, 2004) and help individuals celebrate diversity while respecting cultural and racial differences (Pan, 2006).

Participation in this study is completely voluntary and in no way can students be rewarded or punished for participating or not participating in this study or the voluntary interview. All data recorded for the purposes of this research will be confidential and participants will select a pseudonym to help protect their identities. Participation in this research study will require both your signature and the signature of a parent or guardian. Participants may choose to withdraw from this study at any time for any reason. Expectations for participants outside of normal classroom hours are outlined in the table below.

Week and Topic	Requirements for Participants	Approx. Time to Complete
Week 1 Introduction	Permission Letters Pre Survey Reflection Log	5 Minutes 15 Minutes 5 Minutes
Week 2 Atomic Structure	Reflection Log	5 Minutes
Week 3 Atomic Structure	Reflection Log	5 Minutes
Week 4 Solids, Liquids, Gases	Reflection Log	5 Minutes
Week 5 Solids, Liquids, Gases	Reflection Log	5 Minutes
Week 6 Final Reflections	Post Survey Optional Interview	15 Minutes 30 Minutes

Your participation in this study would provide valuable, firsthand information from your own perspective and your own experiences. If you decide to participate in this research study, please complete the attached paperwork. I look forward to working with you to learn how I can improve my teaching practices and help you love Chemistry as much as I do! Thank you very much for your time and consideration.

Sincerely,

Jason Sox

Active Consent Form

Participants:

Please make sure you have read and understand the expectations for participants in this study. Participation in this study is completely voluntary. There is no penalty for not participating. Participants may withdraw from the study at any time without penalty.

☐ I WILL participate in this study.

☐ I WILL NOT participate in this study.

Participant Name (Printed): _____

Participant Signature: _____

Parent/Guardians:

For students who wish to participate, a parent or guardian signature is required. The school district is neither sponsoring nor conducting this research. Participation in this study is completely voluntary. There is no penalty for not participating. Participants may withdraw from the study at any time without penalty.

☐ I ALLOW my child to participate in this study.

☐ I DO NOT wish for my child to participate in this study.

Parent/Guardian Name (Printed): _____

Parent/Guardian Signature: _____

If you have any questions about this research study, please feel free to contact me at jason_sox@charleston.k12.sc.us.

APPENDIX B

LETTER TO PARENTS AND GUARDIANS

Dear Parents and Guardians,

This letter is to inform you about a research opportunity in your child's classroom and provide additional details regarding its purpose. As part of my doctoral program at the University of South Carolina, I am conducting an action research study, and your student's participation would provide a valuable firsthand perspective to help me better understand the impact of my teaching. I hope you will encourage and allow them to participate!

The purpose of my action research is to explore student experiences in AP Chemistry when taught from the lens of culturally relevant pedagogy. Culturally relevant pedagogy focuses on instruction that connects students' personal identity, culture, and experiences with content already embedded within the curriculum (Escudero, 2019, Gay 2002, Ladson-Billings, 1995). Connecting the information discussed in class with personal and real-world applications can work to propel individuals toward academic excellence (García & Guerra, 2004) and help individuals celebrate diversity (Pan, 2006).

As a practiced educator, a goal of mine has always been to create a classroom where every student is welcome and provide a supportive environment where students are comfortable to be themselves. Part of that goal is to create lessons that are engaging for all students and for all learners to observe how aspects of Chemistry are part of their daily lives. My research aims to accomplish this by providing opportunities to acknowledge and celebrate diversity such that all students can develop a sense of belonging in the classroom, a critical component and predictor of academic achievement (Miles & Naumann, 2021, Zeldin & Pajares, 2000).

The chosen activities and lessons throughout this 6-week study will not remove or replace any requirements prescribed by College Board and the approved AP Chemistry curriculum. Instead, activities and lessons within this research study will be used to support what is already being taught within the curriculum. Participation in this study is completely voluntary and in no way can students be rewarded or punished for participating or not participating in this study or the voluntary interview. Participants may choose to withdraw from this study at any time for any reason. All data will be secured on password-protected files and will

only be used for the purposes of this research. Additional practices have been put into place to help ensure the anonymity of student responses.

Parents and Guardians also have the right to inspect all instructional materials, surveys, and all other non-secured documents used in conjunction with this research. To have access to these materials, or if you have any other questions, please email me at jason_sox@charleston.k12.sc.us

Students who participate in this study will be expected to complete a pre survey at the beginning of the study and a post survey at the end. Participants will also complete weekly log entries where students answer questions about their experiences and reflect on the activities during the week. The completion of both surveys and reflection logs must be completed outside of normal classroom instructional time. At the conclusion of the study, all participants will be invited to share additional thoughts, perspectives, and details in a voluntary interview session, during which parents and guardians are welcome to observe.

Whether you decide to allow your student to participate in this research study or not, I am truly looking forward to working with them this year! Teaching Chemistry is a passion for me and I look forward to sharing my love of the subject with your child. Regardless of your choice, please indicate if your child will be participating or not, and sign the consent form that was sent home with your student. Thank you for your consideration and please feel free to email me at jason_sox@charleston.k12.sc.us should you have additional questions or want to follow up with me.

Sincerely,

Jason Sox

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APPENDIX C

PRE-INTERVENTION SURVEY

Please provide your actual name. Last name, first name.
How would you classify your race/ethnicity? American Indian or Native Alaskan Asian Black or African American Hispanic/Latina(o) Native Hawaiian or Pacific Islander White Other
Based on your experiences, how would you define culture?
Based on your personal experiences, please indicate the extent to which you agree or disagree with each of the following statements.
1) Different genders, races, and cultures were included in topics, lessons, and activities discussed in my previous science classes. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
2) It is important for students to consider the different cultures, perspectives, and personal experiences of other students. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
3) It is important for teachers to consider the different cultures, perspectives, and personal experiences of other students. Strongly Agree Agree Neutral Disagree Strongly Disagree

Please elaborate on your choice for the previous question.
4) I feel that my culture, perspective, and personal experience was considered in previous science classes. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
5) Topics, lessons, and activities in previous science classes were relevant to my personal experiences. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
6) Topics, lessons, and activities in previous science classes addressed problems in society today. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
7) Topics, lessons, and activities in previous science classes empowered me to advocate for change. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.

APPENDIX D

POST-INTERVENTION SURVEY

Based on your experiences, how would you define culture?
Based on your personal experiences, please indicate the extent to which you agree or disagree with each of the following statements.
1) Different genders, races, and cultures were included in the topics, lessons, and activities discussed in this class. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
4) I feel that my culture, perspective, and personal experiences were considered in this class. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
5) Topics, lessons, and activities in this class were relevant to my personal experiences. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
6) Topics, lessons, and activities in this class addressed problems in society today. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.

7) Topics, lessons, and activities in this class empowered me to advocate for change. Strongly Agree Agree Neutral Disagree Strongly Disagree
Please elaborate on your choice for the previous question.
8) Do you think that Mr. Sox was successful in creating and teaching a Chemistry class that was more culturally and socially relevant? Yes No
Please elaborate on your choice for the previous question.
9) How could the lessons and activities included in these units be modified to better suit the needs and interests of diverse student populations?
10) Choose one word to describe how you experienced this modified Chemistry curriculum.
Please elaborate on your choice for the previous question.
11) Would you be willing and interested in participating in an optional follow-up interview to discuss your participation in Mr. Sox's research study? (Likely after school one day)
12) Optional Question: If you would like to participate in the interview, what are some things/topics/ideas you would like to discuss? Do you have any questions that you think would be good for the group to discuss?

APPENDIX E

OBSERVATION PROTOCOL FORM

Date of Observation:

Activities:

Purpose of Observation (behaviors, interactions, responses):

How does this observation reflect what I want to know:

What is important here?

What do I want to focus on more closely when I analyze to this observation:

Descriptive Field Notes	**Reflective Field Notes**

APPENDIX F

STUDENT REFLECTION LOG

Please provide the pseudonym you have chosen for this study.
1) What are your thoughts on the activities and lessons completed in this unit?
2) Describe how the activities and lessons completed in this unit related to or connected to your personal experiences?
3) Was there anything during this unit's activities and lessons that you felt was personally meaningful or relevant to you?
4) Please elaborate on your response to the previous question.
5) Was there anything during this unit's activities and lessons that encouraged you to consider the perspectives of others?
6) Please elaborate on your response to the previous question.
7) Was there anything during this unit's activities and lessons that encouraged you to consider social inequities or advocate for social justice?
8) Please elaborate on your response to the previous question.
9) Was there anything during the unit's activities and lessons that improved your understanding of the Chemistry concepts taught?
10) Please elaborate on your responses to the previous question.
11) Is there anything else that happened this unit that you would like to comment on?

APPENDIX G

TEACHER REFLECTION LOG

1) What were my personal experiences during classroom activities and lessons this unit?
2) What are my feelings from the past unit?
3) What specific changes did I make in my instruction to help my curriculum more culturally and socially relevant?
4) Was there anything during the past week that was difficult or challenging?
5) Was there any significant events or interactions with participants during this unit?
6) What are some things I want to improve on or be more conscious of as the study continues?
7) How does my positionality and biases influence the instructional design and my interpretations during this unit?

APPENDIX H

FOCUS GROUP INVITATION

Thank you for your interest in participating in a follow-up session as indicated by your responses on the post survey! This letter serves as a formal invitation to join me and a few other students to participate in a small focus group targeting specific feedback related to your participation in this study.

The goal of this focus group is to capture additional data that best describes your perspective and experiences while learning in AP Chemistry as well as address some of your questions and responses made in your reflection logs throughout the research period. Your critical feedback is appreciated and honest responses are encouraged. The focus group will be recorded and recordings will be transcribed to ensure validity and accuracy during my analysis. All interview data will remain confidential and you may choose to stop the interview at any point with no penalty.

I would like to have our focus group this Thursday (11/17) right after school. The focus group should last approximately 30 to 45 minutes. The following are a few of the questions that I would like for the group to discuss, but I also welcome any other thoughts or opinions you may have, and would be willing to share.

1) How effective were the activities and lessons completed in the units at immersing students in different cultures?

2) How effective were the activities and lessons completed in the units in their representation of your culture?

3) What are some things you learned or gleaned from the curriculum as a whole?

4) How can science classes be more mindful and respectful of the cultures of students in the classroom?

If you are interested and available in participating in this optional focus group, please email me indicating your intent to participate. Again, this focus group is entirely optional and your decision to participate or not participate will have an impact on your grade. Either way, I sincerely appreciate your thoughtful insights throughout the study and am grateful for your participation so far! See you on Monday!

APPENDIX I

LEADERS IN STEM: OPTIONAL SCIENTIST LIST

The following is a small list of individuals to help you start your investigation. I encourage you to investigate several people before you commit to one specific person to feature in your project. You are also welcome to choose an individual not featured on this list if you believe they would be a good candidate for this project!

Alice Ball
Benjamin Banneker
Edward Bouchet
St. Elmo Brady
Santiago Ramon y Cajal
George Carruthers
Kalpana Chawla
Linda Garcia Cubero
Charles Drew
Lloyd Noel Ferguson
John Andrew Harris
Alma Levant Hayden
Mae Carol Jemison
Percy Lavon Julian
Robert Henry Lawrence Jr.
James Ellis Lu Valle
Ynes Mexia
Mario Molina
Sabrina Gonzalez Pasterski
Alfredo Quinones-Hinojosa
Irene Uchida
Tak Wah Mak
Josephine Silone Yates
Albert Baez
David Blackwell
Otis Boykin
Winifred Burks-Houck
Alexa Canady
George Washington Carver
Bibha Chowdhuri
Marie Maynard Daly
Annie Easley
Bettye Washington Greene
Walter Lincoln Hawkins
Mary Elliott Hill
Katherine Johnson
Angie Turner King
Fei Fei Li
Samuel P. Massie
Cesar Milstein
Ellen Ochoa
Barry Paw
Venki Ramakrishan
Nianshuang Wang
Gladys West
Roger Arliner Young

APPENDIX J

REFLECTIVE REVIEW OF RESEARCH QUESTIONS

1. How do my students experience a more culturally and socially relevant science curriculum?

Expected Themes:
a) I think students will learn more from the modified curriculum as it relates more to their personal experiences.

b) I believe students of color will learn more from a curriculum that is more inclusive of their perspectives.

c) I believe White students may struggle learning from a curriculum that seemingly deviates from their cultural norms.

d) I believe some students will feel that time spent researching cultural and social connections is a waste of time because it detracts from time spent learning content.

2. How does planning and implementing a culturally and socially relevant science curriculum impact my experiences as a teacher?

Expected Themes:
a) I believe I will struggle to find cultural and social connections that relate to chemistry.

b) I believe I will feel inadequate in my ability to deliver culturally and relevant chemistry content initially, but will hopefully improve in my abilities throughout the research period.

c) I believe I will be more fulfilled as an instructor as I provide lessons that are more culturally relevant and appropriate for students.

d) I believe I will feel overwhelmed trying to implement a number of different activities and lessons as part of my modified curriculum.

e) I believe that a more critical examination of what I teach and why I teach will improve the quality of my teaching.