

**Investigation of Secondary Science Teachers' Perspectives of a Culturally Responsive  
Lesson on Race and Human Genetics**

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by

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## Abstract

**Background:** High school students are not taught that race is a social rather than biological construct, and this pedagogical omission has led to biological essentialism. Biological essentialism is the belief that race can be used in predictable ways to determine intellect and/or behavior. Biological essentialism can result in the belief that unscientifically-proven racial stereotypes are true. Additional work is needed to support the teaching of a scientifically accurate understanding of human diversity in high schools. Teachers' perceptions have huge impacts on what is taught in the classroom. Therefore, understanding teachers' perceptions on teaching about race and human diversity is a crucial step in addressing gaps within the high school biology curriculum. **Purpose:** The purpose of this qualitative study was to investigate teachers' perceptions of a specific culturally responsive lesson on the social construct of race. The three research questions were the following: (a) In what ways, if any, do in-service high school biology teachers' positionalities affect their perceptions of a specific culturally responsive lesson on race and human diversity?; (b) What impacts, if any, do in-service biology teachers perceive the lesson to have on students' understandings of the social construction of race?; (c) What impacts, if any, do in-service high school biology teachers perceive the lesson on race and human diversity to have on students' scientific argumentation skills? **Methods:** This qualitative investigation used a multiple case study approach that reported findings across a group of cases within the context of a single study. Through purposeful sampling methods, four teachers reported their experiences teaching a culturally responsive genetics lesson. Data was collected through individual teacher interviews, teacher reflection notes, and a focus group interview with all teacher participants. A repository of all data was created and analyzed through an iterative process to code for themes within each case. **Results:** Three themes emerged from this

investigation. Firstly, teacher positionality concerning the three tenets of Culturally Responsive Pedagogy (CRP) ranged from high to moderate to low orientations. The other major themes identified include observed shifts in students' thinking and teaching strategies used during instruction. **Conclusion:** The use of argumentation strategies in high school instruction can support students' abilities to identify unscientific claims regarding race and reduce students' beliefs in racial stereotypes. Lastly, the amount of training in CRP a teacher receives is a significant indicator of the extent to which they incorporate the three tenets of CRP into their instruction.

## Table of Contents

I. Introduction.....	1
Statement of Problem.....	3
Purpose of Study.....	6
Significance of Study.....	6
Theoretical Framework.....	7
Research Questions.....	10
Overview of Research Design.....	10
Definition of Terms.....	11
Summary.....	12
II. Literature Review.....	14
Literature Search Strategy.....	15
Teacher Perceptions.....	16
Historical Teaching of Race & Essentialism Beliefs.....	17
Current Biology Curriculum & Essentialism.....	19
Scientifically Accurate Teaching of Race and Human Diversity.....	22
What is Missing from High School Biology Curriculum?.....	24
Use of Argument and Discourse.....	28
Teaching Strategies and Considerations to Address Race and Human Diversity.....	33
Gap in Literature.....	42
Summary.....	44
III Methodology.....	45
Philosophical Foundation.....	45
Research Questions.....	47
Procedures.....	47
Recruitment Methods.....	53

Setting.....	54
Participants.....	54
Intervention Lesson.....	56
Data Collection.....	57
Data Analysis.....	58
Role of Researcher.....	60
Summary.....	64
IV Results.....	64
Results.....	64
Theme 1: Teacher Positionality.....	65
Theme 2: Observed shifts in student thinking.....	85
Theme 3: Instructional Strategies.....	103
V Findings.....	103
Interpretation of Findings.....	104
Ethical Issues & Limitations.....	110
Recommendations for Future Research.....	112
Conclusion.....	112
References.....	114
Appendix A: IRB Approval Letter.....	125
Appendix B: Research Consent Form.....	128
Appendix C: Initial Interview.....	132
Appendix D: Focus Group Interview.....	133
Appendix E: Second Interview.....	135

## List of Tables

Table	Page
1. Summary of Lesson on Race and Human Diversity.....	54
2. Participant Demographics.....	55
3. Orientation Towards Culturally Responsive Teaching.....	59
4. Teacher Positionality to CRP Tenets.....	83
5. Instructional Strategies Used During Instruction.....	103

## List of Figures

Figure	Page
1. Use of race in biology textbooks 1952–2002.....	18
2. Physical genetic variations in penguins versus humans.....	42
3. Data analysis procedure.....	59
4. Public broadcasting system interactive game (PBS).....	71
5. Rationalized Experiences vs. CRP Positionality.....	83
6. CPR Training vs. CRP Positionality.....	84
7. Teaching Experience vs. CRP Positionality.....	84

## Chapter I

### Introduction

Students in primary and secondary classrooms are often recipients of direct and indirect messages about race. When these messages are based on biases and negative stereotypes, it can have a profound impact on students' perceived ability to be successful (Welton, Harris, LaLonde, & Moyer, 2015). When analyzing success in K–12 science courses or interest in pursuing careers in science after graduation, patterns are often observed along racial lines (Doerschuk et al., 2016; Riegle-Crumb, Moore, & Ramos-Wada, 2011). Trends report that White Americans and Asian Americans have higher academic success in science when compared to Black Americans and Latino Americans (Zeng & Poelzer, 2016). Although all students regardless of their race are capable of being successful in a science classroom, the trends in success patterns do not favor all students equally. To learn more about what factors contribute to high schools students' success in the science classroom, Grossman and Porche (2013) conducted interviews with 53 students in Grades 9 and 10 graders at four different magnet schools. During the interviews 42% of minority students reported societal perceptions about race playing a role in their perceived ability to be successful in their science courses (Grossman & Porche, 2013). Study participants shared how these incidents affected their perceived ability do well in science. Marcus, an African American student, reported:

A lot of people look at a Black person and see that they're not gonna succeed. Like you know, they're going to be always depending on somebody else, and they might look at Chinese and see that they're always going to be good at science, and like that's not always the case. I know a lot of Chinese people that get Ds in science (Grossman & Porche, 2013).

Henry, a Latino student in the same study, shared how he felt victim of racial microaggression by peer groups:

There's probably some doubt that we won't be able to do a job right, because of all the, you know, the jokes and like the racism... anybody sees a Hispanic person, they're like "Oh, he's Mexican, all he does is mow lawns," or something like that (Grossman & Porche, 2013).

Minnie, a Caucasian student in the study shared, "I think it's only difficult for like people if some people see them as like different, [for example] 'cause that guy's Black, he can't do it' or stuff like that..." (Grossman & Porche, 2013).

Direct and indirect messages about race can influence adolescents. This can result in feelings of inferiority and thereby affect success in the classroom. A survey of the literature found that many high school students hold unscientific views about race and human diversity (Donovan, 2016a, 2016b; Donovan et al., 2019). Present literature provides evidence that high school students have misconceptions about race and human diversity that have led them to believe racial classifications are a predictable way to determine an individual's intellect and overall capabilities (Dar-Nimrod & Heine, 2011; Donovan, 2016a, 2016b; Donovan et al., 2019; Hubbard, 2017a). Although this thinking is not supported by scientific findings, it is still a widely held belief among adolescents and even some adults (Beckwith et al., 2017).

One of the goals of science education is to provide young scholars with an accurate and scientific way to see and interpret their world. Therefore, it is of utmost important that widely-held misconceptions about race and human diversity be addressed via the teaching of accurate science instruction (Donovan et al., 2019). When students understand race and factors that

contribute to variations in skin tone, they become more likely to refute negative messages linking race to intellectual or behavioral tendencies before.

### **Statement of Problem**

A close look at students' assumptions about human diversity led to the question of what can be done to address the problem. The answer to this question has prompted the investigation in this current study. Educational researcher Donovan (2015) asserts that the way genetics is currently being taught within high school biology courses promotes racially biased beliefs in high school students. His research and that of others has identified that many biology textbooks and curriculum are written in such a way that they do not accurately align to modern scientific knowledge of race (i.e., social grouping based on skin color) and human diversity (i.e., naturally-occurring differences among members of human species; Donovan 2015; Morning, 2008). For example, sickle cell disease patterns are a common in places where incidences of malaria are high. Having sickle cell can reduce the chances of getting malaria; therefore, people in parts of the world where malaria cases are higher (i.e., Mediterranean regions, Sub-Saharan Africa, the Middle East, Asia, and the Caribbean) have higher incidences of sickle cell anemia (Jarrett, Williams, Horn, Radford, & Wyss, 2016). However, many high school biology textbooks simply state, "Black people have higher incidence of sickle cell," without explaining the environmental conditions related to the disease (Donovan, 2016a). There is no significant nor direct correlation between one's race and one's susceptibility to genetic diseases such as sickle cell anemia. Research shows that sickle cell disease is due to environmental factors. However, 90% of textbooks use race to explain prevalence of this disease (Morning, 2008; Donovan, 2015). Research shows that when students learn prevalence of diseases such as sickle cell

anemia are common among certain racial groups this increase biased beliefs that other traits (intelligence or behavior) can also be linked to race (Donovan, 2015; Donovan et al., 2019).

In the absence of direct instruction on the social construction of race, students hold inaccurate and biased racial beliefs about race and human diversity. Therefore, it is in the interest of those seeking to support students' knowledge with accurate teaching of race and human diversity to revisit the way in which the topic of race is being taught or not taught in high school science courses. Because the high school biology class serves as the basis for many students' understanding of complex issues related to life science, this course is the ideal place for research addressing unscientific ideologies about variations in human traits such as skin color, or what is commonly referred to as *race*.

In the late 1960s Jensen published his widely cited paper asserting that intelligence is determined based on an individual's genetic composition (as cited in Donovan, 2016a, p. 379). Jensen's work postulated that there are inherent differences that result in "whites having higher IQ's than blacks" (Jensen, 1973, p. 407). Jensen's research was accepted as accurate until modern advancements in genetic technologies debunked such thinking (Rosenberg, 2011). Despite modern understanding of human differences, studies conducted since Jensen's claims show that 22% of non-Black Americans believe that intelligence and race are inherently tied together (Donovan, 2016a). Unfortunately, current biology curricula have not been modernized to develop students' ability to respond to unscientific claims about race and human diversity (Donovan 2015; Morning, 2008). Researchers have hypothesized that because the high school biology course serves as the basis of students' genetics understanding this course is ideal to

investigate students' beliefs about intelligence and behavior and their presumed relationship between one's race (Dawson & Venville, 2013; Donovan, 2015, 2016a; Donovan et al., 2019).

Additionally, it is not as effective to only teach students an accurate understanding of race and human diversity. Students must also be equipped with the tools needed to utilize this knowledge. One of the most powerful ways that students can articulate science concepts is through the process of argumentation. The process of argumentation allows students to use scientific evidence to refute or support claims. Argumentation has proven to be very effective in the development of students' critical thinking skills—especially in respect to social science issues (e.g., the use of race in society; Sadler & Dawson, 2012). By teaching the science needed to debunk racial stereotypes students will be less likely to subscribe to, internalize, or endorse unscientific beliefs about race.

Teachers play a crucial role in teaching topics such as race and human diversity because it is the teacher who initiates and facilitates instruction. The topic of race can be viewed as controversial. However, this should not deter the discussion of the subject within the classroom. On the contrary, the classroom is actually an ideal place for such discussions to take place because of the increased diversity in ideology compared to one's family unit or social organizations (Hess & Posselt, 2002; Kuş & Öztürk, 2019). Teachers' perceptions or views on the use of controversial issues within instruction have huge implications on how they deliver instruction (Journell, 2011); therefore, understanding teachers' perceptions on the teaching of race within the science classroom is a crucial step in addressing misconceptions and gaps within curriculum.

### **Purpose of Study**

The purpose of this study was to investigate four in-service high school biology teachers' perceptions during the implementation of a culturally responsive lesson exploring the social construct of race and genetics. This study uses a multiple case study design to respond to the research questions being investigated. During the two-week intervention lesson students explored historical, social, and scientific findings on race and human diversity. The intervention lesson was designed using a 5E lesson model (Bybee & Landes, 1990), which included the opportunity for students to develop their scientific argumentation skills using claims, evidence, and reasoning in a strategy known as CER (McNeill & Krajcik, 2011). At the conclusion of the study teachers provided their insight on the observable changes in students' ability to determine scientific and unscientific claims about race and human diversity using CER writing prompts. Data for the study was collected through individual and focus group teacher interviews. Teacher interviews were transcribed and coded to produce themes related to their unique perceptions during the facilitation of the science lesson.

### **Significance of Study**

The interconnectedness between science and society are so tightly woven that the lines can become blurred. This meshing of science and society has been proven to be positive when informed by accurate scientific findings. However, it has proven to be grave and dangerous when pseudoscience has been mistaken as factual (Gould, 1981). The lack of understanding of human diversity and the perceived inheritance of race can be problematic. These beliefs have led to the unscientific assumption that race can be used in a predictable way to measure an individual's intellect, behavior, and general nature (Dar-Nimrod & Heine, 2011). Negative assumptions about race and human diversity have resulted in discriminatory policies (Welton et

al., 2015), hierarchal ranking of human beings (Gould, 1981), inequalities in education (Doerschuk et al., 2016; Freire, 2000), and the mistreatment of minority groups (Wright & Counsell, 2018) in the United States. To this, anthropologist and educational researcher Hubbard (2017b) states, “Among the most dangerous of myths about the nature of human variation is the “biological race” concept” (p. 538). These inequalities in education have resulted systemic issues such as the school to prison pipeline, lack of equitable resources in the inner city, and low academic identities among certain racial groups, illustrating that more work is needed to be done in this area (Wright & Counsell, 2018).

Over the course of U.S. history, there have been great educational progress. However, there are still disparities as a result of perceived inequalities based upon American society’s lack of scientific understanding of race and human diversity. To say that an accurate understanding of race and human diversity is important is quite an understatement given the huge impact that it has had on our society. In an effort to ensure that outdated ways of seeing and understanding of human diversity is eradicated among young scholars, learning and re-learning must take place. With the power that science has to shape society it is of paramount importance that science education, particularly in foundational science courses such as biology, be taught as accurately as possible.

### **Theoretical Framework**

This research utilizes two theoretical frameworks to address the research questions: social constructivist theory of learning and culturally relevant pedagogy (CRP).

**Social constructivism.** The social constructivist theory of learning will be used as the framework that supports scientific argumentation development during the implementation of the intervention lesson. Scientific argumentation differs from other types of argumentation as it

refers to a student's ability to make a claim and support it with scientific evidence (Grooms, Sampson, & Enderle, 2018). Social constructivism states that students learn or construct meaning by activating their prior knowledge through verbal exchanges. Students use their prior knowledge to build a bridge to connect to new ideas, in so doing students undergo the cognitive process of learning. Social constructivism further asserts "language" is the primary vehicle that allows for learning to take place, thus placing a high value in use of discourse during instruction (Vygotsky, 1978).

Vygotsky (1978) stated when students collaborate and discuss with one another it creates an environment that forces the brain to make new connections. These connections are initiated through the dialog students have with one another. Vygotsky's theory also supports teachers' use of small group discussions to build students' content knowledge by increasing the students' zone of proximal development (ZPD). ZPD is the process whereby students learn from their fellow peers. For example, teachers who partner an academically stronger student with a student who is academically weaker can capitalize on increased student interaction to increase learning opportunities. Therefore the more interactions or more social exchanges that occur in a classroom, the broader the ZPD allowing for increase in learning opportunities.

Teachers can also support social constructivist interaction by stimulating student thinking with probing and open-ended questioning. Through inquiry-based instruction teachers can challenge students to use evidence-based reasoning to support their claims. Vygotsky's theory of social learning places great emphasis on the use of classroom discourse and student interaction. By utilizing social constructivist strategies, teachers can gain a deeper understanding of how students are processing and interpreting academic content.

In this study teachers monitored discussions and CER writing prompts to observe shifts and patterns in students' scientific argumentation development. The social constructivist theory of learning, when used in science learning, has been shown to sharpen students' critical thinking skills (Chaipichit, Jantharajit, & Chookhampaen, 2015). Critical thinking is an important learning outcome that will better support students' ability to determine scientific and unscientific claims about race and human diversity. The ability to think critically is highly valued in processing and interpreting science content knowledge, again providing further justification for the use of constructivist framework in the present study.

**Culturally relevant pedagogy.** CRP will be used as the conceptual framework guiding the lesson design and instructional practices of the current study. CRP supports teachers' use of instructional strategies that develop students' sociopolitical consciousness related to issues of race, gender, class, and policy (Gay, 2010; Aronson & Laughter, 2016). CRP positions the classroom as a learning space where teachers empower students to critically analyze and discuss the intersection of established curriculum and societal implications through development of students' sociopolitical consciousness (Billings, 1995). Because students' racial identities are embedded into their experiences, both in and out of the classroom setting, CRP serves as an ideal pedagogical teaching framework in a genetics lesson about race and human diversity.

CRP instructional teaching strategies support the notion that all students can learn regardless of their ethnic or racial affiliation (Aronson & Laughter, 2016). A belief that all students can learn is an important component of CRP, especially in teaching and instruction that addresses negative racial stereotypes that students might have about themselves or others. This framework of learning places the onus on teachers to provide an appropriate classroom climate to support students' learning. The lesson designed within this study incorporates culturally

responsive teaching practices that work to make the classroom a safe space. Culturally responsive lessons are designed to consider students' socioemotional needs and allow students to freely exchange academic ideas as well as personal experiences as it relates to race. This supportive style of instruction will prove to be quite beneficial as students engage in dialog to process the concept of race from a scientific and a social standpoint. The role of CRP as an instructional strategy will be explored in more depth in subsequent sections of this document.

### **Research Questions**

1. In what ways, if any, do in-service biology teachers' positionality affect their perception of a culturally responsive lesson on race and human diversity?
2. What impact, if any, do in-service biology teachers perceive a culturally responsive lesson on race and human diversity has on students' understanding of the social construction of race?
3. What impact, if any, do in-service biology teachers perceive a culturally responsive lesson on race and human diversity has on students' scientific argumentation skills?

### **Overview of Research Design**

This study uses a multiple case study design to gather data through several sources such as interviews, focus groups, and teacher reflection notes. All evidence collected was then systematically analyzed, grouped into meaningful ways, and then interpreted to present the themes or findings of the study (Merriam & Tisdell, 2016). For the scope of this study each teacher will be analyzed as an individually-bounded system and each teacher's interview will be interpreted based on his or her unique interpretation within the framework of this investigation.

Prior to teaching the lesson, teachers were invited to participate in a two-hour professional development workshop to review the lesson used for this study. The lesson was taught at the end of a business-as-usual three week genetics unit. At the conclusion of the

genetics unit, teachers provided instruction on the modern teaching of race and human diversity to extend what students learned about genetics. No new science content was taught, but rather students were expected to use their prior knowledge about genetics and apply it to the social construct of race and human diversity. The intervention lesson provided a real world application of the genetics topics students had previously learned. The intervention lesson included discussions on the historical origins of race and incorporated research-based teachings to debunk biological essentialism. Biological essentialism is the belief that race is a discrete trait that can be used to predict behavior or intelligence. The lesson also included discussions on how racial classification systems have led to discrimination against and stereotypes about marginalized groups. At the conclusion of the two-week study teachers participated in two individual semi-structured interviews and one focus group interview. Interviews were transcribed and coded for themes.

### **Definition of Terms**

**Ancestry.** This is a process-based concept; a statement about an individual's relationship to other individuals in their genealogical history (Yudell, Roberts, DeSalle, & Tishkoff, 2016).

**CER.** CER is a scientific explanation framework defined by three components: claims, evidence, and reasoning (McNeill & Krajcik, 2008).

**Claim (C).** This is a statement that answers a question (McNeill & Krajcik, 2011).

**Evidence (E).** This is the data that supports a claim (McNeill & Krajcik, 2011).

**Reasoning (R).** This explains how or why data supports claim using scientific evidence (McNeill & Krajcik, 2011).

**Ethnicity/ethnic group.** This is a cultural variable term describing a group of people who are *perceived* to share cultural features, such as language, dress, cuisine (Hubbard, 2017a).

**Genetic essentialism.** This is the tendency to infer a person's characteristics and behaviors from his or her perceived genetic makeup (Dar-Nimrod & Heine, 2011).

**Genotypic.** Genetic makeup of a trait (Hubbard, 2017a).

**Humane genetics education.** Teaching practices that focus on reduction in the prevalence of racial bias by changing the way that students perceive human genetic variations (Donovan et al., 2019).

**Phenotypic.** Physical features of a trait (Hubbard, 2017a).

**Positionality.** Conscience or unconscious stance undertaken by a teacher that influences and guides their teaching philosophy, perspective of learners/learning, and teacher practices (Teo, 2015).

**Race/racial group.** This is a culturally variable term describing a group of people who are *perceived* as sharing biological features, such as skin color, eye color, and hair texture (Hubbard, 2017b).

**Teacher Perceptions.** The thoughts or mental images that teachers' possess concerning their professional activities and their students, which are shaped by their background knowledge and life experiences, and influence their professional behavior (Mozafari & Wray, 2015).

### Summary

This chapter shines a light on the problematic way adolescent students might perceive themselves and others because of their racial classification. This section also contains data that supports adjusting the way race and human diversity have been approached within genetics lessons. The superficial attention played to race in high school genetics lessons has contributed to misconceptions students have about race. For example, the mapping of the human genome in 2010 by geneticists provided solid evidence that there is no "race" gene (Rosenberg, 2011), yet

modern biology textbooks and curriculum do not include this among information students are mandated to learn (Donovan, 2015; Morning, 2008). The absence of this learning has left a void in students' proper understanding of race and human diversity. This void in student science knowledge has led to students believing that intelligence and even behavior follow predictable patterns that can be determined by one's racial classification (Donovan 2016a, 2016b). Therefore, teachers should provide instruction that address misconceptions students might have about race and human diversity.

Also presented in this chapter is an overview of the research design and theoretical framework used to respond to the research questions in this investigation. This chapter provides justification for the use of both CRP and the Social Constructivist Theory of Learning to support the research questions brought forth in the present study.

The following chapter will provide a survey of literature beginning with the teaching of race and human diversity in its historical context. Then evidence will be presented to support the use of argumentation within science instruction. Evidence-based research on student outcomes when more accurate instruction on teaching race in the science classroom will follow. Finally, the following chapter will call for an extension of the literature by identifying an acute gap in research related to the accurate teaching of race and human diversity.

## Chapter II

### Literature Review

Racial categories have varied based on time periods and differ from one society to another (Beckwith et al., 2017; Hubbard, 2017a; Morning 2008). Often racial classification is not based upon scientifically accurate information which can lead to widely held misconceptions about race. Misconceptions about race can result in biological essentialism (Beckwith et al., 2017; Dar-Nimrod & Heine, 2011; Donovan, 2016a, 2016b; Donovan et al., 2019). Biological essentialism is the belief that an individual's race genetically predetermines their behavior and/or intelligence. Biological essentialism also presumes that people of different races are discrete groupings of people who are genetically different from members of other races (Dar-Nimrod & Heine, 2011; Donovan, 2016a, 2016b; Donovan et al., 2019). Science does not support biological essentialism or the idea that different races are discrete species that have uniform and predictable behavior and intellectual capabilities (Dar-Nimrod & Heine 2011; Jarrett et al., 2016). Existing research shows that the way genetics is being taught in high school biology classes today results in increased biological essentialism in students (Donovan, 2015, 2016a, 2016b).

Biological essentialism can have important societal implications, especially if these beliefs are inaccurate and widely held. Biological essentialism has been used to support pseudoscience creating hierarchical racial systems, justifying slavery in the United States, and enacting unjust laws (Gould, 1981). Biological essentialism can have a negative effect on political and social decisions which counter society's best interests; such teachings that directly or indirectly support biological essentialism should be addressed (Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012). Existing literature shows that scientifically accurate teaching

(Donovan et al., 2019), alongside argumentation strategies (McNeill & Krajcik, 2008, 2011), can help decrease students' misconceptions about race and human diversity.

The literature review has been organized to first include teacher perspective of the instruction of race followed by literature on the instruction of human diversity from past to present. Then literature is presented to show how this has led to biological essentialism among high school students. Next, research that addresses the scientifically accurate way of understanding race and human diversity will be brought forth, followed by findings from educational researchers that illustrates best teaching practices when providing instruction on this topic. Literature will also be presented that demonstrates reductions in essentialism beliefs and increases in scientific reasoning skills when students are presented with a more accurate way to understand race and human diversity. Lastly, relevant research will be provided to address the role teachers' perceptions play in the delivery of culturally responsive instruction. Literature will be provided that illustrates how teacher perceptions can determine the way in which they teach topics such as race and human diversity.

### **Literature Search Strategy**

The search strategy for this review of literature was conducted by using the following key terms: biology, genetics, race, and high school biology. After review of initial literature, the term essentialism was added to the search terms and entered into search databases. The search database for this study began with Google Scholar as an initial search engine in the process of gathering peer-reviewed journal articles to support the background research for the literature search. Next, ProQuest, ERIC, EBSCOHOST, and Sage databases were used to gather more literature and access peer-reviewed journals. Through the use of these databases, journals such as the *Journal of Research and Science Teaching (JRST)*, *American Educational Research*

*Journal (AERJ)*, *The American Biology Teacher*, and *The Science Teacher* served as major resources for gathering peer-reviewed research articles. Although this is not an exhaustive list literature sources included peer-reviewed journal articles, published dissertations, books, Next Generation Science Standards (NGSS), as well as both state and national statistics from educational agencies. Care was taken to ensure that an overwhelming majority of articles selected were published within the last five years. However, articles older than five years were selected to provide historical perspective on research within the area of high school science.

### **Teacher Perceptions**

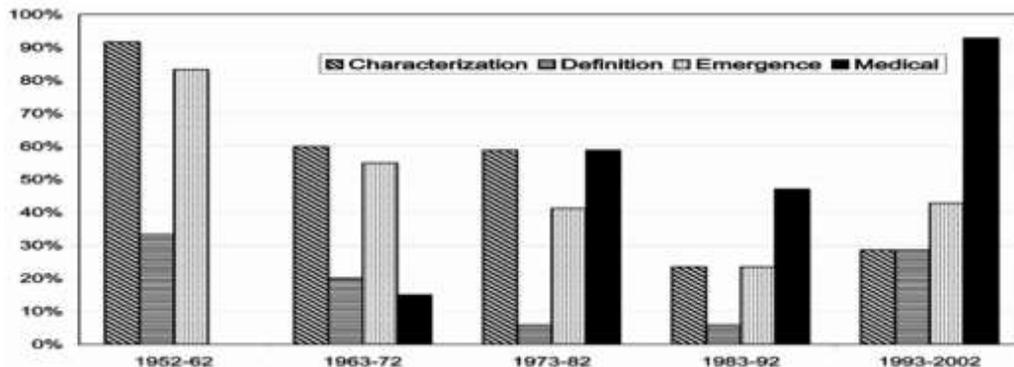
Teacher perceptions have been widely studied in the field of education. A literature search in ERIC, EBSCOHOST, and Google Scholar provided thousands of articles written in the past five years alone related to and exploring teacher perceptions. When specifically looking at science teacher perceptions this does narrow the scope of research, yet a sizable amount of work still exists. However, when looking for research dedicated to understanding the perceptions of science teachers while teaching lessons on race and human diversity, such research is absent resulting in an acute gap in the literature. The research that is available on the teaching and instruction of raced is mostly relegated to social studies curriculum (Hess & Posselt, 2002; Journell, 2011, Kuş & Öztürk, 2019; Lockwood, 1996).

Teacher perceptions are worthy of investigation because they are a culmination of the life experience, culture, and background of teachers, which in turn influence their professional behavior in the classroom space (Mozafari & Wray, 2015). Understanding teacher perceptions is critical particularly when discussing and teaching topics such as race and human diversity, which can be thought of as controversial (Busey & Mooney, 2014; Hess, 2001; Kuş & Öztürk, 2019). Kuş and Öztürk (2019) stated that teaching controversial topics is important because it prepares

students for their role as members of a democratic society, improves critical thinking, and supports the development of interpersonal communication skills. The teacher's role in teaching topics such as race and human diversity is paramount as they are the facilitators of classroom instruction (Kuş & Öztürk, 2019). In addition to the role teachers play, the curriculum which they use is of great importance as it is the vehicle whereby students acquire new knowledge. In efforts to best investigate current curriculum the next section will begin with relevant research regarding the historical context of teaching race and human diversity in the science classroom.

### **Historical Teaching of Race & Essentialism Beliefs**

To have a better understanding of how race has been addressed in high school biology, a historical overview of how textbooks have approached this issue will be examined. A seminal study conducted by Morning (2008) included a review of 80 high school biology textbooks over the course of 20 years, spanning in publication dates from 1952 to 2002 (see Figure 1). One of the first studies of its kind to evaluate high school books for the context of race, it has been widely cited in the scholarship of teaching and understanding race in the public school curriculum. Morning's (2008) study noted that textbooks from the time frame discussed race in four different groupings: its characterization, its definition, its emergence and origin, and in a medical context when discussing the prevalence of disease.



*Figure 1.* Bar graph on the use of race in biology textbooks from 1952–2002. Results show the percentage of textbooks per cohort. Adapted from “Race in Science and Society: Biology Textbooks, 1952-2002” by A. Morning, 2008, *American Journal of Sociology*, 114. Copyright 2008 by The University of Chicago Press.

Starting in the early 1990s, teachings concerning the characterization, definitions, and emergence of race began to disappear from high school biology textbooks. Race began appearing in textbooks with higher frequency to explain the prevalence of diseases among different groups of people. By 2002, 93% of biology textbooks contained examples such as prevalence of sickle cell anemia in Black Americans and cystic fibrosis in White Americans as the only reference to the concept of race (Morning, 2008).

Prior to Morning’s review, Skoog (2005) conducted an examination of high school biology textbooks from 1960 to 1990 focusing on the teaching of evolution in biology textbooks. Although the aims of his study were different, his research did point to biology textbooks directly and indirectly teaching human hierarchy through racial classification systems.

Although recently published textbooks have removed the teachings of racial hierarchies from its pages, they still do not include the social and/or scientific understanding of race and human diversity (Donovan, 2015; Morning, 2008). Students in modern science classrooms often are not taught any context to process societal perceptions or the scientific understanding of race and human diversity (Morning, 2008). By not providing students with this understanding,

research shows this has led to misconceptions about race, beliefs in racial stereotypes, and biases that support essentialism beliefs (Donovan, 2016a, 2016b; Donovan et al., 2019).

Essentialism, from the root word *essence* referring to the inherent, biological make up of an individual, is a belief system that supports the reasoning that by knowing someone's race we can predict behavior patterns (i.e., behavioral essentialism), intelligence level (i.e., biological essentialism), and the overall nature of the individual (Dar-Nimrod & Heine, 2011). Educational researchers do not assert that essentialism beliefs are being directly taught to students, but instead it is the hidden curriculum being supported in the absence of not having accurate and holistic teaching of race and human diversity in the biology classroom (Donovan, 2016a, 2016b; Morning, 2008).

### **Current Biology Curriculum & Essentialism**

Race and human diversity are often viewed as controversial; as a result, there is extraordinarily little research that exists which explores such teaching in the high school biology classroom. In 2015, Donovan conducted a seminal study, as it was one of the first modern studies to explore the topic of race and human diversity in the high school biology course. To further understand the role of biology curriculum on essentialism, Donovan (2016a) conducted a randomized controlled study with high school biology students consisting of 86 ninth graders at a California Bay Area high school. The school, classified as a high socioeconomic status (SES) campus, housed a population comprised of 55% European American/Caucasian, 25.5% Asian American, 8.6% Hispanic/Latino (8.6%), 6.3% multiethnic, and 3.3% African American/Black students (Donovan, 2016a). Donovan's research found that when students learn about race in relationship to prevalence of diseases it promotes bias and beliefs in racial stereotypes.

In Donovan's study students were randomly divided into two groups, an experimental and a control group. Each group was given a pretest and posttest to measure their biological essentialism beliefs (i.e., belief that racial groups are genetically predisposition to behave in a similar pattern) and behavioral essentialism beliefs (i.e., belief that people in a given racial group are predisposed to act in a similar and uniform way). In this study, students in the control group were given a passage to read that resembled the current way biology textbooks discuss race (i.e., using prevalence of diseases) and the experimental group was given a slightly different reading with references to race removed. For example, students in the control group read passages such as, "The allele responsible for sickle cell anemia is particularly common among people of African descent..." (Donovan, 2016a, p. 595). Conversely, students in the control group read a similar passage without the use of race such as, "About 2 million Americans (0.6%) are carriers for the allele responsible for sickle cell anemia" (Donovan, 2016a, p. 595). To measure the outcomes of this study, Donovan used the genetically based racism instrument (GBRI). The GBRI assesses how much an individual believes race can contribute to academic ability, physical strengths, ambition, and overall ability (Parrott et al., 2005).

The results of the study showed that students who read the racially-framed text had higher average GBRI scores, illustrating an increase in essentialism beliefs based upon course readings. Does this mean that textbooks should abandon their use of race to address the prevalence of disease? Donovan did not argue for this point. On the contrary, he called for human genetics education. Human genetics education as an educational theory postulates that learning how humans are more genetically similar than different will reduce students' beliefs in negative racial stereotypes (Donovan et al., 2019). His research suggested that biology curriculum provide better context and understating of human differences (Donovan, 2015,

2016a; Donovan et al., 2019). His research asserts that a more holistic approach should be used when discussing race and human diversity in the biology classroom.

Another study conducted by Jarrett et al. (2016) among high school biology students enrolled in an advanced biology course also provides evidence that the current way of teaching race and human diversity can be problematic. The goal of the laboratory exercise was to support students' understanding of using genetic technologies to analyze DNA sequences. In the study students conducted a full-day inquiry lab to better understand the mutations that lead to sickle cell anemia. Students utilized genetic technologies (i.e., gel electrophoresis, microscopy, and use of restriction enzymes) to examine blood from mice with and without cycle cell anemia (Jarrett et al., 2016).

The lesson, which was facilitated by researchers and graduate students, was followed up with small group discussions (6:1) to help students develop real world applications with what they had just learned. Lesson facilitators then worked with their small group of students to address any misgivings they had about the lesson. What the authors discovered was because sickle cell anemia is more commonly found among Blacks Americans, students believed that if you are not Black you cannot have sickle cell anemia. Facilitators then explained to students that sickle cell anemia is common in places like sub-Saharan Africa, Mediterranean regions, the Middle East and Asia due to genetic benefits for having genes that code of sickle cell. These genes have been shown to be advantageous in protecting against pathogens like malaria (i.e., common in these areas). Therefore through selective pressure, not race, the genes that produce sickle cell anemia are more common in certain regions of the world (Jarrett et al., 2016). At the conclusion of the lab students were able to understand the genetic causes and consequences of carrying a double or single copy of the genes that code for sickle cell anemia. Their work

provides context for why presenting disease prevalence in classroom lessons on race and human diversity can lead to students' misconceptions.

In their investigation Jarrett et al. (2016) demonstrated that when sickle cell anemia is taught through an understanding of genetics rather than race, students have a better understanding of how selective pressures have affected human diversity. The study contributed to science education by providing credence for more scientifically accurate teaching on disease prevalence and race in high school biology courses.

### **Scientifically Accurate Teaching of Race and Human Diversity**

Existing literature shows that when genetics is presented in a scientifically-accurate manner there is a marked reduction in students' biological and behavioral essentialism beliefs (Donovan et al., 2019) and improvements in students' critical thinking and scientific reasoning (Dawson & Venville, 2013). To explore this further we will examine the findings of a high school biology intervention lesson, which investigated students' understanding of race and human diversity conducted by Donovan et al. (2019). Unlike other studies that measured the effects of racialized readings in biology textbooks on students' essentialism beliefs (Donovan, 2016a, 2016b), this study measured the effects of an intervention lesson on students' essentialism beliefs. To gather data for their investigation, Donovan et al. (2019) conducted a randomized controlled test involving 166 high school and middle school students in the San Francisco Bay area. Students involved in the study were from a high SES private middle school ( $n = 52$ , eight graders) and a high SES public high school ( $n = 114$ , ninth graders). The demographics of participants in the study were as followed: White/European American (48%), mixed-race (19.88%), Asian/Asian American (18.1%), and Hispanic (5.42%), with a smaller percentage of students identifying as Black/African American (1.2%; Donovan et al., 2019). The goal of the

study was to determine if students' biological essentialism beliefs and racial stereotyping be reduced if they were taught a more accurate understanding of race and human diversity (Donovan et al., 2019).

In this cross-over trial experimental study design students were randomly assigned into two groups. One group received the intervention lesson that included a more accurate teaching of human variations (i.e., experimental) and the other received an alternate lesson (i.e., control). Students received either the experimental or control lesson respective to their group assignment for two weeks.

Students in the experimental group learned that any two individuals are 99.9% genetically similar (Donovan et al., 2019). Students also learned that of the 0.1% that differs between any two individuals there are more differences when comparing people of the same U.S. census racial grouping to those of a different racial group. A Black/African American individual has more genetic variations when being compared to another Black/African American individual and fewer genetic variations when compared to individuals of other racial groups, such as White/European American, and vice versa.

At the conclusion of the study, experimental group students who received the relatively more accurate lesson on human variation showed reduction in racial bias when analyzing pretest and posttest data (Donovan et al., 2019). Students in the experimental group had more accurate perceptions of the amount of similarities (99.9%) that exists between any two humans regardless of their race. To measure the long-term effects of the intervention lesson, researchers administered a second posttest three weeks after the intervention lesson. Results from the posttest showed students who participated in the intervention lesson still held a more accurate view of human variations in skin tone when compared to the control group. The implications of

this study support the idea that students can benefit on a scientific and social level when they are taught more scientifically accurate information related to race and human diversity.

### **What is Missing from High School Biology Curriculum?**

Studies have shown high school students (Donovan, 2016a, 2016b) and even college students (Hubbard, 2017a) have huge misconceptions when it comes to race and biological essentialism. For teachers to address the misconceptions students have about race and human diversity, instructors should have a strong genetics science background (McChesney, 2015). McChesney (2015) cites five key principles that all science educators must know to provide adequate instruction on human diversity. Existing research also supports these basic genetic principles:

1. All people today are one biological species which originated in Africa (Barsh, 2003; Jablonski & Chaplin 2000; McChesney, 2015).
2. Geography and environmental factors influence the structure of human population through natural selection (Barsh, 2003; Jablonski & Chaplin, 2000; McChesney, 2015).
3. There is more diversity within racial groups than between racial groups (Donovan et al., 2019; Rosenberg, 2011; McChesney, 2015).
4. There is no discreteness of traits among people categorized into racial groups (Rosenburg, 2011; McChesney, 2015).
5. There is no uniformity of traits that can be used to reliably divide people into racial groups (Kalinowski, Andrews, Leonard, & Snodgrass, 2012; Hubbard, 2017a; McChesney, 2015).

In this section, data will be presented from a geneticist, educational researchers, and an anthropologist to support these genetics principles and their relevance to the teaching of race and human diversity.

**African origins and environmental factors.** According to extensive research conducted by Jablonski and Chaplin (2000), variations in skin tones are a result of positive selective pressure for early humans to adapt to changes in ultraviolet (UV) radiations. Homo sapiens can trace their origins approximately to the equatorial regions of Africa before humans left the continent to inhabit other lands. The skin tone of most people at this time was dark because of the high levels of melanin, a protein that gives skin its pigmentation. This higher concentration of melanin was an adaptation that allowed for the protection of folate, an important micronutrient (Jablonski & Chaplin, 2000).

A pregnant woman with low levels of folate is less likely to have a healthy baby that will reach the age of puberty and be able to reproduce. As an early survival mechanism it was more favorable for humans to have darker skin. However, as individuals began to migrate out of equatorial Africa into areas that received relatively little sun light (i.e., reduction in UV radiation), selective pressures supported individuals with lower melanin production (i.e., lighter skin) because this allowed for the sun to penetrate through the skin more easily (Jablonski & Chaplin, 2000). The theory that selective pressure in response to varying amounts of sunlight resulted in variations in skin tone is seldom taught in public-school biology courses and is not mentioned in many popular textbooks (Skoog, 2005). The inclusion of early humans' origins out of equatorial Africa and human response to UV exposure in biology curriculum would be effective in reducing biological essentialism beliefs. These concepts would provide students with the scientific reasoning that *all* humans have similar origins and variations in skin tone seen

around the world can be attributed to environmental adaptations (Barsh, 2003; Jablonski & Chaplin, 2000).

**More diversity within racial groups.** Have physical differences lead to discrete and uniform behavior among individuals with different skin hues? When following the hypothesized human migration out of Africa, researchers have found that genetic diversity across the globe has actually decreased, meaning that humans have more genetic similarities than differences (Donovan et al., 2019; Rosenberg, 2011). Research supports that the most genetic human diversity existed in sub-Saharan Africa. As humans began to travel and exit this region of the world, diversity decreased.

Decreases in diversity or genetic differences can be attributed to scientific belief that small populations of people would migrate to a new geographic location and over time grow in numbers (Jablonski & Chaplin, 2000). The gene pool or genetic variation within these groups would only contain a subset of the variations or small amount of the different forms of a trait compared to the larger population. Among the variations of traits that were available, those that were more advantageous would be seen increasingly frequently within a given population due to selective pressures (Jablonski & Chaplin, 2000; Jarrett et al., 2016).

With the mapping of the human genome scientists have found that all humans share 99.9% similar DNA, supporting the assertion made that all humans are more similar than they are different (Donovan et al., 2019; Rosenberg, 2011). Scientists have shown through mapping of the human genome that all humans have the same genes, but these genes appear in variations or different forms. The variations of genes produce the diversity that exists in humans in the form of different blood types, hair texture, and even skin tone. Scientist have confirmed that

there is no “race” gene, only different variations in which human traits such as skin color are expressed (Rosenburg, 2011).

Many students assume there would be more genetic differences when comparing people of different racial groups; however, science does not support this thinking (Donovan, 2016a; 2016b). This is an important scientific finding that can help debunk students’ biological essentialism beliefs but is not included in high school curriculum as a part of mandatory teaching on human genetics (Morning, 2008).

**Uniformity and discreteness.** Genetic ancestry tests have become very popular. However, interpretations of ancestry results do not support uniqueness nor uniformity within people of similar races (Kalinowski et al., 2012). In a study conducted with college biology majors in an evolution and ecology laboratory course, students engaged in an inquiry-based lab to investigate if Africans, Europeans, and Asians were genetically different races. The study was conducted over the course of two semesters ( $N = 100$ , 59 students fall semester and 41 students spring semester), with a majority of students intending to pursue careers in medicine post-graduation. The course met for three hours two times a week. This study involved students’ use of DNA sequences to compare individuals of Asian, European, and African descent.

In the study, students were asked to create an initial hypothesis stating if they believed that Asians, Europeans, and Africans are genetically different races (Kalinowski et al., 2012). Students then worked in cooperative groups to design and conduct an experiment to test their hypothesis. DNA sequences used in this study were first sequenced in a seminal study by Ingman, Kaessmann, Paabo, and Gyllensten (2000) and were adapted for the lesson used with the college students enrolled in the evolution and ecology lab.

At the conclusion of the study students were able to determine that there was no genetic uniformity that exists within Asians, Europeans, and Africans to classify these groups as separate races (Kalinowski et al., 2012). In the students' analysis of the DNA sequences they were not able to find uniformity of traits within similar groups. They also did not observe any DNA sequences that were common only in one group and not the other. The authors of the study assert that because such a small amount of human DNA is responsible for determining skin tone, there are not enough differences to constitute discreteness resulting in genetically dissimilar racial groups between Asians, Europeans, and Africans (Kalinowski et al., 2012).

The authors of the study attribute difference in human skin tone to one of many variations that exist among all humans (Kalinowski et al., 2012). Other observable common variations they note are height and eye color. Students in this study were able to conclude through the use of DNA sequencing that humans are genetically similar regardless of their skin tone.

Observed differences based on geographic location provide historical context for the geographic location of one's ancestry, but do not constitute genetic uniformity or discrete racial groups (Rosenberg 2011; Kalinowski et al., 2012). This study supports the need for more accurate teaching to support students' understating of variations in skin tone in relation to human diversity. The findings of this study help to illustrate that ancestry information provides historical information on the geographic location of one's ancestors but it does not constitute discreteness or uniformity of people within similar racial groupings.

### **Use of Argument and Discourse**

Adolescents often struggle in creating clear concise arguments to articulate their ideas and research shows that as students get older little growth is seen in this area (Klaczynski & Gordon, 1996). The ability to create a concise argument and validate it with claims is an art

form that is not well developed in school-age children; however, research shows that the ability to process and package ideas into meaningful ways and communicate them to others is a crucial step in deepening scientific understanding (McNeill & Krajcik, 2011; Friedrichsen, Sadler, Graham, & Brown, 2016).

To understand how student discourse can support students' critical thinking and deepen their understanding of race and human diversity we will examine a study lead by Harvard University professor Beckwith and colleagues. During the City of Cambridge's annual Science Festival, Beckwith et al. (2017) presented a strategy that explored how schools and other organizations can structure lessons to teach students a more accurate way of understanding race and human diversity through analyzing dialogues and responding to questions prompts. Their research conducted through the Genetics and Society Working Group explored how classroom discourse can be used as a part of lessons designed to address students' misconceptions about genetics and racial constructs.

Their study design consisted of three skits. The dialogues within the scripts included conversations of common misconceptions students and the general public have about race that lead to biological essentialism (Beckwith et al., 2017). Their lessons used dialogues which allowed students to discuss their understanding of human variations, race, and popular genetics ancestry tests.

In the study, the skits were performed for two different audiences, attendees at the Cambridge Science Festival and students in an undergraduate science course. After each skit was presented, viewers engaged in an open forum that allowed them to ask questions or share their perspectives on the performance. The researchers noted that both groups held deterministic views of themselves and others based upon their race (Beckwith et al., 2017). At the science fair

one attendee, a healthcare worker, felt that he could provide better care for his patient if he knew their race.

One of the scenarios in their lesson framework showed how genetic ancestry results can contradict U.S. racial categories. This contradiction was used to explain to students that current race classification systems are modern societal methods of grouping individuals and are not based on genetic accuracy (Beckwith et al., 2017). Their work also provided learners with a framework for understanding how dialogue can be used in the science classroom to help students explore a more scientifically-accurate understanding of race and genetics.

The dialogue used by Beckwith et al. (2017) was able to break down barriers to student learning and provide an opportunity for scientific discourse. Although, the work was conducted primarily with college students the authors state that the skits can be adapted for high school lessons as well (Beckwith et al., 2017). The use of discourse by Beckwith et al. (2017) provides evidence that discourse can be used in science curriculum to create opportunities for open discussion and increase interest in learning more accurate ways of thinking about race and human diversity.

Class discourse can be a powerful tool to facilitate students' learning. To illustrate this, we will examine a study conducted by Dawson and Venville. Dawson and Venville (2013) conducted a study to measure the transference of teacher professional development on students' genetics understanding. In their quasi-experimental mixed methods study the authors investigated teachers' ( $n = 5$ ) participation in professional developments and their ability to transfer their knowledge to ninth grade biology students' argumentation and genetics understanding (Dawson & Venville, 2013).

Dawson and Venville (2013) embarked upon their research because they found a lack of continuity within genetics instruction in high school biology courses. They observed that the teaching of the structure and function of DNA is taught separately from the production of proteins, which code for physical traits such as skin color. In other words, they found that students could explain the shape and parts of DNA helix, but they were not able to use this knowledge to account for how DNA affects growth and development in humans (Dawson & Venville, 2013). They found that this gap in student understanding was primarily due to students' ability to recite facts about the role of DNA and its structure but inability to apply critical thinking skills needed for making connections at a deeper, more meaningful level. To address this divide in student learning of academic content and critical thinking skills they designed an argumentation intervention lesson for a high school biology class.

In their study teachers participated in a professional development on how to teach argumentation strategies in class. Students were then divided into experimental ( $n = 133$ ) and control ( $n = 160$ ) groups. Teachers then taught an eight to 10-week unit on genetics (Dawson & Venville, 2013). Students in the both control group and experimental group received the business-as-usual genetics lessons. At the conclusion of the lesson the experimental group participated in argumentation lessons instruction and the control group did not. An analysis of variance (ANOVA) was then used to determine interaction between the two independent variables of time (i.e., pre- and post-instruction) and argumentation (i.e., experimental and control group; Dawson & Venville, 2013). Results from the study showed that although all students made gains in genetics content knowledge, students in the experimental group had statistically significant higher scores in their genetics understanding. When analyzing student argumentation level and informal reasoning, students in the experimental group showed greater

gains when compared to control group (Dawson & Venville, 2013). Their research and that of others (Donovan et al., 2019; Sadler & Dawson, 2012) have provided strong evidence that argumentation can play a monumental role in the teaching and learning of genetics and social issues in the biology classroom.

What exactly does argumentation within a genetics unit look like? To answer this question, we look at the work of McNeill and Krajcik (2008) on the use of argumentation research in the science classroom. The research of McNeill and Krajcik (2008) provides a structure for students to use when developing an argument to respond to questions posed during instruction. Their framework includes three parts: claims, evidence, and reasoning or more commonly called CER (McNeill & Krajcik, 2008). Using CER, students develop a claim or an answer to a question. Next, students present scientific evidence related to their claim. Finally, students justify how the evidence they presented supports their claim in the third step called reasoning. In this way CER can be used to help students respond to critical questions within lessons on the more accurate teaching of race and human diversity.

McNeill and Krajcik (2008) suggested that teachers using CER in science instruction should do so by first defining CER and then modeling the development of an argument using CER. Their research shows that starting with a real world example (e.g., “Which energy drink provides the most energy?”) and then scaffolding into specific examples in science (e.g., “Does a person’s race predetermine their intellectual and behavioral propensities?”) is the best approach to students’ argumentation development with CER (McNeill & Krajcik, 2008).

The use of CER argumentation can be implemented in both oral and written responses during classroom instruction. Educational researchers using CER have reported that students are best able to support their assertions using CER if they have a firm grasp of the science content

(i.e., race and human diversity) prior to writing their response (Emenaha, 2019; McNeill & Krajcik, 2008, Sadler & Dawson, 2012). In this way McNeill & Krajcik (2008) used CER to serve as a pretest/posttest analysis in their research to understand student argumentation within science instruction. Analysis of their study was made using CER rubrics to measure students' ability to organize well-developed scientific arguments. From students' CER responses, teachers can identify misconceptions in students' scientific reasoning and work to address gaps in student learning.

### **Teaching Strategies and Considerations to Address Race and Human Diversity**

An overwhelming amount of literature has been presented to demonstrate the need to revisit the way genetics is being taught in many high school biology courses. A more modern and scientifically-accurate manner of understanding diversity among humans could present a paradigm shift for students, challenging the way they have previously processed the world around them. Instruction efforts to support students' ability to process a new way of thinking should be grounded in research that employs best teaching practices. The subsequent portion of this discussion will provide research to explain the ideal context and manner of instruction in the teaching of race and human diversity within a biology class.

In this section, literature will be presented to discuss important components that science educators should include in lessons designed to teach students a more accurate understanding of race and human diversity. This section will address culturally responsive teaching considerations, application of critical race theory (CRT), cognitive considerations, and instructional considerations pertaining the teaching of race and human diversity in the science classroom.

**Culturally responsive practices.** Scientists are aware that all humans' brains, regardless of their race or ethnicity, function in a similar fashion (Rosenburg, 2011). Furthermore, biological essentialism beliefs or the belief that race is discrete and can be used to make predictable assumptions about one's intelligence or behavior has been shown to be scientifically inaccurate (Dar-Nimrod & Heine, 2011). Despite the abundant amount of literature that states race is a social construct, race and racial groupings have huge implications in society. The marginalization of racial minoritized groups, particularly Black American and Latino American students has resulted in both groups' lower academic performance in science and math subjects (Gay, 2014). If scientists (Jablonski & Chaplin, 2000), a geneticist (Rosenburg, 2011), and an anthropologist (Hubbard, 2017b) have all concluded that race is a social construct and is not positively correlated to cognitive abilities, then what accounts for the gaps in Black American and Latino American academic success rates?

Contemporary researchers point to lack of culturally appropriate teaching methods as one major factor to explain gaps in educational success rates between different racial groups. Hammond, an educational researcher, has conducted extensive research to explain how culture impacts cognitive development. Her work and that of others has shown that the constructivist teaching strategies of CRP are crucial to teaching, particularly in urban school settings (Hammond, 2015). Ladson-Billings, an American theorist and educator, was the first researcher to organize the ideas and teaching philosophy surrounding CRP. CRP is a teaching strategy that utilizes students' culture as a mode of instruction (Gay, 2014). CRP framework identifies that curriculum and instruction in many public schools is positively biased towards Eurocentric cultures, despite increasingly diverse students populations. A total of 48% of students in public schools are members of minority racial and ethnic groups, with Latino American students

accounting for the majority of this population (National Center for Educational Statistics, 2019). This juxtaposition of cultural ideologies that do not mirror the student population has been cited as problematic and results in students' inability to make authentic connections between themselves and the learning (Gay, 2014; Ladson-Billings, 2014). However, utilizing CRP as a framework for teaching can work to support students' cultural needs by incorporating students' own cultures into instruction.

***Teacher positionality within CRP.*** Teacher positionality refers to the conscious or unconscious stance teachers take that influences and guides their teaching philosophy, perspective of learners and learning, and teacher practices (Teo, 2015). Teacher positionality can be measured by exploring his or her perceived agency, which influences the ability or willingness to incorporate culturally responsive teaching into instruction (Gay, 2014; Hadar & Benish-Weisman, 2019). Research shows that culturally responsive teachers possess a high sense of agency (Hadar & Benish-Weisman, 2019). Teacher agency refers to the perceived level of autonomy teachers have in the classroom to direct student learning and facilitate their own personal growth (Hadar & Benish-Weisman, 2019). A teacher's sense of agency, as understood through the lens of CRP, can be the litmus test to measure the extent an instructor does or does not implement tenets of culturally responsive teaching. According to Ladson-Billings (1995) there are three tenets of CRP: (a) high belief in student achievement; (b) affirmation of students' cultural competence; and (c) the development of student's sociopolitical consciousness. Two major factors that affect teacher agency include a teacher's personal experience (social and cultural) and professional experiences (preservice and in-service; Buchanan, 2015). A heightened sense of teaching agency puts teachers at the forefront of instruction as change agents versus as recipients of top-down instructions which they must adhere to without question

(Golombek & Johnson, 2017). Teachers who perceive themselves to have a high level of agency are more likely to implement the tenants of CRP with fidelity than teachers with low senses of agency (Golombek & Johnson, 2017; Ladson-Billings, 2014). Therefore, it proves quite beneficial to understand the role of teacher agency as it relates to teacher positionality within culturally responsive curriculum.

First, CRP brings students' culture and way of knowing into the science classroom. For example, culturally responsive teachers draw upon historic figures, traditions, and colloquialisms that are representative of their students' backgrounds and culture. When students can identify with leaders in science that have their same racial and ethnic backgrounds, it has been shown to increase their science identity and science efficacy, thereby increasing their academic performance and interest in science courses (Brotman & Moore, 2008).

Next, culturally responsive teachers believe that all students can succeed regardless of their race, gender, or ethnicity. To accomplish this, teachers must be willing address their own implicit or explicit racial biases. Gay stated teachers can accomplish this through reflective questioning and teaching practices (Gay & Kirkland, 2003; Gay, 2014). Reflective questioning is the process of asking oneself questions to address or uncover racial biases and stereotypes. Through reflective questioning, culturally responsive teachers can work through long-held biases that might impede their ability to support students' success. This process can support learners as teachers can avoid teaching from a deficit mindset, due to either consciously or subconsciously subscribing to biological essentialism or racist ideologies.

Finally, culturally responsive teachers develop students' sociopolitical consciousness. Critical constructivists, such as Kincheloe (2008) and Freire (2000) argue that sociopolitical consciousness is the awareness that there are power structures that inhibit the academic success

of marginalized groups. Sociopolitical consciousness development helps students to find ways that science influences the conditions of their local communities and their local communities in turn influence science. It also supports student activism towards addressing issues that might be in opposition to the status quo and to provide equity and equality for marginalized groups.

**Critical race theory.** To truly develop students' sociopolitical consciousness, relevant research supports the use critical race theory to explain the gaps in genetics teaching on race and human diversity. To understand the tenants of CRT, it is important to provide a definition for the word *critical* and its use as a theoretical framework. The term *critical*, according to well-known critical theorist Freire (2000), is the analysis of school systems through the power play between the oppressed (i.e., marginalized students) and the oppressor (i.e., school systems). According to Freire (2000) and other critical pedagogy philosophers, the educational system is a highly political landscape where those in power maintain their position by inhibiting the critical thinking and development of sociopolitical consciousness of students and even teachers. Specifically, CRT asserts that race is the medium that power structures use to marginalize oppressed groups. CRT originated in legal practices but has since been widely-used in educational research (Tate, 1997). Freire is not alone in the call for education and educators to utilize a critical perspective of education. Kincheloe, yet another pioneer in education reform, asserted that a critical stance is necessary to address issues of race, equity, and inequality in urban education. Kincheloe (2008) defined critical pedagogy as an approach to education, stating education is a "political animal". As with many political structures, there are differing and conflicting agendas at work. Critical race theorists would argue that the omission of modern genetics emphasizing scientific findings to debunk racist and biased beliefs from the biology curriculum is intentional. By not teaching that race is a social construct or presenting scientific

findings that debunk racist stereotypes, current science teaching actually perpetuates biological essentialism, thereby maintaining racial conflicts in society.

Those in the educational sphere who want to dismantle systems of oppression that perpetuate racist ideologies must also take a critical approach to education (Gay & Kirkland, 2003). In a qualitative case study conducted by Morales-Doyle (2017) she worked with 29 Black and Latino American high school students to investigate environmental racism in their community. Students in the study collected soil samples from various parts of their communities as part of a class science project. Analysis of the soil samples provided strong evidence that the location of power plants emitting pollutants were in areas with a majority of Black and Latino American residents. As students became aware of the location of power plants and their role in perpetrating environmental racism, their critical consciousness deepened. Students were then empowered to take action and raise awareness about the impact of the power plant on marginalized racial groups. Through use of CRT and CRP the study conducted by Morales-Doyle (2017) exemplifies how a critical approach to teaching science supports students' critical thinking and development of sociopolitical consciousness. In teaching high school students the evidence to support the social construction of race, students must also be challenged to examine why such teachings are not a part of a mandatory genetics curriculum. By doing so students can develop not only a more sound understanding of race and human diversity, but also provide further context and awareness of larger systems outside of the biology curriculum that promote racial stereotypes and biased ideologies.

**Cognitive considerations.** When creating an intervention lesson about race, researchers are very aware that the topic can be viewed as controversial. Additionally, the concept that most humans are more genetically similar than they are different could challenge students long-held

beliefs which could lead to the Lewandowsky effect (Donovan et al., 2019). According to the Lewandowsky effect, if a more complex idea (e.g., all humans are 99.9% genetically similar) attempts to replace a simple idea (e.g., people of the same racial grouping are more genetically similar) students will have a tendency to reject the new idea (Lewandowsky et al., 2012). To avoid the Lewandowsky effect, lessons on more accurate teaching of race and human diversity should use a scaffolding refutational curriculum approach (Donovan et al., 2019; Lewandowsky et al., 2012). In the refutational curriculum approach information is presented to students in a systematic way to allow students to process new information and make a shift in their thinking. In this approach students are: (a) first presented with information that supports their misconception; (b) then the misconception is labeled as incorrect; (c) next scientific evidence is used to support the more accurate information; and (d) lastly students are presented with an explanation as to why the initial misconception is widely accepted as true even though it is inaccurate (Donovan et al., 2019; Lewandowsky et al., 2012).

For example, when educational researcher McChesney's (2015) prepared to work with preservice teachers on expanding their understanding of race and human diversity, she began her teaching by allowing students to share their thoughts on racial categories. She then stated that former president Barack Obama (i.e., son of African father with darker skin and White American with light skin mother) is considered "Black" in the United States. She continued to explain that because of the color of his skin if he were in Brazil he would be raced as "White" while if the former president was born in South Africa he would be racialized as "Colored" (McChesney, 2015).

Next, she provided instruction to support accurate understandings of race and human diversity while utilizing a scaffolding refutational curriculum to support learning. This teaching

method has proven to be effective in challenging students' ideas that the concept of race is fixed and inherent (McChesney, 2015).

Additionally, Lewandowsky et al. (2012) noted that when presenting topics that can challenge students' long-held beliefs lessons should: (a) provide reasons as to why the misinformation exists; (b) avoid spending too much class discussion on the inaccurate way students have processed information—avoid repeating the myth; (c) create a short list of reasons to debunk the inaccurate way of thinking—too many points refuting long-held beliefs can result in overkill leading students to reject the new way of thinking; and (d) lessons should be designed to affirm students' world views.

When teaching lessons it is important for teachers to affirm students' worldviews, such as their cultural and ethnic affiliations or traditions. By presenting lessons in an affirming way, educators will be teaching in a culturally responsive manner (Ladson-Billings, 1995) as well as increasing the likelihood that students will accept the new way of viewing themselves and the world around them (Lewandowsky et al., 2012).

**Instructional considerations.** According to noted anthropologist and researcher Hubbard, teaching about race and variations in skin tone can be perceived in different ways depending upon student's racial identity and worldview. Therefore, certain considerations should be included in such instruction. Hubbard (2017a) asserted that teachers' understanding of student experiences are important to supporting the learning process. Her research has found that during lessons on the topic of race White students might deal with feelings of awareness and overcoming discomfort while non-White students deal with realizing and processing societal perceptions about race (Hubbard, 2017a). To support students' learning Hubbard suggested educators incorporate specific strategies into their instruction.

One teaching strategies Hubbard (2017a) proposed is the use humor, when appropriate, to create sense of ease when discussing race and its social implication. An example of this would be asking students, “Who finds the subject uncomfortable? Don’t worry you’re normal.” (Hubbard, 2017a, p. 517). Next, teachers should set expectations for student conversation and behavior during classroom discourse. Hubbard (2017a) suggested providing students with sentences stems to guide their communication such as “I am struggling to understand...” instead of “I don’t want to sound racist, but...” which would support students during class discourse (p. 517).

Next, she suggested educators share personal stories about their experience with knowing and understanding race. Hubbard asserts that when non-White teachers share their experiences, this helps to humanize them and create a stronger connection between the teacher and students. It has also been noted that when White American teachers share experiences with race, such as advantages, disadvantages, or times when they experienced a shift in their views about race it can support White American students in being more critical of their personal views about race (Hubbard, 2017a).

Hubbard also encouraged the use of visuals to support students’ learning during instruction on race and human diversity (2017a). She notes that because the discussion of race in genetics is a phenotypic or physical variation, images can help teachers foster student understanding of the topic (see Figure 2).



*Figure 2. Physical genetic variations in penguins versus humans. Adapted from “Teaching race (bioculturally) matters: A visual approach for college biology courses.,” by A. Hubbard, 2017a, *American Biology Teacher*, 79(7), 519. Copyright Year by2017.*

Pictures can support students’ understanding that variations in physical appearance are very common among all living organisms. Although Hubbard’s (2017a) teaching on race and social justice issues were conducted at the collegiate level her work is applicable to high school lessons as well.

### **Gap in Literature**

Donovan, a pioneer in research focused specifically on how high school biology affects students’ essentialism beliefs, has contributed a great deal to the scholarship of teaching scientifically-accurate lessons on race and human diversity. However, his work does have significant limitations. One such limitation to his research is the lack of diversity (i.e., racially and economically) among participants in his studies. An overwhelming majority of his research participants are from socially and racially privileged groups (Donovan, 2016a; 2016b; Donovan et al., 2019), which leaves a void in the field of educational research.

Existing literature does not show what the results would be with a similar research design to Donovan’s utilized among a racially and economically diverse student population in an urban school setting. Dawson and Venville’s (2013) work with high school students comes closest to answering this question as their research was conducted with a more diverse student population. Although there is great merit to the works of Dawson and Venville, their investigation did not

provide specific evidence to support students' understanding of race and human diversity within a genetics lesson. Instead the focus of their investigation was on how argumentation affects high school students' general genetics knowledge (i.e., sexual reproduction, mitosis, meiosis, Mendelian genetics, and human genetic diseases). Dawson and Venville's (2013) research design did not include any investigations into students' genetic understanding as it relates to race and human diversity. Also worth noting, Dawson and Venville's research was conducted in Australia, which has a different racial history than the United States. The different racial histories between the two countries provides more evidence of the need for work to be done, particularly in U.S. public schools.

A third set of researchers, Yang et al. (2017), used race to explore genetics in a high school biology course. However, they stated "We have not collected formal data on students' learning regarding race and ancestry or their attitudes about race" (Yang et al., 2017, p. 5). Their research design allowed students to use their own DNA to gain a better understanding of how genetic technologies are used to sequence DNA and determine genetic ancestry, not to investigate students' understanding of race and human diversity.

The scholarship and teaching that has provided data on the use of argumentation skills to support students' understanding of accurate race and human genetics instruction in diversely-populated secondary biology classes is found wanting. There is an obvious gap in the landscape of educational research in the teaching of race and human diversity, particularly in diverse urban schools.

The next chapter presents an overview of a multiple case study design intended to investigate teachers' experiences in the teaching of a culturally responsive lesson addressing the topic of race and human diversity within the high school science classroom.

## Summary

The messages students receive about race and human diversity can have a negative impact on their perceived ability to be successful. Science has provided evidence that race and intellectual capabilities are not inherent. However, students are not being exposed to such teachings. Lack of adequate instruction on race and human diversity has led to biased beliefs about race. It has been shown that modernizing genetics curriculum and incorporating scientific argumentation into science instruction can reduce student misconceptions about race.

For many high school students, biology forms the foundation of their understanding of life and differences that exist among living organisms. Due to this important role that high school biology courses hold, it is crucial that research be conducted investigating methods to ensure that it is taught with fidelity and accuracy.

## **Chapter III**

### **Methodology**

The aim of this study is to investigate in-service biology teachers' experience in the implementation of a CRP lesson exploring the social construct of race and genetics. This study uses a multiple case study design to respond to the research questions being investigated. Qualitative research is characterized by the interpretation of experiences via processes of inductive reasoning (Merriam & Tisdell, 2016). In qualitative research the researcher is the primary instrument in the collection and analysis data (Creswell, 2015; Merriam & Tisdell, 2016). Data is gathered through robust collection of sources such as interviews, focus groups, and observations. All evidence collected is then systematically analyzed, grouped into meaningful ways, and then interpreted to present the themes or findings of a study (Merriam & Tisdell, 2016). Specifically, a qualitative case study is a methodological approach that assesses individuals or an institution as a bounded system (Merriam & Tisdell, 2016). A bounded system allows researchers to put a "fence" around the case being investigated to delineate the parameters that will be the focus of the investigation. For the scope of this study each teacher will be analyzed as an individually-bounded system and each teacher's interview will be interpreted based on his or her unique interpretation within the framework of this investigation.

### **Philosophical Foundation**

One of the most widely-used philosophical perspectives of qualitative research is an interpretive or constructive orientation (Merriam & Tisdell, 2016). When using a constructivist orientation, the researcher believes that knowledge is constructed and there is no singular reality (Jones, Torres, & Arminio, 2014). Rather, one's reality is constructed through various social exchanges and interactions (Merriam & Tisdell, 2016). Qualitative researchers rely heavily on

the *words* gathered in various ways of their participant in the construction of meaning, which culminate to determine the findings of a study (Merriam & Tisdell, 2016; O'Toole, 2018).

Merriam and Tisdell (2016) present four epistemological perspectives when conducting qualitative research: positivist (i.e., making generalizations), constructivist (i.e., context bound/multiple realities), critical (i.e., analysis of power dynamics), and postmodern/poststructuralism (i.e., use of questioning to construct/deconstruct meaning). Taking a pragmatic approach to research, I believe the research questions should determine the epistemological approach used here in a qualitative study. Therefore, a constructivist epistemological approach will be used as this is the most appropriate fit for the design and research questions within this present study. A constructivist perspective asserts that knowledge is created through describing, understanding, and interpreting data within a bound context. This epistemological approach is most appropriate as each teacher in the present study delivers his or her instruction independently of other study participants. Therefore, all participants bring with them their unique teaching style, educational philosophies, and personal stories that culminate to create their teacher identity which shapes their perspectives.

Teachers construct and deconstruct their reality based upon the various identities they encompass (Court, Merav, & Ornan, 2009). Teacher identities are very complex and nuanced. Their identities are a combination of factors including preservice teacher preparation experience (Izadinia, 2013) and in-service teacher professional developments (Golombek & Johnson, 2017; Yuan & Lee, 2016). To appropriately interpret the reality of each participant and not interject the assumption that every teacher will experience the same scenario in the exact same way, a constructivist epistemological approach is beneficial in preserving the integrity of each teachers' experience of the intervention lesson on race and human diversity.

## Research Questions

1. What ways, if any, do in-service biology teachers' positionality affect their perception of a culturally responsive lesson on race and human diversity?
2. What impact, if any, do in-service biology teachers perceive a culturally responsive lesson on race and human diversity has on students' understanding of the social construction of race?
3. What impact, if any, do in-service biology teachers perceive a culturally responsive lesson on race and human diversity has on students' scientific argumentation skill?

## Procedures

**Pilot study.** This section contains details about the procedures for the pilot study, which included a single teacher case study, and details related to the lesson design and structure. The pilot study was conducted using a qualitative single-teacher case study in the year prior to the present dissertation study. The teacher participant in the case study was selected through purposeful sampling as the teacher was a part of a larger study funded by the National Science Foundation (NSF). The NSF study provided opportunities for in-service secondary science, technology, engineering, and math (STEM) teachers to obtain graduate-level training focused on incorporating CRP strategies into their teaching practices. The participant in the single-teacher case study, Mr. Santori (pseudonym) has six years of teaching experience and is a state certified science teacher.

**Instructional schedule.** Mr. Santori taught a total of six academic courses, teaching three each day for a total of 90 minutes each. His classes were arranged into "A" day and "B" day. On an "A" day he taught three 90-minute classes to half of his student population. Then the next school day, or "B" day, he taught the same lesson from the previous day to the other half

of his student population. Within a two-day period (i.e., “A” day and “B” day) he would have taught all six sections of his biology classes. This type of scheduling is referred to as block scheduling. Block scheduling allows students to have longer instructional time per day in comparison to traditional scheduling. Block scheduling is different from traditional scheduling options, where teachers teach all academic and elective courses, in 45- or 50-minute increments within one school day.

Mr. Santori, taught biology, which is a required course for graduation and is offered to students in their first year of high school. The first year of high school is referred to as freshmen year or ninth grade. A majority of students enrolled in his biology class were classified as freshmen or ninth graders. Students who are not classified as ninth graders and were enrolled in biology either transferred from different schools or previously took the course and did not complete with a passing grade.

**Modern genetics lesson.** As a former biology teacher, I designed the intervention lesson taught by Mr. Santori. The intervention lesson was aligned with the Texas state standards for the teaching of genetics and variations of traits. This lesson was adapted from a previously taught lesson taught by Mr. Santori on genetics and patterns of inheritance. For the purposes of this study the lesson was redesigned to provide a more explicit teaching of race, human diversity, and CER argumentation writing strategies.

When the lesson was initially taught discussions of race were limited to prevalence of diseases or phenotypic (i.e., physical) traits passed from parent to offspring. A typical genetics unit includes academic content related to inheritance of traits, such as making predictions using Punnett squares to predict genotypic (i.e., genetic) and phenotypic outcomes from parent to offspring. The redesigned lesson added to this instruction by teaching the historical origins of

race and using modern genetics research to debunk biological essentialism. This version of the lesson also included the ways that race and racial classification systems have led to discrimination and stereotypes of marginalized groups.

Instruction for the lesson was written using a 5E lesson framework (Bybee & Landes, 1990). The 5E lesson structure consists of five distinct parts taught in the following order: engage (i.e., creates interest in the topic), explore (i.e., allow students to construct meaning from previous experience), explain (i.e., students learn academic language associated with the lesson), elaborate (i.e., students apply what they know to a different, but similar scenario), and evaluate (i.e., student learning is independently accessed; Idsardi, Hahn, Bokor, & Luft, 2019). The 5E lesson design was used to support student inquiry and appropriate scaffolding of content. “I would like to say that the lesson PowerPoints were well done. They were easy to follow. I really liked them. The kids enjoyed them [too],” stated Mr. Santori during the exit interview. The lesson included multiple learning strategies such as using CER as a means for students to respond to questions throughout the lesson. Mr. Santori administered the lesson for the study at the end of his usual three-week genetics unit. Following the three-week traditional genetic lesson, Mr. Santori then taught the intervention lesson over a span of two weeks (i.e., 5 A days/5 B days).

Table 1

*Summary of Lesson on Race and Human Diversity*

5E lesson component	Description of activities and content
Engage	<i>National Geographic: The Mixed Race Siblings Activity</i>
Explore	“Sorting People” Activity

Explain	There's no scientific basis for race, reading and activity sheet
Elaborate	Each group will be provided with articles and allowed to access the internet to research evidence to support and to refute the big question. Engage in group discussions to share their positions on the unit question in small group and whole group settings.
Evaluate	CER writing prompts

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**Instructional fidelity.** During the pilot study three 30-minute observations were conducted. The goal of the observations was to ensure Mr. Santori was facilitating the lessons with the intent with which it was written. Feedback was provided as needed during non-instructional time to support the proper facilitation of the lesson.

Additionally, Mr. Santori completed a Culturally Responsive Science Teaching–TS Lesson Analysis Tool (TEACH MATH, 2012), an instrument adapted from culturally responsive math teaching and validated for use on culturally relevant science teaching. All data collected was used to revise the lesson to adjust for time constraints, providing more insight on ways to develop student scientific argumentative skills and refine interview questions used in the current study.

One major adjustment to the lesson was revisions to student readings. Readings were reduced from six articles in the pilot study to four in the dissertation study. Lengthier readings were summarized to not exceed two and one half to three pages per reading. These changes were made based upon feedback from Mr. Santori:

The readings make perfect sense. It aligns, it connects with the topic that we're going over, but for some of my classes we had to read it as a class, because of the length of some of the articles... some students had challenges getting through it. But I really like

what the article was talking about and from student response it helped clear up a lot of misconceptions (Mr. Santori, personal communication, January 17, 2019).

During the interview Mr. Santori was asked how closely he felt the lesson aligned to science content:

The science content was very much aligned. I liked how you had incorporated, the Punnett squares into it 'cause that was actually on our test. On the state exam, they do have to know Punnett squares (Mr. Santori, personal communication, January 17, 2019).

Finally, adjustments were made to the interview protocol and questions were refined to gather more detailed data on teachers' perceptions of their students' argumentation skill development.

Sample interview questions are as follows:

1. What did you learn about your students as they completed the CER activities?
2. Did students rationale for their arguments remain the same or change as the lesson progressed? If so, in what ways?

**Validating the lesson.** In addition to feedback obtained during the single-teacher case study, the lesson was reviewed by an external reviewer. The use of outsider reviewers helps to increase the validity and relatability of the study (Creswell, Klassen, Plano Clark, & Smith, 2011). Brian Donovan, a research scientist at Biological Sciences Curriculum Study, served as the external reviewer for the intervention lesson. A nationally recognized researcher, Donovan's work focuses on how genetics education at the secondary science level can help adolescents make sense of complex social science issues, such as race, through evidence-based reasoning.

An initial correspondence was sent via email requesting for Donovan to contribute his expertise as an external reviewer for the intervention lesson on race and human diversity at the conclusion of the pilot study. After reviewing the intervention lesson Donovan provided

feedback via a one-hour Skype call. One of the key suggestions addressed during the call was how to prevent backfiring. Backfiring is the inclination for students to resist accepting a new concept or idea because it is too huge of a shift from their personal ideology or worldview (Lewandowsky et al., 2012).

Backfiring can occur within lessons if a student realizes they harbor stereotypes about race that are unscientific or racist (B. Donovan, personal communication, December 2, 2019). This could be a triggering event for a student, which could result in the student feeling attacked thus leading to resistance to new information being taught. Students in marginalized groups might experience backfiring that reifies negative perceptions about themselves, which would be an unintended consequence if not addressed (B. Donovan, personal communication, December 2, 2019). To address backfiring, it was suggested to use fictitious characters. Fictional characters would allow students to discuss the social issues related to the lesson from the characters' point of view. This strategy has been showed to reduce backfiring by allowing students to explore the topic through the lens of the characters, reducing a student's tendency to feel personally attacked by ideas shared during classroom discourse (B. Donovan, personal communication, December 2, 2019).

**Dissertation study.** In the year following the pilot study the lesson was refined based upon data collected during Mr. Santori's interview and recommendations from expert external reviewer Donovan. The next phase of the study included obtaining Institutional Review Board (IRB) approval to conduct the present dissertation research. Separate IRB approval was needed as the pilot study was conducted with a participant in an NSF funded research project. Inclusion criteria for the dissertation study was not exclusive to participants from the NSF program,

therefore a new IRB was obtained to conduct the dissertation research. In the next section I will discuss recruitment methods, participants, and data collection methods for the dissertation study.

### **Recruitment Methods**

After participating in the initial pilot study in the following year Mr. Santori shared his experience teaching the lesson with three other biology teachers. Mr. Santori's colleagues expressed strong interest in incorporating the lesson into their instruction and taught the lesson at the end of their regular genetics' instruction. After teaching the lesson Mr. Santori shared with me that he and his colleagues had taught the lesson and they felt that it was very supportive of students' learning. Teachers who taught the lesson were then asked if they would participate in a series of interviews to gather data on their experience teaching the lesson. This method of sampling is referred to as purposeful sampling or convenience sampling (Creswell et al., 2011). In convenience sampling researchers recruit participants based on accessibility, availability, or location (Creswell et al., 2011).

**Protection of participant privacy.** Once the participants were selected approval was then obtained at the university level through the IRB and then at the campus level. Teachers were informed that participation in interviews was not compulsory. Invited teachers were aware that they were being asked to share their perspectives on a lesson they had taught during their genetics unit and all information shared would be made confidential. Teachers were made aware they could exit the study at any time without penalty or consequences (Creswell et al., 2011). Teachers were given a consent form to review and provided two weeks to decline or accept the invitation to participate in the study. After the two-week period all four teachers accepted the invitation to participate in the research study.

The consent statements emphasized that results of the study would remain anonymous and would not be shared with school administration, participating teachers, or other district personnel. Neither will the name of the high school nor the names of teachers be used when data was being recorded, collected, and or during the writing of the results be made known. Neither were the names associated with the study used in discussions with other professionals or researchers. All data was collected and stored in a secure online database and all participants names were changed to pseudonyms to provide anonymity to the participants. The design of the study was done in such a way as not to create any damage to the reputations of the school or teachers. Considerations were also put in place to ensure there was no physical and/or psychological harm to anyone involved in the present study.

### **Setting**

The participants worked in large, urban city in Southeast Texas. They taught at a traditional public four-year high school with Grades 9-12. In the 2017-2018 school year, according to state data the school had a total enrollment of 3,351 (Texas Education Agency, 2018). The campus' student demographics are as follows: 32.9% African American, 36.6 Hispanic, 24% White, 4.7% Asian, 0.4% Native American, and 1.7% two or more races as reported (Texas Education Agency, 2018). The rich racial diversity of the student population of the high school selected for this study made the school an ideal setting to conduct this research exploring teachers' experiences in teaching the social construct of race.

### **Participants**

Participants this study consisted of four in-service biology teachers. All four teachers taught at the same school and collectively made up the entire biology team at their high school. For the purposes of the study each teacher will be given a pseudonym to protect their identity

and privacy. Mr. Santori, one of the four teachers in the study, has six years of teaching experience entirely at the high school level. He recently completed his master's degree in education taking courses specifically in the theory and application of CRP. Mr. Santori was also a participant in the pilot study conducted the year prior to the present study. Ms. Patterson (pseudonym) and Ms. Sanchez (pseudonym), both had less than one year of teaching experience at the time of the study. Both Ms. Patterson and Ms. Sanchez reported receiving CPR training during their teacher programs. Mrs. Lee (pseudonym), the fourth teacher in the study, had six years of teaching experience at the time of the study. She admits that she has had very little training and experience with CPR prior to implementation of the lesson discussed in this study.

Table 2

*Participant Demographics*

Participants	Gender	Ethnicity	Teaching experience	Course(s) taught	Highest degree obtained
Mr. Santori	Male	Latino	6 years	Biology	Master's degree in STEM Education
Ms. Patterson	Female	African American	< 1 year	Biology	Bachelor's degree in Biology
Ms. Sanchez	Female	Latina	< 1 year	Biology	Bachelor's degree in Biology
Mrs. Lee	Female	African American & Asian American	6 years	Biology, Advanced Science	Master's degree in Education

## **Intervention Lesson**

**Instructional fidelity.** Teachers in the study routinely worked together throughout the normal year to plan lessons as a team. Prior to teaching the lesson, teachers reported they did meet to plan how they would teach the lesson. During the planning teachers reviewed worksheets, virtual slides, and CER questions they would use during their instruction. They also collaborated to plan the logistics of making copies and to discuss different reading strategies that would allow students finish the different readings in the allotted amount of time. No classroom observations were conducted as teacher interviews were conducted several weeks after teachers had taught the lesson.

**Modern genetics lesson.** The teachers taught the lesson at the end of the traditional three-week genetics unit. The genetics unit included academic content related to inheritance of traits, such as making predictions using Punnett squares to determine genotypic (i.e., genetic) and phenotypic (i.e., physical) outcomes from parent to offspring. Following the three-week traditional genetics lesson, all teachers participating in the study then taught the intervention lesson over a span of two weeks (i.e., 5 A days/5 B days). Teachers taught a similar lesson to the lesson taught during the pilot study (see Table 1), however the lesson taught during the present study had undergone two phases of revisions. Initial revisions were made based upon classroom observations and the exit interview conducted during the pilot study. The second round of revisions took place after feedback was provided by an external expert reviewer.

## **Data Collection**

Data collection for this study consisted of two 30–45-minute semi-structured individual interviews, a one-hour focus group interview, and the teachers' written reflections notes. The next section will provide more details on the data collection method for this study.

**Initial teacher interviews.** Teachers were invited to participate in a 30–45-minute semi-structured interview at the conclusion of the study. The goal of the teacher interview was to assess: (a) whether they would continue to use the intervention lesson in science classrooms; (b) teachers' perceived significance and challenges of social issues such as race in science; and (c) teachers' perceptions of the lesson's ability to support student scientific argumentation. Each interview was recorded and the audio recordings were transcribed. Teacher consent to be audio recorded was obtained prior to interviews. At the conclusion of the interview the recordings were transferred to a password-protected secure database. Audio recordings were destroyed after the interview transcription was complete. As stated earlier, teachers participating in the study were given pseudonyms which were used during the analysis of interview transcripts and during any publication of data obtained from interviews.

**Focus group interview.** According to Merriam and Tisdell (2016), focus group interviews are very similar to individual interviews, however they provide participants an opportunity to share their views, learn from the views of others, and even redefine their own perspective on a particular topic. Two weeks after the exit interview all four teachers were invited participate in a 60-minute semi-structured focus group interview. This interview was also audio recorded and transcribed.

**Final teacher interviews.** Three weeks after the focus group interview a second round of 30-minute semi-structured individual teacher interviews was conducted. The interviews were

done via online conferencing to better accommodate each teacher's schedule. One of the purposes of the follow-up interview was to conduct member checks. Member checking is a way to increase the validity and trustworthiness of qualitative research by providing respondents with an opportunity to clarify comments made in previous interviews (Creswell et al., 2011; Merriam & Tisdell, 2016). Another goal of the follow-up interview was to gather more data to address the topic of teachers' perceived experiences on use of culturally responsive teaching in the science classroom.

### **Data Analysis**

**Analysis.** Once interviews were transcribed, the data analysis process consisted of a period of intense analysis by first creating a data repository of all interview transcripts and teacher reflection notes. Then initial open coding was conducted followed by an iterative process of axial coding or analytical coding. Axial coding is the process of opening coding where data is put into groups or categories based on similarities (Merriam & Tisdell, 2016). Axial coding involves making interpretations based upon observed pattern followed by creating groupings or categories (Merriam & Tisdell, 2016). A running list of groups was created during each iteration of analytical coding for each teacher in the study. This process was completed over three to four cycles for each case within the study. During each cycle of axial coding categories were reduced to create fewer groups. During each cycle the groups were also renamed to better describe the emerging patterns in each newly created category.

**Thematic coding.** Rationale for each new category was made using research questions as a guide (Creswell et al., 2011; Merriam & Tisdell, 2016). A time period of one to two days was given between each cycle of coding. The wait period between each cycle of coding helped to provide time to analyze new codes and approach each coding cycle with a fresh perspective.

Codes were created to be mutually exclusive, meaning data grouped into a code could not be placed into another category (Merriam & Tisdell, 2016). The final iteration of coding produced the themes or findings of the investigation.

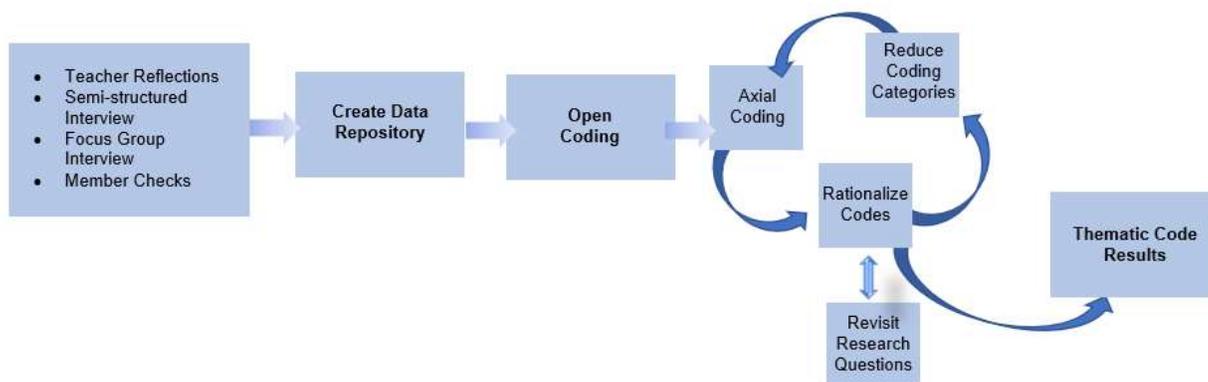


Figure 3. Data analysis process.

**Coding for CRP orientation.** When analyzing each teacher’s orientation towards CRP it became evident that there needed to be a distinction made among the three tenets of CRP. Previous literature often describes instructors, curriculum, and teaching as either in alignment with CRP or not in alignment with CRP; however, the coding process revealed a unique perspective that illustrates teachers can indeed practice CRP in part and to varying degrees. As a result, I created a system that categorizes each participant as having high, moderate, or low orientation towards CRP. Table 3 provides each category and its description as related to the findings of the present study.

Table 3

*Orientation Towards Culturally Responsive Teaching*

Category	Orientation level	Description
Academic Achievement	High	Most high school biology students can be successful when learning about the social construction of race
	Moderate	Some high school biology students can be successful when learning about the social construction of race

	Low	High school biology students <i>cannot</i> be successful when learning about the social construction of race
Cultural Competency	High	Utilizes students' culture as a context for learning biology
	Moderate	Sometimes utilizes students' culture as a context for learning biology
	Low	Does not utilize students' culture as a context for learning biology
Sociopolitical Consciousness	High	Uses biology instruction to develop students' critical consciousness
	Moderate	Sometimes uses biology instruction to develop students' critical consciousness
	Low	Does not use biology instruction to develop students' critical consciousness

**Cross-case analysis of CRP orientation.** The primary method of data analysis for this investigation was conducted via within-case analysis. To better understand findings related to teacher positionality within CRP, an additional comparative or cross-case analysis was conducted using the findings related to teacher positionality. A cross-case analysis can provide generalizations across teachers within this study (Merriam & Tisdell, 2016)), thus providing a broader context in responding to the research questions.

### **Role of Researcher**

**Researcher reflexivity.** In qualitative investigations the researcher is the primary instrument in the interpretation of data gathered during a study (Creswell et al., 2011; Merriam & Tisdell, 2016). As the primary investigator, I was responsible for all the data collection and analysis. Because of my role as a qualitative researcher, to find meaning from the experience of others, the onus lay on me to disclose any personal biases that I may harbor. The process of sharing personal connections, experiences, or bias that intersect between me and the focus of the research is referred to as the *researcher's position* or *reflexivity of the researcher* (Merriam &

Tisdell, 2016). Providing researcher reflexivity is a powerful way to increase the reliability or credibility of qualitative research (Merriam & Tisdell, 2016). To address my reflexivity or positionality within the context of this study I will narrate my personal story as it pertains to the nature of this research, explain steps taken to reduce personal bias, and share my methodological worldview.

**Personal narrative.** As a Black female of West African descent, I have had to handle, overcome, and navigate through racial stereotypes experienced in both my formal schooling and social settings. The assumptions that race or skin color can be a determining factor in one's intellectual potential or behavior are not scientifically accurate, yet I know firsthand that this way of thinking can be very common. I can recall during my secondary school experience in a public school in Southeast Texas during the mid-1990s, parents gathered at the local middle school to express their opposition to students from a "Black" neighborhood having been assigned to the same school as their children. Their qualms were that children from my neighborhood would be behaviorally and academically problematic. My childhood neighborhood was predominantly Black as a result of a social phenomenon referred to as *white flight*. *White flight* refers to the outmigration of White residents in response to an increase in residents from minoritized racial groups (Crowder & South, 2008). Among many contributing factors, this type of change in the demographics of a community can be attributed to race-related stereotypes and misconceptions.

The parents' protest was not successful and in the fall students from my neighborhood matriculated to the middle school despite opposition from members in the community. It was during this school year that I learned through many direct and indirect encounters that there were strongly held beliefs that people of certain races were perceived to be unintelligent and prone to misbehavior.

Later, as a secondary science teacher, I observed from the perspective of an educator that students of color, like myself, were recipients of these unspoken, but very real, messages that behavior and academic achievement could be linked to race. Extensive research has been conducted that explains the racial disparities in academic success among school age children in science is not a result of a predisposition of some racial groups to excel compared to others (Hammond, 2015; Ladson-Billings, 2014). Factors such as inequitable distribution of resources, systemic racism (Wright & Counsell, 2018), and lack of culturally responsive teaching (Hammond, 2015; Ladson-Billings, 2014) have all been shown to contribute to the disparities in academic preferences among minoritized racial groups. In my reflexivity as a researcher I disclose my personal story to acknowledge that it has led me to focus my research on addressing misconceptions about race in an effort to support scientifically accurate understandings of human diversity.

**Reducing bias.** Being aware of personal biases increase the likelihood of objectivity as it increases one's self-awareness (Goleman, 1995), an important attribute needed to take a neutral stance within the scope of qualitative research (Creswell et al., 2011). During this investigation a host of steps were taken to reduce researcher bias during the gathering and interpretation of data. Initial steps were taken during the design of the lesson to ensure that the content of the lesson was well balanced and free from persuasive unscientific information. Content added to the lesson was retrieved from research-based findings on modern genetics from researchers in the areas of anthropology (Jablonski & Chaplin, 2000), education (Donovan, 2016b; Hubbard, 2017b), and genetics (Dar-Nimrod & Heine, 2011). The use of an outside reviewer, a pilot study, and member checking was conducted to provide external critiques of the intervention lesson and interpretation of interviews.

Additionally, during interview process I did not disclose or share my personal beliefs or views with participants. I avoided the use of leading questions and framed all questions as open-ended which allowed respondents to determine the way in which they saw best fit to answer questions. I also used Merriam and Tisdell's (2016) systematic process of coding, consisting of multiple iterations and extensive reviews of the data before final interpretations were made. During this process I allowed the findings to naturally emerge and remained neutral in my interpretation of the findings.

**Methodological worldview.** I believe that both qualitative and quantitative data collection are valid approaches to respond to research questions. I believe the research question should be the prime driver of how an investigation is designed—in this way, I take a pragmatic approach to research. There are research questions that are best answered using a mixed or mono-method approach, and so the best route should be determine by the research questions and accessibility to needed resources to conduct the study. The nature of social research involves explaining human phenomena. Therefore, I believe that in this study, an explanation of teacher experiences, lends itself more readily to qualitative investigation.

Teacher experiences are not confined to the first and last day of class but are rather the totality of their life experiences from childhood to the present day. The understanding that life experiences play a vital role in how teachers learn and thus shapes how they teach is founded in Dewey's (1916, 1938) theory on experiential learning. Experiential learning considers the ongoing and continuous process of constructing and reconstructing knowledge based on life experience (Craig et al., 2018; Connelly & Clandinin, 2005). Taking this into account, qualitative inquiries embrace the continuous process of learning and how the understanding of this ongoing process is necessary for adequate analysis of teachers' experiences. Teachers

cannot separate who they are from their instruction, even in a concrete subject like science, so this investigation acknowledges these experiences as a meaningful part of understanding teachers as individuals and their role as facilitators of instruction.

### **Summary**

This chapter contains an outline of the methodological strategies used to answer the research questions of the present study. Recruitment methods, participants, and details of research procedure were delineated within this chapter. This chapter also contains an explanation of the methods of data collection and analysis. Finally, processes used to measure outcomes of the study were discussed. To increase the validity and reliability of the study the researcher explained the role of expert panel and positionality of the researcher was addressed to reduced issues of bias.

## **Chapter IV**

### **Results**

When analyzing teacher positionality in delivering a culturally responsive lesson on race and human diversity, three major categories emerged. Each category was in alignment with the three tenets of culturally responsive teaching, which are the teachers' views on student academic achievement, the teachers' cultural competency, and the teachers' ability to support the development of students' sociopolitical consciousness. When reviewing the data each teacher expressed varying levels of the tenets of CPR, therefore to distinguish between each teacher's level a hierarchical ranking system was developed to assign a high, moderate, or low ranking to each of the CRP tenants (see Table 4). Coding for each category was mutually exclusive, meaning a teacher could rank high in academic achievement, but low or moderate on cultural competence.

## Theme 1: Teacher positionality to tenets CRP

### Mr. Santori

**Orientation towards academic achievement.** Analysis from Mr. Santori's interviews showed that he has a high orientation towards students' academic achievement when giving instruction on race and human diversity in the biology classroom. Mr. Santori stated that he did believe that high school biology is an appropriate setting for students to learn about ways that science intersects with society.

When I first read the lesson plan, I was really excited to participate. I am always looking for ways to bring culturally responsive lessons to my students. I think race is the elephant in the room that we need to address, but don't. But I liked how we were still able to discuss it but still stay on topic, we were still going over Mendelian and non-Mendelian genetics too.

When asked if Mr. Santori thought certain groups of students would be more successful in the lesson, he stated that he thought all students could benefit from the lesson. He believes all students receive messages about race and therefore all students could benefit from instruction to address misconceptions about the construct of race.

The way the lesson is written, there is no reaching, it's right there for students to read and make sense of it in a way that's real and works with their everyday lives. The kids [students] get messages about race all the time, but they don't get the science behind it that they need that that's why I felt like it was important to teach this in my genetics unit.

Although, Mr. Santori has a high orientation towards all students' academic achievement, he believes that his identity as a Latino teacher plays a more significant role with students who share a similar background as his:

When you look inside our DNA is big time similar, but we experience the world in different ways. I can relate a lot to my kids [students] from Latin America cause that's where I'm from. So, I know some of the unique challenges that the community faces, very real challenges, you know. And I'm familiar with the stereotypes that students might encounter, so I'm taking this opportunity to tell them, tell all my kids [students] like your race that color stuff is not a limitation. It really isn't, we're all capable of getting it. You know you can succeed too; I'm bringing home to them so they can be like yeah definitely I can succeed too.

**Orientation towards cultural competence.** Data analysis of Mr. Santori's interviews showed that he has a high orientation towards cultural competence because he incorporates the use of his lived experiences and elicits the lived experience and culture of his students as a part of the learning process:

I have brought everything with me into the lesson, everything I have gone through, experienced, and read...I tried to synthesize it and package it in a way that it could be meaningful so that no matter who is in my room they will be able to get something from the lesson. For example, I retold a story from my past—it was a highly racialized negative experience, you know. And I could see my minority kids [students] getting excited, but, just before they brought out the picket signs [he jokes] I reminded them that every successful movement that we've had, you know as a country that's brought about change has included White, Black, Brown, all the colors of the rainbow. Then I could see them kinda sit back. So, I hope they realized that it's gotta be more of a team effort to deal with these social issues like racism and stuff. Now, they might not remember

everything I said, but they can draw back on that emotion and I know that's going to make an impact.

Mr. Santori is also aware of some the unique challenges that his students face at his school, as he reported having observed racial tension between students at his school. In his interviews he views his role as a science teacher is to support students in dealing with social issues in a positive way. He is not sure about the long-term impacts of the lesson, but he does hope that it creates a lasting impression in how his current students view and handle racial issues.

Being in a racially-diverse school I think they need to hear this 'cause these are issues we are dealing with, like the other day two girls were walking in the hallway and one student bumped into each other then the next thing I hear is, "Uh the White people don't know how to say excuse me." Now, I didn't teach the girl this year, but she was my student in the past, so I really didn't have an opportunity to have this kind of instruction with her. But, even with these students we won't know for sure how this all plays out two, three years down the line—the verdict is still out but my hope is that we are getting through to the kids.

Mr. Santori attributed to his high orientation towards cultural competence to his experiences as a child of two immigrant parents growing up in a home with limited resources. He shared that he and his family were mistreated by others because of stereotypes about Latinos. These experiences, he says, are what allowed him to be one of the first members of his family to attend college. His teaching practices are highly informed through his life experiences and his training in CRP.

I grew up in a poorer neighborhood with people of color and I noticed that we were treated differently based on our race, it taught me that normal is very different for

different people. For me all I know is a racialized America, I remember seeing how my parents were treated when I was younger and that stuck with me. Even throughout my life many of my experiences I have experienced through the lens of a racialized society, so I bring my experiences with me in the classroom, [I] think it's important that students realized the different realities that exist among various groups, there are so many different American experiences and the more of them they are aware of the more socially conscious they will be.

**Orientation towards sociopolitical consciousness.** In line with the first two tenets of CPR, Mr. Santori also has a high orientation towards the development of students' sociopolitical consciousness. Mr. Santori stated, "I do my best to point out the inequalities that exist and I challenge my students, what they do with that is up to them." Mr. Santori believed that what students are learning in his class can lead to future political and economic decisions, as can be seen in the following statement:

Ninth graders should definitely be exposed to this type of instruction before they are out making economic and political decisions that are affecting society as adults. These conversations allow them to pull from different experiences in different groups in America, not just the experience in their home...as students move in to adulthood they should have a wealth of experiences that represent the many different American experiences so they can use it going forward to take with them.

Mr. Santori's overall positionality as a culturally responsive teacher when delivering a culturally responsive lesson on race and human diversity is a high orientation in student academic achievement, a high orientation in culturally competencies, and a high orientation towards the development of students' sociopolitical consciousness.

**Ms. Patterson.**

**Orientation towards academic achievement.** The analysis of Ms. Patterson's interviews showed that she has a moderate orientation towards students' academic achievement when giving instruction on race and human diversity in the biology classroom. Ms. Patterson did express that high school biology is an appropriate setting for students to learn about ways that science intersects with society, "We've talked about social issues before. So, in terms of what the lesson was about, I don't think that my kids were surprised coming from me." However, she does feel that some students might not be as successful as others in processing information in the lesson as a result of ideologies expressed in their family structure and/or personal biases as it relates to race and human genetics. Ms. Patterson stated that she had a few students who have previously expressed strong beliefs in racial stereotypes. She recalled an example of students who expressed belief in racial stereotypes:

For example there is this one kid named Erickson (pseudonym), he likes to cause trouble, once he yelled in class out of nowhere "White power!" or he once drew a rainbow flag on a poster and put a big "X" over it to see how I would react.

Although his behavior had been reported to school administrators, she did not believe enough efforts were being done to address his behavior. When asked how this student responded to the lesson, she was not able to make enough observations, due to a school suspension for behavior problems and several absences.

Ms. Patterson's moderate orientation towards academic achievement was also attributed to her belief that some of her White students would be less receptive to her instruction during the intervention. She believed that they would assume her instruction was based on a personal agenda and not academic content.

I feel like it's easier for some them [White students] to dismiss me as like another one of those socially-concerned Black people or something like that. And if they were to talk to their parents about the lesson, I feel like, again, it would be easy to dismiss me as someone who's trying to be woke [social conscious] or something along those lines and not as like, a science teacher presenting accurate and true scientific information.

Ms. Patterson also noted that her minoritized students felt more comfortable engaging in dialogue during class discussions. Although her rating was a moderate overall for academic achievement, she did express belief that most students could benefit from the lesson if they were open-minded, but she felt it would be particularly beneficial to her non-White or minoritized students.

It [was] beneficial especially towards my minority kids or any of the kids who have a positive worldview of those types of things. Because I think that them [Black students] seeing somebody who looks like them or who has shared experiences with them, who's open and willing to talk about these things. I think could be really powerful for them.

Although Ms. Patterson believed that some of her non-Black students might struggle with the lesson, she expressed strong beliefs that all students at an early age should be presented with scientific facts on the social construction of race.

I care a lot about the actual content of biology, and I think it's important that kids know about issues that face them today. Like, the genetics of people and how that fits in society and how we might discriminate or not discriminate on people based on things that are social constructs. So, if at a young age you take that away, then hopefully some balance can be achieved. It is one of the biggest determining factors of where you end up, but, at the same time, there's no scientific basis for it.

**Orientation towards cultural competence.** Analysis of the data showed that Ms. Patterson has a high orientation towards culture competencies. She was aware that her students all brought different strengths and challenges to the table and as a part of her teaching philosophy she worked to make her classroom a space where students felt accepted. She attributed this practice to previous training she received both in the work setting as well as during her preservice teacher training.

When I was being trained at a day camp, a long time ago my trainer said, “I don’t care if the child stinks. I don’t care what their hair looks like. I don’t care. I don’t care. I don’t care. When somebody walks in here, you’ve got to leave whatever it is that you have going on at the door because you don’t know what they went through before they came in.” You don’t know how they got here or anything. And so even if there are things that you can look at them and you think that you know, you need to get to know them first and that’s the priority. And that’s the philosophy I try to live by as a teacher.



*Figure 4.* Screenshot of the “Sorting People” online interactive activity from PBS’ *Race: The Power of Illusion* documentary series website. Adapted from “Sorting People: Can You Tell Someone’s Race by Looking at Them?” by J. Cheng and I. Shim, 2003. Copyright 2003 by California Newsreel.

Ms. Patterson did not shy away from her personal experiences, but instead she used it as a teachable moment. During the engage activity students completed an online interactive simulation created by Public Broadcasting Service (PBS), an American distributor of educational media, and the goal was to guess people's race based on appearance alone (see Figure 4). As students completed the activity, she observed students verbalizing stereotypes about the characters in the activity. Having a high orientation in cultural competence, she used her personal experiences with race as an opportunity to address what she felt were unkind generalizations.

I had have that conversation with them because when they were doing the PBS activity, they [students] were so insensitive. They were having fun, but when the race of the characters in the interactive was released some students said, "What? There's no way." So, that's when I explained to them what it was like to be told that you are something that you're not, or to just be put in a box that you don't agree with, It's really difficult. And especially when decisions are made on your behalf that have nothing to do with you. And so, then they saw it and were able to modify their behavior.

Ms. Patterson shared with her students her experience being a Black Muslim girl going to school in Pakistan. She shared that although both of her parents were American she dealt with lots of questions based on stereotypes, such as her peers in Pakistan not believing she was American because she was Black and not White. She used her personal experience to discuss how assumptions people make based on race can be inaccurate:

And the reason that I got treated badly by some of the kids over there was because of so many factors that had nothing to do with who I actually was as a person. It was because "How is it possible that you're American but you're Black? All of the Americans I see on

television are White.” So first of all, not possible. Second of all, “You don’t speak our language and it’s not possible for you to be Muslim because you’re from America. And all Americans I see are not Muslim.” So it didn’t work for them. They couldn’t reason through that.

She also shared with her students that when she left Pakistan and moved to America, she also experienced inaccurate assumptions by other American because of her race. She described the stereotypes she encountered based on assumptions people made about her because of her assigned race and her religion.

So then coming back to America, I realized that it’s not really advantageous to be Black in America either, and to be Muslim in America, or to be a woman in America, let alone all three was a lot for me. And then to constantly be told, no, this is what you are, was hard. I get misidentified all the time because of my hijab, people assume that means that I am not American. I explain that I’m African American and they’re like, “But where in Africa are you from?” And I’m like, I don’t know, because my ancestors were slaves. So, I told my kids about this too. I wanted my students to let people tell you who they are. Because race has no scientific backing and it should not be used to make certain decisions about people. I think that you always lose a little bit of knowing anyone when you make assumptions about them first.

Ms. Patterson explained, “I told them like, this is a safe space [the classroom], where you can ask questions and be curious, I wanted them to learn that interaction can be better off if we can avoid coming into things, assuming things about people because of the way they look.” Ms. Patterson expounded, “You should let people tell you who they are.” She told her students that inquiry and

questioning were a part of the lesson. However, telling people who you think they are based on can be inaccurate.

**Orientation towards sociopolitical consciousness.** Ms. Patterson received a rating of high orientation towards sociopolitical consciousness. Ms. Patterson encouraged students to consider how they can use what they are learning in the classroom to bring about societal changes. “They [students] know that we’re comfortable challenging societal patterns from previous lesson,” she stated. Ms. Patterson has a strong orientation towards development of students’ sociopolitical consciousness, as she encouraged her students to ask tough questions and relates issues that impact students’ lives on a local to global scale. She used opportunities within the intervention to explain to students that stereotypes and biases can be roadblocks in achieving a more tolerant society.

And I think that will allow students to be a little bit more understanding towards one another. And then if we can do that, then I think actionable change can happen because then those conversations can be open. And I do think that the key to that is the conversation because it’s hard to have conversations with people who already have assumptions.

Ms. Patterson’s overall positionality as a culturally responsive teacher when delivering a culturally responsive lesson on race and human diversity is a moderate orientation in student academic achievements, a high orientation in cultural competencies, and a high orientation towards the development of students’ sociopolitical consciousness.

**Mrs. Lee.**

**Orientation towards academic achievement.** Analysis of the data gathered from Mrs. Lee showed that she has a low orientation towards students' success when teaching about race and human diversity within high school biology class. Mrs. Lee believed that high school freshmen were not mature enough to discuss the concept of race and human genetics. She stated, "To me, they're still children, they're like hitting puberty." However, Mrs. Lee expressed that students could engage in a lesson on race and human genetics later in their high school career.

I believe it should be taught, but I really think it should be at a higher level, maybe at the 12th grade level because a lot of these kids [students] who come in, they're still very immature. They don't have that right mindset. But I think if you get to the higher-level biology where they have more experience understanding like the proteins and melanin and all of that biological processes that gives us these different features, it would be more appropriate for them. It'll also get them ready for college and being out there in the real world. How do people see them for what and who they are?

Mrs. Lee believed that freshmen did not have enough life experiences to learn about the topic of race and human diversity. She expressed that because many of her students did not have jobs, they had not encountered social issues, particularly those related to race.

But the seniors that I talked to, they have their own experience cause some of them have jobs, they interact with people, they have family members that had been probably mistreated. So, when we talk about things like that, it can be an eye-opener for them.

Mrs. Lee also expressed that she thought students' SES level would affect their academic success when learning about race and human diversity. She believed that high SES students who had privileged upbringings may have been sheltered and might not be able to relate to the lesson content.

Some of them come from backgrounds where they're more privileged than others or economically different from everyone. So, their mindset is not there. They have not had their own experience to be able to talk about these different things because again, they're still under the umbrella of their parents and what they've been taught at home.

Although, Mrs. Lee did not feel strongly that the topic was appropriate for students at the ninth grade level, she did feel that it was a topic that should be discussed because of the societal implications related to race and human genetics. She elaborated, "It definitely aligns with this generation of kids and I really think it needs to be taught because our society is rapidly changing. These kids [students] are extremely sensitive and this a sensitive issue, but they need to be educated."

**Orientation towards cultural competence.** Mrs. Lee received a low ranking in cultural competencies. She did not express a strong orientation in utilizing students' culture and way of knowing as a part of regular classroom instruction. Mrs. Lee believed that she should be very aware of students' diverse racial and economic backgrounds, but as more of a precaution with the goal of not offending anyone.

My students' parents come from different places, different religions, different types of background and money. And we have to be very careful how we talk and respond and present ourselves in class because we don't know who's in that room.... We forget that this school is not just zoned to these kids in this area. We get kids from everywhere and we need to be very mindful of who we're teaching and if we present ourselves and being mindful of that, the kids would be more receptive and engaging in class.

Unlike other teachers in the study, Mrs. Lee also felt that her minoritized students would not be comfortable having a discussion about race and human diversity in classrooms if there

were not an equal number or majority of other students in the class that shared their same background. When asked if she had any concerns about teaching the lesson she explained:

Well, it was a big concern at first because the diversity in my classes are not equally spread out. And I had one class in mind where the number of minorities was far less than any other of my classes. So, I kind of felt like this is going to be a very uncomfortable experience for them [minoritized students].

Mrs. Lee concern for her students may have been a result of her previous experiences with her own racial identity. Mrs. Lee shared that she experienced complex issues with race as a child having one Asian parent and one parent Black parent. Her personal experiences with her own racial identity were a source of stress as she did not believe she was fully accepted in one group or the other. Her personal issues with her own racial identity resurfaced, creating apprehension for her as she provided instruction to her students.

So, the thing is from my personal experience, being at school, it was always a sensitive thing because I didn't know where I belonged because I grew up in the Northern U.S. I was probably one of the very few minorities in the classroom and one of the very few mixed kids in a classroom. I was never accepted by the Asians, the Blacks or whatever because I didn't belong, and I want to talk to the kids about it. So, because of these labels and race, it kind of makes people feel like they don't belong in a certain group because they're not enough this or not enough of that. And so, with my personal experience, I really felt like teaching this lesson caused me a little anxiety because it reminded me of my past being in school and stuff.

**Orientation towards sociopolitical consciousness.** Mrs. Lee received a low ranking as she did not strongly support students' use of academic content to create societal changes. She

instead expressed that education about racial stereotypes can be beneficial but cautioned against speaking up, particularly for minoritized groups. She believed it could result unwanted conflicts with the judicial system or law enforcement officers.

For me with CRP, I feel there is a line. I have worked in an all-White company and although I am half Asian I am seen as a Black woman. For me I teach my students to react to social differences, it's a difference between keeping your job or walking out in silver bracelets. There are a lot of things that will be said, but you have to learn not to react and ignore ignorant comments. In certain situations, it's okay to speak up, but you got be smart 'cause it could cost you your job in the future.

Mrs. Lee shared that past conflicts that her students perceived as racist were not often related to stereotypes or biases, and often a result of individual people's actions, as opposed to larger systemic issues.

Sometimes my students will come back and they go, "Oh look at what happened," "In the news they did this," or "The cops treat people unfairly." But then I ask some other questions like, "What did the person do to put themselves that situation?" And I also tell them there's such thing as being at the wrong place at the wrong time.

Mrs. Lee also shared that on previous occasions when students have expressed that they believed they have experienced racial biases from a teacher, she often finds they do not understand how racial biases work. Mrs. Lee explains that if the teacher or individual did not make a generalized statement then that is not enough evidence for students to use the "race card." She explains, "If they did not say anything about all Black people, they are not racist. If the teacher made a comment to you then it was about you. Students always want to say someone is being racist because the card everyone plays."

Mrs. Lee received a low rating across the board for all three tenets of CRP. Mrs. Lee has also never received any training in the use of CRP in the classroom, but she believed it could be helpful to her and other colleagues, “I do wish we would have some type of training on CRP, because a few things other teachers have done have caught my eye as not very culturally responsive, and I think training would help.” Mrs. Lee also shared that she has little experience using CRP in her instruction, “this lesson was the first time I’ve done anything culturally relevant ‘cause I wanted to stay away from that ‘cause, you know, it’s a sensitive subject. But I took a risk, because I really like how you organized the information it was focusing on science and very straight forward.”

**Ms. Sanchez.**

**Orientation towards academic achievement.** The analysis of Ms. Sanchez’s interviews showed that she has a high orientation towards students’ academic achievement when delivering a culturally responsive lesson on race and human diversity. Ms. Sanchez believed her role as a teacher is to develop student’s ability to be independent thinkers. She did not distinguish between different type of learners as she described her goals as an instructor. In her interviews she expressed a general belief that her students would benefit from instruction she delivered during the study.

Yes, I definitely think this is a good topic for high school biology lesson. It is biology, it is science too. This topic happens in real life and that is why biology is important in the real world. For me, my job as a biology teacher is to get my students to think critically and see how science applies to their lives. I feel like this lesson was able to do that for the kids [student].

When Ms. Sanchez she observed her students' thinking process, she noticed they did not readily make the connection between the concept of race, human diversity, and science. She commented after the initial engage activity, "A lot of students were like, 'We are talking about race in a science class, shouldn't we talk about this in AP Human Geo or something like that?' But as we got into it, they saw we were talking about genetics and that was able to help them bridge the real world and science." Ms. Sanchez focused her instruction on supporting students throughout the process of learning science by supporting their ability to think and analyze data in scientific ways. She made room for uncertainties and ambiguity, which helped develop student scientific reasoning. Her ability to allow students to take the lead in their learning process is in line with a high teaching orientation in regard to student achievement.

When we look at the Punnett squares students realized that race was not just one gene.

So, I could see them going back and forth trying to figure it out. That is what science is supposed to do, help students think critically and go back to the drawing board to revisit new ideas and using evidence to think through problems to either come up with a conclusion or even sometimes still not have an exact conclusion or one right answer.

**Orientation towards cultural competence.** When asked about her prior experience with delivering culturally responsive instruction, Ms. Sanchez, stated that she was comfortable using CRP in her instruction because she was exposed to CRP in her preservice teacher program. She expressed that she believes her teaching philosophy is closely aligned to the tenets of CRP.

Before teaching the lesson I did wonder how my students would respond, but I have used culturally responsive teaching back when I was in school, during student teaching I was able to see a lot of CRP being used to teach science, so that experience really helped me prepare for this lesson. I mean, I have done stuff with CRP before, I try to make sure

what I am teaching is relevant to my kids [students], but this topic can be controversial to some, so I wanted my students to get the science out of it and see how it relates to their real lives.

Ms. Sanchez also shared that she uses her own culture to support students' learning. She shared with her students her experience as a young girl moving to the U.S. and having to learn English. She expressed that she uses her story to relate to her students. She believes that her experiences made her more relatable to students who share her same cultural background.

My students know that I came to the U.S. when I was very little. I didn't learn English until I was like in the third grade, so sometimes when I say things in class my accent comes out. I told them my story and I think it helps so they can relate, you know. I am very open with them sharing things about me in class. I definitely feel like it helps me relate with them more. I feel like it makes a difference especially with my minority students 'cause some of them have the same experiences as me.

Ms. Sanchez was identified as having a high orientation toward cultural competencies due to her preservice teacher experience in combination with her acceptance and use of various cultures in the classroom.

**Orientation towards sociopolitical consciousness.** Ms. Sanchez has a high orientation towards sociopolitical consciousness development. Ms. Sanchez attended a high school with a large population of minoritized students. As an adult, she later realized that there were differences in schools based on racial demographics. She believes the difference contributed to opportunity gaps that exist between non-minoritized and minoritized student groups. She has used her role as a teacher to inform students of these gaps and has encouraged them to seek ways to be bring about change.

As a student, I was aware of racial issues but in a very subtle way, as I got older it became more apparent to me how race can be a determining factor in education. As a kid I knew there were kids in better schools or neighborhood, but the level of disparities that exist was something that I was not aware of especially until I went back in the classroom to do my student teaching. I learned that my experience had been very different. So, I really want my students to be aware that there are differences that exist, and those differences make an impact on their future. I don't want them to find out too late like I did.

One example of how Ms. Sanchez supports her students' sociopolitical consciousness occurred during the lesson. Students read a short article about pseudoscience called, craniometry. Craniometry proposed that skull size was related to intelligence. Researchers in the early 1800s used biased data collection methods to rank human intelligence by skull size and results from these studies were used to advance racist agendas. Ms. Sanchez used this an opportunity to share with students the relevance of ethical practices in science, "When we read about Morton, students were able to see scientific bias and have a conversation about how scientists should be honest in the way they report things. A lot of the students were able to see that Morton was intentionally biased."

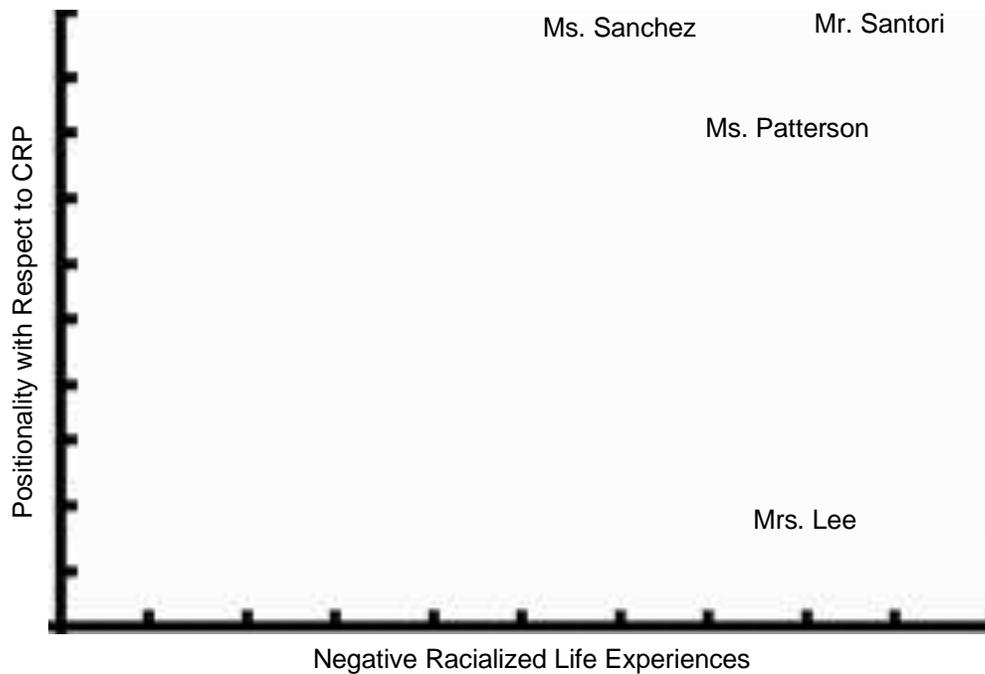
Ms. Sanchez's overall positionality as a culturally responsive teacher when delivering a culturally responsive lesson on race and human diversity is a high orientation in student academic achievement, a high orientation in culturally competencies, and a high orientation towards the development of students' sociopolitical consciousness.

### Theme 1: Teacher Positionality to CPR Tenets

Table 4

#### *Teacher Positionality to CRP Tenets*

Participants	CRP tenets		
	Academic achievement	Cultural competence	Sociopolitical consciousness
Mr. Santori	High	High	High
Ms. Patterson	Moderate	High	High
Ms. Sanchez	High	High	High
Mrs. Lee	Low	Low	Low



*Figure 5.* Scatter plot graph displaying the relationship between teachers' CRP positionality and negative racialized experiences.

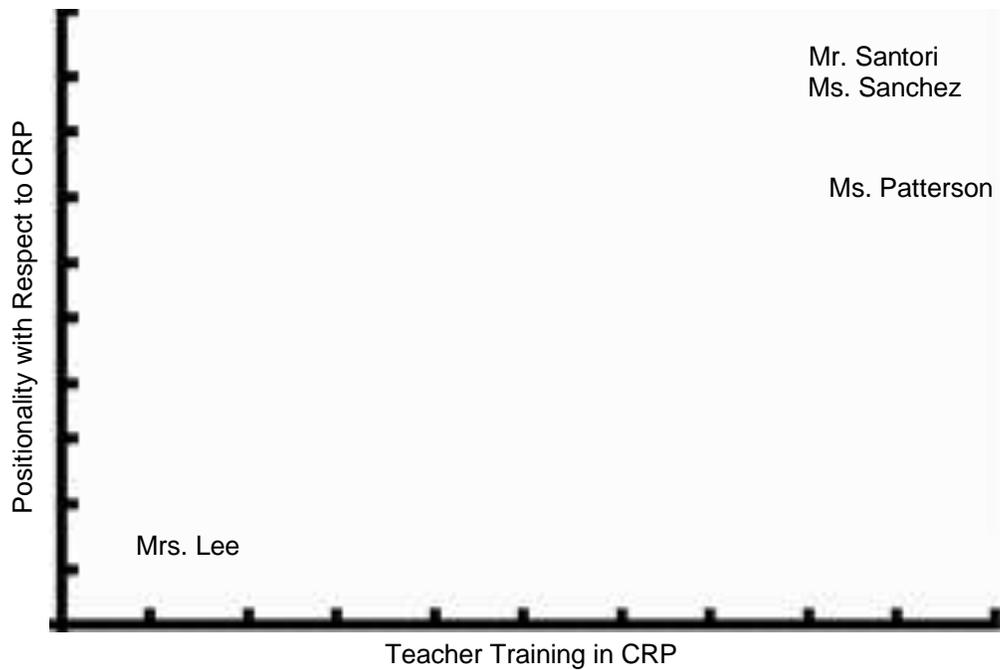


Figure 6. Scatter plot graph displaying the relationship between teachers' CRP positionality and amount of CRP training received.

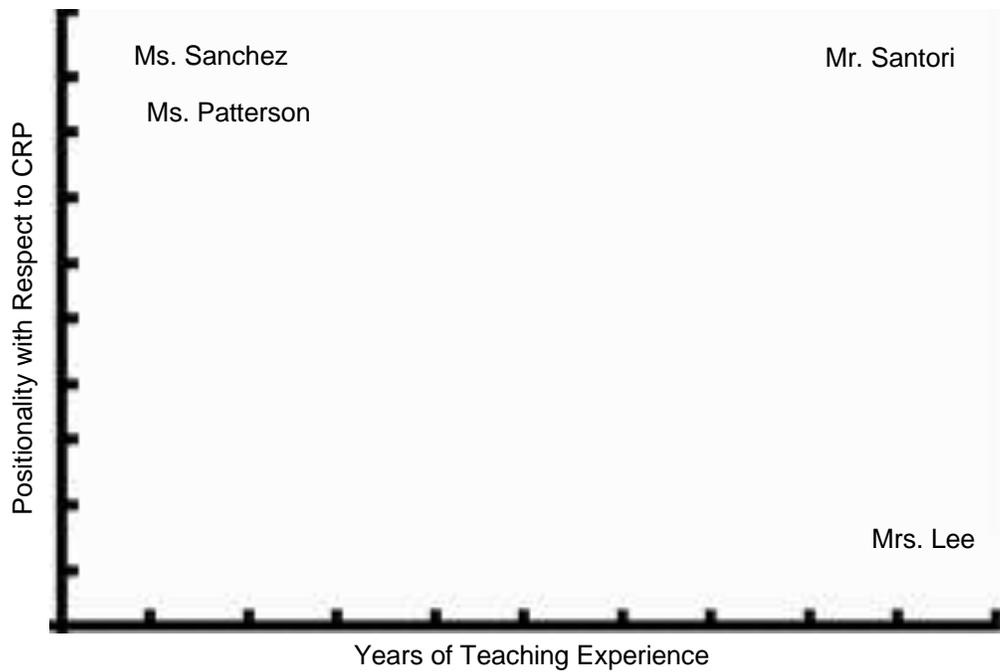


Figure 7. Scatter plot graph displaying the relationship between teachers' CRP positionality and years in the classroom.

## **Theme 2: Observed shifts in student thinking**

When analyzing teachers' perception of student understanding and scientific argumentation skill development during instruction of a genetics lesson on race and human diversity, two major themes emerged: (a) shifts in students thinking; and (b) instructional strategies used. In the next section we will discuss findings from each theme starting first with shifts in student thinking.

### **Mr. Santori**

Mr. Santori's initial observation was that his students subscribed to many racial stereotypes and strongly believed that people acted and behaved in certain ways because of their race. He observed an initial shift in students' ideologies about race when student completed the interactive activity by PBS (see Figure 4). After completing the PBS activity, he observed students raising interesting questions about what it means to classify by race. Students were also very surprised at how unsuccessfully they determined racial identity by appearance alone. He recalled, "When the students completed the PBS activity and they had to like try to match the races, the shock on their faces was interesting. They were so surprised they could not get it right; I think that was when they started raise some interesting questions."

As students began to engage in the lesson and small group discussions, Mr. Santori recollected one student pulling him to the side to ask a question privately after the students completed the PBS activity. The student was unsure what the difference was between making observations and passing judgment. Mr. Santori was able to explain to his student that making observations is part of being an effective scientist, but when people use observations to create stereotypes and biases then this thinking becomes unscientific.

I had one little girl say to me, “Mr. Santori, I feel racist.” I asked her why, she explained that when you classify people by the color of their skin isn’t that racist. I explain to her that we are just making observations about people using phenotypes, but when you start passing judgment about people and suppress people, that’s racist. So, she was like, “Okay, okay, good.” Now, that was an interesting conversation to have, but I think science is [the] best place to teach students it’s okay to be curious, just not to pass judgment based on skin color.

Mr. Santori also commented that using a framework such as CER provided students at all levels with a much-needed resource to structure their arguments and gain confidence to participate in scientific discourse with their peers. He noted that students were less intimidated because they were not being graded on having one singular answer that was either correct or incorrect. Students were given an opportunity to express their authentic ideas as long as they provided a rationale for their argument.

I have a diverse population of kids, a lot of them have not passed the science exam-like ever—it’s documented I can go back in their files and see it. So, they’re really intimidated when it comes to science, but I feel like the CER framework gave them something to use to start with you know, like I got one kid that sits in the back of the class and he kind [of] gives me this, “I don’t know man, I can’t do this stuff” attitude. Socially he feels like he’s the man, but academically he wants to shrink and point to other kid and say, “Call on him, his answer is better than mine,” but I was able to walk through one paragraph and just say let’s ignore the science stuff, just try and pick out the claim. And I was like, “Yo, that was a good claim,” so he felt like he could be more successful because it was not multiple choice.

Mr. Santori reported an increase in students' ability to develop stronger arguments after participating in the intervention, "After the lessons and all those CERs, I have noticed students are asking more thoughtful questions. I feel like they are starting think about how evidence works and how opinions work. I can see that in the level of questions I have been getting." When asked why he attributed the increase in students' argumentation to the lesson he explained that there had been previous attempts to develop student reasoning and argumentation skills on a schoolwide level, however he did not find those interventions were successful. He describes a short online course students are required to take at the beginning of the year. The goal of the course was to support students in identifying false claims, particularly in the media. Mr. Santori reported that he was not able to observe any changes in students' ability to identify good pieces of evidence to support their claims after completing the school mandated modules.

The students in the past would complete this online module and the goal was to get them to determine what are credible sources. They did the first few weeks in their homeroom course, they'd eventually have to create a product sharing what they learned and I'll be honest with you it was not that great. But after using CER, I feel like they had a framework to better look for good sources of data, they moved away from saying "I believe" to having to really use evidence to support the claims they were making, so I definitely thought saw that growth as they moved through the lesson

Mr. Santori also commented that students were able to challenge their peers when they made inaccurate statements regarding race. He described an exchange between two of his Black American students where he was able to see his students applying what they had learned:

I had one student who did not do the readings I assigned for the lesson, so when it came to talking about race she was like, “Oh yeah, my mom don’t want me to act Black.”

Then another student spoke up and said, “Hold on, what’s acting Black?”

“Well you know how people act...”

“Where, what’s your evidence for that?”

The student really went in, she wouldn’t allow her to just use her opinions to explain. And you know what’s funny the next day, the young lady [student] who hadn’t read, made sure she was caught up on her readings. My student added, “We’re not talking about your personal experience, if you can find this happening over and over then you have something to go on, but you just talking about your experience that’s not good evidence.”

At the conclusion of the intervention, Mr. Santori believed his students were able to understand scientifically there is only one race of people in many variations of skin color. He concluded the lesson by posing a final CER question, “Do you think it is good or bad to classify by race?” He reminded his students that there was not right or wrong answer as long as they could justify their claims with evidence.

At the conclusions we had our final decision about is it good to classify by race, and I had one of my White students say, yes. My first reaction was [to] wonder how other students would perceive it, but he explained that certain races have had disadvantages and that if we don’t identify them then how can we do something about the way some people are being treated. As teacher, it was hard at times, but I just had to step back and let the kids have those conversations. A lot of other students of all races agreed. So yeah, I had to really fall back and just push them to use evidence to support whatever claims they made.

Mr. Santori reported significant shifts in student's argumentation and understanding of the social construct of race. Having participated in the current study and the pilot study the previous year he did share that he does plan to continue using the lesson in his genetics instruction.

### **Ms. Patterson**

When Ms. Patterson first began the lesson, she observed many students supporting the belief that race is scientifically based. She recalled one student in particular, who expressed views that he believed some racial groups have different physical attributes and often used racial stereotypes during his conversations with his peers, "I think that part of him definitely believes in the differences in race. Like when he says things like 'Black people are faster,' I think he genuinely believes that." Ms. Patterson also noticed that Black students in her class felt noticeably more confident in their ability to identify someone's race based on their appearance. She describes her students' surprise after completing the PBS online interactive (see Figure 4) when they were not able to accurately group people into the correct racial categories. Her highest-class success rate was 30% accuracy in their ability to match individuals' pictures to their correct US census racial category.

I did see that even my Black kids felt really confident in their ability to place people into racial groups, especially the racial group Black. My Black kids thought that they could pick out all the Black people and it didn't always work. And I think they were all surprised when they weren't able to do it as easily.

Ms. Patterson also observed differences in what her higher-level students found to be interesting. She noted that students in her advanced level biology classes were more engaged in discussions about the scientific inaccuracies of U.S. racial categories. As students gathered evidence for

their final claim, she noticed many of them used evidence from the readings explaining there is no one singular gene or trait found in one group of people to justify the racial groupings. She found that they were most intrigued by the lack of scientific evidence to support U.S. racial categories.

Especially my higher-level kids were really interested in the idea that not only does race categorize people messily but it's really not good for any scientific study. It's just not quantifiable and it's just not a good category. And I think that they also found that interesting. Aside from the more social parts of the conversation.

Ms. Patterson reported that the readings and use of the fictional characters supported students as they had discussions about the use of race in society. She explained that it allowed students to share ideas without feeling like they would be attacked:

But I think that the readings helped and the three kids in the story helped, particularly my White kids [students] kind of break down some of those barriers a little bit because it came from a perspective outside of my role and outside of theirs.

Ms. Patterson noted that at the end of the lesson when students were asked to write their final CER explaining if they believed that people should be classified into racial groups, she observed that many students did write statements based on evidence that classifying by race is not scientifically accurate. But students did add that due to social reasons, such as health disparities among certain racial groups, it could provide some societal benefits to group people by race. Ms. Patterson stated, "I think that for a lot of kids, their concept and opinion of race changed in that they realize that it's not actually based on anything factual, it's not based on anything scientific. And I think that they were able to accept that."

When asked if she thought the lesson had any impact outside of the study she remembered in a later unit on body systems students were able to understand that disease clusters among racial groups are often attributed to environmental and social factors rather than factors assigned to race.

When we were looking at something where there was a disparity among the different groups, I want to say it was in human body systems, I remember students being able to vocalize and recognize that the disparities that we were looking at were not because, African-Americans were genetically inferior, but because of socioeconomic status and, issues and concerns related that. More to nurture than to nature. So yes, I think they were able to still carry what we learned into other areas.

Ms. Patterson did notice that a few weeks after the lesson some students still exhibited misconceptions about race. In another lesson on viruses taught after the body systems lesson, she had some of her students share that they believed that some viruses could not infect Black people but were able to infect people of different races. She stated, “Like, I had a few girls at the very, beginning of when Corona virus was making headlines in the United States who came and told me that Black people can’t get Corona.” Ms. Patterson realized that one week of instruction was not enough to fully deconstruct students misconceptions about race, but she did state that the lesson served as a strong foundation for students to understand human genetics and the intersections between perceived ideas about race.

Of course, it’s really hard to point [to] any change in an ideology to just one week of learning in one class in one grade and I definitely understand. But I think that this lesson can definitely cause a spark for a lot of students and at the very least make them

understand that there's no evidence behind these opinions and ideals that we hold about race. That doesn't necessarily mean opinions and ideals are going to go right away.

Although Ms. Patterson did not believe that one lesson made a huge shift in students ideologies about race, she did believe they gained a better understanding of the lack of evidence to support it and the assumptions people make based on race. She hoped that students have become more tolerant as a result of her instruction on race and genetics.

### **Mrs. Lee**

Mrs. Lee reported that students struggled with the activities because they harbored misconceptions about the concept of race. She stated that their maturity level was a huge hurdle in their ability to successfully engage on the initial discussions.

So, for the freshman level, I feel like it was not hard, but again, the maturity wasn't there for them to see the point because they love calling their teachers racist or something like that. But when I kept going back to the question, "What is race?" they could not absorb and just really focus on that particular question because they were so everywhere else.

As students progressed through the various activities, Mrs. Lee reported that her Black students were very confident in their ability to determine someone's race by appearance alone. She also used this misconception as way to let her students know that it is not good to pass judgment on others solely based on appearance.

When they were doing the PBS online interactive their minds were blown because the Black students were like, "Oh, I know Black people" or "I know all the Black people." And when they were doing the card sort, they were so shocked. I'm like, the whole thing is about not judging a book by its cover. I told them when you first met me as your teacher, what did you think? And they were like, "uh we thought you were Black" and

I'm like exactly. You're doing the exact same thing to those people on the screen. You don't know if they're mixed, biracial, multiracial, whatever. So, it's like you have to be careful, and they're like, "Oh, okay, okay."

Mrs. Lee also noticed that students had misconceptions about race because of instruction received in their Human Geography class. She found that students experienced some confusion because the idea of race had been reinforced in their Human Geography course, however in the science lesson they were learning that race is a social construct and not scientifically based. She stated,

And I also noticed that, in AP Human Geo, they define race differently than how we do in biology so there's a disconnect there. So, they talked about race earlier, but when they come to biology we talked more about the biological process. And they're [students] like, "Wait, what?"

Mrs. Lee did report that the CER framework was very supportive during the instruction. She used the CER framework to support student's scientific argumentation skill development as they transition from relying on their opinions to creating evidence-based claims.

And I said, "As a scientist, do we use opinions or facts? Remember we have to collect data. We have to use facts. You need that data to support that claim because you can't just say things out without having something to back it up." So, when they read the papers, they were making notes and putting quotations around things that they saw that was evidence for them to support their claim and to put into their reasoning.

Mrs. Lee did not start out the lesson having expectations that students would use what they learned in class later on in life, "Well, right now, again, they're young so I don't know if

they'll remember anything about what we talked about." Later she did observe students transferring what they learned about argumentation in subsequent science lessons.

So, when we were doing the next unit in natural selection, I didn't even mention CER, but I asked them to write what they know about each animal. Well one student asked should we give you our evidence? I was very excited he asked me that. I did have them do it [CER] and it helped them out a lot on the activity.

### **Ms. Sanchez**

One major observation noted by Ms. Sanchez was the personal connection students were able to make as they engaged in discussions during the lesson, "...the students also had to be vulnerable. They had to be vulnerable with the science to think and write and pull all of those pieces together to get the task done." As the lesson progressed, Ms. Sanchez also observed shifts in the way students developed their claims as they wrote their CER responses. Ms. Sanchez added, "they could not rely on their opinion, they had to look for evidence for their claims I think this made them slow down and have to really think."

Like other teachers in the study Ms. Sanchez's students also believed they had a high level of accuracy when determining an individual's racial classification.

They really liked the PBS activity. Because at first, they thought they would get it all correct then the score popped up and they only had three out of 20. I think that part really shook some of their initial ideas about determining others' race.

She explained that students were also very intrigued by the cover of *National Geographic* that showed two Black parents who had a White baby. The magazine cover created a contradiction in students' previous ideas about race and genetics and served as a starting part for student dialogues.

They also were really interested in the *National Geographic* story with the two parents were the same race and the child was a different race. They even thought the picture was fake. ...and those were the two parts I think that really shocked them and made them think. I could hear some of them questioning themselves as they worked to try to create a definition for the word race.

Ms. Sanchez, similar to other participants, found that the three fictional characters in the lesson played a significant role in supporting student discussion. She recalled how one student was able to get the conversation started by using the character Zeus as a reference for her inquiry:

I remember my one student, she was genuinely curious and ask about it “Yeah, so I don’t get why Zeus doesn’t want to talk about race. I just want to know what makes people feel uncomfortable when it comes to race?” The students were able to explain to each other that it’s okay to talk about controversial topics cause that’s how we get change to happen this is how we become informed. That was really cool. That was really what opened up the conversation for students.

Ms. Sanchez believed that many of her students made shifts in how they think based on their response in the final CER. She also saw students utilizing knowledge from the genetics unit in other lessons. The following anecdote recounts how her students applied their knowledge from the genetics unit to human evolution.

After the lesson we moved on to evolution and students were able to see that being close to the equator, many people have darker skin and they could see skin color as an adaption, like it was natural selection, that made me feel like the lesson was successful.

Ms. Sanchez also added,

I eat lunch with the students and I heard a student in the cafeteria after the lesson say, “Well if you think about it, it’s just a social construct, like race it’s something we made up.” I thought that was really, really cool for kids to start to see and explain things like social constructs at this age.

Overall, Ms. Sanchez did believe that the lesson supported students’ argumentation skill development and created a better understating of how science intersects with society.

There’s a lot of times kids will say, “I am never going to do biology,” “I am never going to use science,” or, ‘That’s not what I want to be when I grow up.’ But the lesson opens up their minds to think maybe I do need to know science to have conversations like this in the real world.

Shifts in students’ thinking and the instructional strategies used by teachers emerged as the two themes when examining data addressing the teachers’ perception of student understanding and scientific argumentation skill development during this genetics intervention lesson. In the next section we will discuss findings from the latter, instructional strategies.

### **Mr. Santori**

**Critical questioning.** When providing instruction on race and human diversity, one instructional strategy Mr. Santori employed was the use of critical questions. Mr. Santori used critical questions to support students’ ability to read with a critical eye when engaging in context related to race and human diversity. Mr. Santori chose this questioning strategy to support students’ ability to gage credibility and underlying messages in resources they are reading. This is evident in the following description:

What’s their angle? Do they have an angle? Why are they saying this? When you ask these questions, you can see different people in society’s motives. I think that was cool,

‘cause they were starting discuss other things they heard, you know like in the news or something and I could hear them asking questions like I wonder if this is real. Which is what we want, you know we want these kids questioning society and not afraid to challenge old ways of thinking.

**Repetition.** Another teaching strategy Mr. Santori used was repetition. Even outside of assigned class discussion, he would have students provide claims for ideas or comments they made. He laughed as he explained:

I really been hammering CER with the students, like even in non-science topics, I had a student ask to go to his locker and I asked him to give me a CER to support why he needed to go to his locker.

Repetition is a common teaching strategy that he uses to support students’ learning.

**Eliciting emotions.** Mr. Santori often provided several examples of how he would elicit students’ emotions to create deeper connection between science content and student learning, “I can see their faces and how this is really hitting them in their personal lives, they are really having to think about what’s going on in the world and how is that supported by science.” In another example he described how he appreciated being able to use a cartoon character the students were familiar with in an activity to review genetics topics covered in the study. He related, “They really had fun doing the Sponge Bob genetics, ‘cause you know these kids grew up on Sponge Bob so they were really into that, I feel like that also helped keep them engaged.”

**Cross disciplinary connection.** Mr. Santori made connections between strategies students learn in English with the process of CER. Mr. Santori admitted he was not able to make a cross-disciplinary connection with subjects like math, but he stated that he is working towards that in the future.

What I am working on with the CER is looking to see if we can bring it in to other subjects. 'Cause I see the same thing happening in English, you know they have to justify their claims, but they don't use the same language. But I think it would be really powerful if we could bring that all together, You know if they are hearing the same thing in each class and having to think crucially I think it would be a good thing, but I'm still trying to figure out how that would work in math. But, overall, I really see it being a good way to bring up their scores on the state exams, if they are seeing CER in more than one class.

Mr. Santori utilized four unique teaching strategies when teaching the intervention lesson on race and human genetics—critical questioning, repetition, eliciting emotions and cross disciplinary connection.

### **Ms. Patterson**

**Round robin.** Interview transcripts from Ms. Patterson showed that she incorporated several reading and writing strategies into her instruction. One strategy Ms. Patterson used was a round robin reading strategy. During the round robin reading session, students were placed in cooperative groups consisting of four students per group. Each student in the group was given a different article to read. She would number students from one to four. She then placed all the ones in a group, all of the twos in a group, and so forth until new groups were formed with students who were all assigned the same article. Students would then take turns reading the article aloud and discussing what evidence they found in the articles. Once all students had completed the readings, they returned to their original group to share out the evidence they had gathered. Ms. Patterson encouraged students to take notes as their group members explained

each reading, “I saw them write down other people’s evidence as they presented. This helped so they had a good foundation for when they had to do their final CER.”

**Close readings.** A close reading is a type of guided reading activity that allows teachers to go through a written passage and support students in finding the main idea of each paragraph. Ms. Patterson reported using this strategy during the intervention to address a student with who did not provide strong scientific arguments for their claims.

I went and sat him down one day and I had brought the articles out and I asked him, based on evidence, please show me where this part came from and he couldn’t do it. I do not think he used the readings properly. He just thought about the question and he thought about, “Well, what can I say about this question?” And he wrote about it and then he just made up a page number. So, we did a close reading together of the pages that he pointed out. And we summarized the information that those pages actually contained.

Then I asked whether or not it aligned with what he had written down, which it did not.

When asked why she believed the student was not able to use the readings properly, she explained:

He has a history of saying racialized comments for attention. I believe he did [it] partly because he didn’t feel like doing the work and because that’s the lens that he sees the world through. So, with this student in particular I don’t know if it necessarily got through to him, but I think he knows the truth now.

**Scaffolding CERs.** During the lesson Ms. Patterson developed students’ scientific argumentation by scaffolding her instruction. She had students write several CERs before they wrote their final CER at the conclusion of the lesson. As students read different articles, they wrote what Ms. Patterson referred to as “smaller CERs.” She explained, “My hope was by the

end of the lesson they would have a good starting point because they had all written at least one complete CER then use that evidence to write their final CER.” Ms. Patterson stated, “As their CER started to build I noticed their arguments got better.” She noted that most students were growing in their ability to use scientific data to support their claims.

**Alternate modes of assessment.** Ms. Patterson provided alternate means for students to complete assignments based on their academic level. Ms. Patterson clarified, “Because my special education kids sometimes struggle with reading if they didn’t have their CER complete because they were struggling I would have them say something interesting about the article, just one thing they remembered.”

Ms. Patterson used four unique teaching strategies—round robin, close readings, scaffolding CERs, and alternate modes of assessment when teaching the intervention lesson on race and human diversity.

### **Mrs. Lee**

**Re-writing.** One teaching strategy Mrs. Lee used was having her students rewrite important information to guide them in staying on topic. She stated, “You cannot stray away from the question. I told the kids ‘Write the question, now your claim has to answer that question.’” She used this strategy because she observed students getting distracted by things that were not in line with the purpose of the question.

**Positive framing.** When Mrs. Lee noticed students engaging in ways that did not facilitate inclusive group discussion she would redirect in a positive way. Mrs. Lee noted that some groups were using a common language that not all group members could not understand. She used positive framing to affirm their native language but requested that they use a shared language among all group members.

No, I'm not going to deny a child speaking their native tongue. That's not right. But I let them know that there are other people around them, they don't know sometimes. But just letting them know in a very nice way to be mindful. It's all about how you approach these children and how you kind of communicate versus yelling or saying don't do this.

**Alternate modes of assessment.** Mrs. Lee allowed students to be assessed based on not only what they had written but also by participating in class discussions. She adapted based on an individual student's strengths:

I can see who is participating in class, they will raise their hand and join in on the discussions. When they can connect what we are talking about in classrooms to something else, I feel like that is success! It's evident that they're learning. It doesn't have to always be paper and pencil like standardized tests.

**Scaffolding CER.** Mrs. Lee supported students in developing their CERs by breaking down each component. She was able to use this strategy to support students in putting together all three parts of the CER to produce their final response.

I had them restate their claim, then we worked to add evidence. I told them the evidence is there to support your claim. The reasoning is like your summary you are putting all the parts together. I made sure to emphasize they had to use recessive, dominant, and all of that. They needed to use the genetics terms we learned.

Mrs. Lee used three unique teaching strategies—rewriting, positive framing, and scaffolding CER's when teaching the intervention lesson on race and human diversity.

### **Ms. Sanchez**

**Menu selection.** Ms. Sanchez supported students' choice by allowing students to pick which article they would read. Students then read and summarized the articles. Next students

shared their summary with members of their group who read a different article. Ms. Sanchez explained, “Each student picked an article they wanted to read. Students were reading and highlighting important things, then they would share with the group.”

**Peer Review.** As students tackled the evidence the readings Ms. Sanchez facilitated opportunities for peer review, “they worked with a partner to review their CER and their partner would tell them if they had good evidence or needed to get more evidence, so they were able to peer review each other’s work.” Using peer review allowed students to critique the arguments of other students. Peer review is in strong alignment with social constructivist process of learning.

**Multiple revisions.** Ms. Sanchez’s teaching philosophy placed priority on students’ ability to critically think. She also emphasized that the scientific process is not linear. She stated that “even after the due date students were still going back to add to their CER, ‘cause they read something or found some new information.” Allowing students to adjust their thinking when presented with new evidence illustrates students’ ability to engage in scientific argumentation.

Ms. Sanchez used three unique teaching strategies—menu selection, peer review, and multiple revisions when teaching the intervention lesson on race and human diversity.

Participants in the study used a wide variety of teaching methods during their instruction. Instructional strategies were selected based on teacher style, personality, and/or classroom dynamic. Teachers reported using alternative methods of measuring student success for those whose reading and/or writing skills were not at grade level. All teachers used some sort of scaffolding technique to build students’ use of CER for scientific argumentation development. Teachers in the study also emphasized creating a safe classroom culture to support student discussions.

### Theme 3: Instructional Strategies

Table 5

#### *Instructional Strategies Used During Instruction*

Mr. Santori	Ms. Patterson	Ms. Sanchez	Mrs. Lee
Critical questioning	Round robin	Menu selection	Rewriting
Repetition	Close readings	Peer review	Positive framing
Eliciting emotions	Scaffolding CERs	Multiple revisions	Scaffolding CER
Cross-disciplinary connection	Alternate modes of assessment.		

## Chapter V

### Discussion

The purpose of this qualitative multiple case study was to investigate secondary science teachers' perceptions of teaching a culturally responsive lesson on race and human diversity. To this end the study was designed to address the following research questions:

1. In what ways, if any, do in-service biology teachers' positionality affect their perception of a culturally responsive lesson on race and human diversity?
2. What impact, if any, do in-service biology teachers perceive a culturally responsive lesson on race and human diversity has on students' understanding of the social construction of race?
3. What impact, if any, do in-service biology teachers perceive a culturally responsive lesson on race and human diversity has on students' scientific argumentation skills?

This chapter contains an interpretation of the findings, a discussion of the limitations of the study, and recommendations for future research.

## **Interpretation of Findings**

This study's findings resulted in three major themes: (a) teacher positionality within CRP; (b) teacher perceptions of shifts in student thinking; and (c) instructional strategies used during the intervention lesson. This section represents a synthesis of all three themes and interpretations of their relevance in science education.

### ***RQ1. In what ways, if any, do in-service biology teachers' positionality affect their perception of a culturally responsive lesson on race and human diversity?***

One of the unique findings of this investigation is that teachers can exhibit varying positions with respect to the three tenets of CRP. This study provides evidence for the individual analysis of the three tenets of CPR within an individual teacher's instructional practices; additionally, each tenet of culturally responsive teaching can be measured using a scale of high, moderate, or low orientation. Findings from this study are novel, because there is no research that measures the three tenets of CRP nor provides a way to measure the varying ranges as to which CRP tenets can be execute. These findings lay the groundwork to make a shift from discussing CRP as a holistic way of instruction but provides evidence for CRP analysis all tenets that comprise CRP. The ultimate goal in looking at culturally responsive teaching in this way is to ensure that it is being implemented in a manner that truly aligns to the core principles of this pedagogical teaching practice.

All teacher participants identified as members of minoritized groups and reported having negative experiences with racial stereotypes, however experiencing racial bias does not automatically ensure a higher orientation of CRP when teaching about race and human diversity. The data establishes that previous training in CRP was the strongest indicator in having a high or moderate orientation towards the three tenets of CRP (see Figure 6). Therefore, the evidence

provided indicates that it is not enough to simply place teachers of color in classrooms with students of color and assume that this will provide the cultural and classroom support students need. Instead, this study reveals that there is a need for direct teacher training on the three tenets of CRP, regardless of racial affiliation or experiences with racial bias.

In the analysis of the four teacher participants we see that teachers with previous exposure to CRP training had higher orientations across the three tenets of CRP, regardless of their years of teaching experience (see Figures 6 & 7). Additionally, teachers without previous exposure to CRP training, even when provided curriculum that aligns to culturally relevant teaching, are less likely to deliver instruction at high or moderate level. For example, although Mrs. Lee, who had no prior training in CRP, used similar lesson to other participants however, her overall ranking was lower when compared to other participants. Teachers with stronger positionality within CRP are more empowered and are better able to support the development of students' sociopolitical consciousness (Freire, 2000). When CRP is taught with fidelity there is an equal importance on academic content as there is in supporting student's ability to advocate for change (Gay, 2010). Teacher support of student advocacy using CRP is important because although public schools in the United States of America are increasing in diversity the accepted curriculum continues to prioritize Eurocentric ideologies (Grossman & Porche, 2013). Teaching diverse students with a one-size-fits-all approach can inevitably perpetuate racial biases by implying that science and the doing of science are solely exclusive to one group. This situates the findings of this study in an important position in education as it emphasizes the importance of CRP's use not only in teaching science, but also how it can be used to address racial biases amongst students of diverse backgrounds.

This brings to the forefront the crucial role of CRP teacher training as the evidence shows that even less experienced teachers enter the classroom better positioned to provide CRP instruction that responds to the needs of diverse student populations (see Figures 6 & 7). Therefore, a lack of teacher training that addresses the three tenants of CPR can result in a lower CPR teacher positionality and missed opportunities for students of diverse backgrounds. There is an urgent need to revisit current teacher practices that can better support all students. This need can be addressed by providing research-based strategies, such as CRP, that have been shown to create an inclusive learning environment for all students.

***RQ2. What impact, if any, do in-service biology teachers perceive a culturally responsive lesson on race and human diversity has on students' understanding of the social construction of race?***

Study participants all reported that students expressed misconceptions about race prior to participating in the intervention study. At the conclusion of the study all teachers reported observable shifts in students' concept of the social construct of race. Teachers reported students were able to see that racial categories are not scientifically based. Teachers also reported that as classroom discussion took place students were able to hold each other accountable. As students made claims about race and human diversity, their peers were able to require that assertions being made be backed with evidence from the readings. Furthermore, the lesson and delivery of instruction also worked to create a safe space for students to discuss ideas they have about other races in efforts to provide understanding and dispel myths. Teachers in the study were able to facilitate discussions and support open dialogue about race and human diversity in a highly-diverse classroom setting. The lesson design and use of CRP were both instrumental in supporting teachers as they navigated through the instruction.

One of the key components of the lesson that was shown to be most effective in facilitating classroom discourse was the use of fictional characters within the lesson to reduce backfiring. Backfiring, as stated in chapter two, is the inability for students to process instruction on race and human diversity in a way that allows for reduction in biological essentialism beliefs (Lewandowsky et al., 2012). Backfiring can occur when a student is unwilling to accept information because it requires a huge shift in their current thinking as it relates to race and human diversity. Backfiring can occur when students feel attacked because they realize they either knowingly or unknowingly subscribe to biological essentialism beliefs (B. Donovan, personal communication, December 2, 2019). If a student feels attacked as a self-preservation mechanism, he or she can resist processing new information that conflicts with their personal views (Lewandowsky et al., 2012). Backfiring can also result when a member of a minoritized group is exposed to racially-biased claims and then internalizes the claims to be true. Internalizing racially-biased beliefs can be problematic as it can result in student's inability to process teachings that debunk biological essentialism (B. Donovan, personal communication, December 2, 2019).

To prevent backfiring, students were shown three characters who had opposing views: (a) the first student did not want to address issues related to race and human diversity for fear it would make others uncomfortable; (b) the second student felt that it was important to discuss racial stereotypes because they are not scientifically accurate; and (c) the third student felt it was important to discuss racial stereotypes because they are true and learning about them would help people of different racial groups understand one another. All teachers reported that having these characters to reference gave students an outside entity to filter their own questions about race through during the discussion. Teachers also reported that it reduced backfiring because students

were discussing the characters' views, not their own personal ideologies. Data from the study reveals that all teachers reported shifts in students thinking, however teachers with moderate to high orientations of CRP did observe greater shifts in students' understanding. At the conclusion of the lesson teachers did report that some students still agreed in using racial classification system, but their reasoning was to easily identify and provide support to people who have been disenfranchised or marginalized by society.

***RQ3. What impact, if any, do in-service biology teachers perceive a culturally responsive lesson on race and human diversity has on students' scientific argumentation skills?***

Scientific argumentation is arguably the foundation and the goal of scientific instruction (McNeill & Krajcik, 2008; Sadler & Dawson, 2012). Scientific argumentation provides a way to view, communicate, and use science in accurate and effective ways. As stated in the review of literature, scientific argumentation is the process of formulating claims and substantiating said claims with scientific evidence (McNeill & Krajcik, 2008). Adolescents have a natural inclination to use their own ideas or opinions to support claims they believe to be true; however, using the CER framework discourages this type of thinking. When using CER students must search for specific scientific evidence to support the ideas they make during class discussions.

In the study, teachers reported that students initially responded to questions related to race and human diversity based on opinions and not facts. However, as students engaged in the assigned readings, they were required to use evidence to support their claims. Teachers reported students were then able to realize some of their beliefs about race and human diversity were not scientifically accurate. This type of student-centered instruction is a powerful learning model that aligns to the social constructivist methodology, which serves as the foundation of the intervention lesson design. Teachers also reported that the instructional readings materials used

within the intervention lesson were effective in providing students with the data needed to understand modern genetic findings asserting that all humans, regardless of race, are 99.9% genetically similar. As students were explicitly taught that variations in skin color were a result of selective pressures to sun exposure, teachers observed students realizing their own biological essentialism beliefs.

The lesson structure also supported students' understanding on race and human diversity as it included the historical and social context with which race was initially used. Making the cross-curricular connection between the social sciences and biology proved beneficial as it put the learning into an applicable and relatable context.

Teacher interviews illustrate that CER is a strong scientific writing framework for supporting students' shifts from opinion-based to fact-based scientific argumentation. All participants reported shifts in students use of opinion-based evidence to more fact-based evidence when making claims about race and human diversity. Three out of the four participants reported that students were able to transfer knowledge about the social construction of race in other contexts outside of the genetics unit. When discussions of race and human diversity were brought up in subsequent lessons, students were able to use their scientific reasoning skills and attribute trends among racial groups to culture, societal stratifications, or even environmental factors. This represents a shift from the assumption that race is a predictable way to explain societal patterns to a more scientifically advanced and accurate conclusion about observable trends among various racial groups. Therefore, the use of CER framework, incorporating teaching strategies that address backfiring, in conjunction with instructional resources on modern genetics findings are effective ways to support students' ability to determine scientific and nonscientific claims about race and human diversity.

Additionally, this study presents evidence that high school students even in racially and ethnically diverse learning environments can subscribe to unscientific racial stereotypes. Belief in racial stereotypes is problematic as it has resulted in unjust policies that have led to the marginalization of certain racial groups (Leonard, 2011). This study provides justification for the inclusion of modernized genetic instruction that addresses misconceptions high school students have about the social construct of race. Interpretation of the results show teachers observed significant shifts in students' thinking from the belief in racial stereotypes to understanding that race is a social construct with societal implications.

Overall, the findings of this multiple-teacher case study provide strong evidence that culturally responsive lessons on race and human genetics can support instruction that addresses misconceptions about race and supports scientific argumentation development.

### **Ethical Issues & Limitations**

**Ethical issues.** The topic of race and diversity can be a very polarizing topic, so it will be important for researchers and teachers to facilitate group discussions, so stereotypes and misconceptions are not used to promote divisive classroom culture as students engage in discussions.

An accurate teaching of race and human diversity can challenge students' long-held views about who they are and how others perceive them. In efforts to support student socioemotional needs during the intervention lessons, teaching strategies (previously discussed in Chapter II) that involve being mindful of student wellbeing were infused into the lessons.

**Limitations.** Teacher beliefs and perceptions are both compounding factors that impact students' learning. To mitigate this prior to intervention lesson implementation, the researcher met with teachers for a half-day debriefing on how to implement the 5E intervention lesson. The

goal of the debriefing was to support consistency in the implementation of the lesson.

Additionally, teacher participants had already exposed students to CER argumentation writing so all students had prior experience with using this method to support their scientific assertions.

Students' tendency to seek out the right answer might put more weight on the teachers' opinions of the topic. To address this issue, teachers were encouraged to use an inquiry-based approach in their instructional delivery. Teachers did not present themselves as the gate keeper of knowledge, but as facilitators guiding students with use of student-centered instruction. Students were encouraged to take ownership of their learning by leading class discussions throughout the intervention lesson.

Finally, time constraints were a limitation of this study. Two weeks was enough time for students to process the information in the lesson, but more data would be needed to determine the long-term impacts of the study on students' understandings of race and human diversity.

### **Implications**

Donovan et al. (2019) issued a call for a more humane teaching of genetics. Humane genetics involves being intentional and explicit about addressing myths that students have about race and human diversity. By teaching in this way, humane genetics can eliminate negative ideologies one might have about someone because of their race. This use of humane genetics can also work to dismantle the rationalized use of race to marginalize people based upon variations in skin tone (Donovan et al., 2019).

This approach to teaching and scholarship can contribute to increased understanding and tolerance. Bullard's (1996) work supports the notion that racial tolerance and intolerance can be taught and puts the onus on educators to incorporate teaching and practice of tolerance into their instruction. By participating in a humane genetics lesson and classroom discourse on the topic of

race and human diversity students will be better equipped to solve 21<sup>st</sup>-century social issues with tolerance, effective communication, and accurate scientific evidence.

### **Recommendations for Future Research**

Opportunities to further develop this study include increasing the sample size by including more teachers. An increase in sample size can provide greater insight on teacher perceptions when providing instruction on race and human diversity. Furthermore, based on the findings of the study there is evidence that suggests a need for research on teacher professional development concerning the use of CPR in the secondary science classroom.

This research can also be extended to include students as participants. Qualitative data can be collected through analysis of student CERs and student interviews at the conclusion of future studies. Students who participate in instruction can be interviewed to support researchers in understanding factors that contribute to student misconceptions about race and human diversity as well as the rationale for any shifts in student thinking.

### **Conclusion**

This study adds to the body of educational research on methods to address biological essentialism among high school students. The study shares the experience of four in-service biology teachers who embraced an opportunity to challenge students' perceptions of others and address racial stereotypes through use of scientific evidence. It is evident from the study that more work is needed to address misconceptions that students possess about race and human diversity. The evidence brought forth in this investigation proves that actionable steps can be taken to support students' scientific discourse and communication as it related to social construction of race. The aim of this work is not to erase students' racial identities, albeit a social construct, one's race has very real implications in society. The long-range goal of this

work is transitioning to a better understanding and celebration of human diversity. This research illustrates that by adding modern genetics concepts into the high school biology curriculum, teachers can support students in having better understandings of the intersection between curriculum and social issues.

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## Appendix A

### IRB Approval Letter



May 11, 2020

Uchenna Emenaha [ubemenaha@uh.edu](mailto:ubemenaha@uh.edu)

Dear Uchenna Emenaha:

On May 4, 2020, the IRB reviewed the following submission:

Type of Review:	Modification
Title of Study:	Investigation High School Biology Student's Understanding of Human Diversity Using a Genetics Intervention Lesson: A Mixed Methods Study
Investigator:	Uchenna Emenaha
IRB ID:	STUDY00001948
Submission ID:	MOD00002633
Funding/ Proposed Funding:	Name: Unfunded
Award ID:	None
Award Title:	
IND, IDE, or HDE:	None
Documents Reviewed:	<ul style="list-style-type: none"> <li>• IRB modification version 3 May 2020.pdf, Category: IRB Protocol;</li> <li>• Uchenna Emenaha UH research letter1.PDF, Category: Letters of Cooperation / Permission;</li> </ul>

UNIVERSITY of  
**HOUSTON**

DIVISION OF RESEARCH  
Institutional Review Boards

	• Teacher Consent , Category: Consent Form;
Review Category:	Expedited
Committee Name:	Noncommittee review
IRB Coordinator:	<a href="#">Maria Martinez</a>

The IRB approved the following revision on May 11, 2020.

Summary of approved modification(s):

The initial study was written to collect data from students and conducted teacher interviews. I am now requesting to modify the study as I will only collect data from teachers. No, student data has been collected and no student data will be collected and used for any purpose of this study. Information provided by teachers via interview will serve as the primary source of data used in the study. Teacher interviews have already been collected after teacher consent forms were completed.

Students' data was not collected because the initial research question was changed to a qualitative study to determine teacher perspectives of teaching the intervention study. This was done to create more focus in the study as looking at both teacher and student data would be too broad to cover within the scope of a single study. All documents related to students have been removed from the study, including student assent and consent, verbal student request to conduct the study, and pre/posttest questions.

The next change to the study will be to add Nabeela Siddeeqe as a new member of the research team. Nabeela Siddeeqe is an undergraduate research assistant who will be working with me on this project. I will not pay Nabeela Siddeeqe for her services. As an undergraduate research assistant, she is an employee of the University of Houston and has been approved by her supervisor to support me in my research efforts as a part of her role as an undergraduate research assistant. Nabeela Siddeeqe, will help to transcribe interviews. She will not have access to the teacher's names and any other identifying information in the study. She will be provided with a

copy of the audio recorded interviews through a secure online server. She will then manually listen to and transcribe the audio recordings of the interview.

Overall, two major changes are being requested, first to remove students from the IRB as they will not be a part of the study. Finally, to Nabeela Siddeeqe as a member of the research team for the purpose of transcribing interviews.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

If your study meets the NIH or FDA definitions of clinical trial, or may be published in an ICMJE journal, registration at ClinicalTrials.gov is required. See the [UH ClinicalTrials.gov webpage](http://www.clinicaltrials.gov) for guidance and instructions.

Sincerely,

Research Integrity and Oversight (RIO) Office

University of Houston, Division of Research

713 743 9204 [cphs@central.uh.edu](mailto:cphs@central.uh.edu) <http://www.uh.edu/research/compliance/irb-cphs/>

## Appendix B

### Research Consent Form



#### Consent to Take Part in a Human Research Study

**Title of research study:** Investigation Secondary Science Teachers Perspectives' of a Culturally Responsive Lesson on Race and Human Genetics

**Investigator:** Uchenna Emenaha Ph.D. candidate, College of Education, University of Houston

*Key Information:*

The following focused information is being presented to assist you in understanding the key elements of this study, as well as the basic reasons why you may or may not wish to consider taking part. This section is only a summary; more detailed information, including how to contact the research team for additional information or questions, follows within the remainder of this document under the "Detailed Information" heading.

*What should I know about a research study?*

Someone will explain this research study to you.

Taking part in the research is voluntary; whether or not you take part is up to you.

You can choose not to take part.

You can agree to take part and later change your mind.

Your decision will not be held against you.

You can ask all the questions you want before you decide and can ask questions at any time during the study.

We invite you to take part in a research study about teaching lesson concerning human diversity has impacted your teaching and learning because you meet the following criteria of being a biology teacher at the current school where the study will be taking place. In general, your participation in the research involves sharing your experience teaching, teaching a 7-day intervention lesson, and a 45 minute to 1-hour audio recorded exit interview at the conclusion of the study. The primary risk to you in taking part is no greater than that of daily life more than in

normal daily life *which you can compare to the possible benefit* enjoying the science inquiry activities in an engaging and relevant educational environment and learning about how your students reason and communicate with others about real world interdisciplinary issues. Possible positive learning outcomes for your students include improved scientific thinking, academic language, conceptual understanding, and scientific argumentation skill development. However, it is possible that there might be no benefits for your child from the participation.

**Detailed Information:**

The following is more detailed information about this study, in addition to the information listed above.

***Why is this research being done?***

The research is being done to investigate ways to provide students with more scientifically accurate understanding of human differences. This follow-up interview is important because it will inform understanding about how teachers make decisions to teach students about science content. The feedback will also help to find out what your experience was teaching the lesson and in what ways you think it impacted your students. The feedback will improve the curriculum design and delivery of this lesson in the future.

***How long will the research last?***

The lesson will be taught over 7 days and the exit interview will last about 45 minutes to 1 hour.

***How many people will be studied?***

Four teachers from your school to participate in this research study.

***What happens if I say yes, I want to be in this research?***

You will be asked to participate in a one-day workshop at your school. Then you will be provided resources and materials to teach the 7-day lesson on modern teaching of human diversity. Then if you indicate your wiliness to be interviewed and/or audio recorded an exit interview will be scheduled. The researcher, Uchenna Emenaha, will schedule a time to meet with you to conduct the exit interview. The meeting will be at time that is convenient for you, in your classroom or another empty room at your campus if you prefer.

This research study includes the following component(s) where we plan to audio record you as the research subjects:

- € I agree to be [audio recorded] during the interview.
  - € I agree that the [audio recording] can be used in publication/presentations.
  - € I do not agree that the [audio recording] can be used in publication/presentations.
- € I do not agree to be [audio recorded] during the interview.

If you don't provide permission for you to be audio recorded, you can still participate in the project and special arrangements will be made.

***What happens if I do not want to be in this research?***

You can choose not to take part in the research and it will not be held against you. Choosing not to take part will involve no penalty or loss of benefit to which you are otherwise entitled.

***What happens if I say yes, but I change my mind later?***

You can leave the research at any time it will not be held against you. Choosing not to take part will involve no penalty or loss of benefit to which you are otherwise entitled. If you stop being in the research, already collected data will be removed from the study record.

***Is there any way being in this study could be bad for me?***

*There are no foreseeable risks related to the procedures conducted as part of this study. If you choose to provide permission to take part and undergo a negative event you feel is related to the study, please inform the investigator.*

***Will being in this study help me in any way?***

You will not be paid for your participation in the study or the follow-up interview, but instead you will be given a \$10.00 Starbucks Coffee gift card for participating in the study. Additionally, we hope that this experience will enhance your teaching and provide insight on ways to further support your student's science learning.

***What happens to the information collected for the research?***

Participating in teaching the intervention lesson, and the exit interview will provide you the opportunity to reflect on your knowledge, beliefs, and experiences in teaching students to develop their argumentation skills and have a better understanding of human diversity.

***Who can I talk to?***

If you have questions, concerns, or complaints, or think the research has hurt your child, you should talk to the principal investigator Uchenna Emenaha at (832) 628-5688 or email:

[ubemenah@uh.edu](mailto:ubemenah@uh.edu) or her academic advisor Dr. Sissy Wong at (713) 743-1690 or email: [sissywong@uh.edu](mailto:sissywong@uh.edu).

This research has been reviewed and approved by the University of Houston Institutional Review Board (IRB). You may also talk to them at (713) 743-9204 or [cphs@central.uh.edu](mailto:cphs@central.uh.edu) if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.

In the future, our research team may be interested in contacting you for other research studies we undertake, or to conduct a follow-up study to this one. There is never any obligation to take part in additional research. Do we have permission to contact you to provide additional information?

€ Yes

€ No

#### Signature Block for Capable Adult

Your signature documents your consent to take part in this research.

Signature of subject	Date
Printed name of subject	
Signature of person obtaining consent	Date
Printed name of person obtaining consent	

**Appendix C**  
**Initial Interview**

1. So, tell me about your initial thoughts when you first read through the lesson?
2. In what way do you feel the lesson was same or different from other lessons you have taught?
3. What part/s of the lesson do you feel the students found the most engaging and why?
4. If you could redo the lesson are there any parts you would want to change or adapt? If so, explain?
5. In what ways if any do you feel the lesson supported culturally responsive teaching practices?
6. How might students transfer what they learned during the lesson to their personal lives?
7. What did you learn about your students as they completed the Claims Evidence and Reasoning (CER) activities?
8. What specific parts of the lesson do you feel was able supported student's scientific reasoning skills?
9. In what ways did the interventions study support students understanding of themselves and others?
10. To what extent do you feel your role as a facilitator of culturally responsive pedagogy helps support student's success during the lesson?

**Appendix D**  
**Focus Group Interview**

1. What did you learn about your students as they completed the lesson?
  - i. Can you tell me more about that?
2. Is there any part of your previous experiences personally or professional that you feel impacted the way you taught the lesson?
3. Do you think the lesson is relevant for high school biology? If so, why or why not?
4. How is this lesson the same or different than lessons you have taught in the past?
5. Did you observe any changes in student's ability to develop arguments as the lesson progressed? If so, can you provide examples?
6. Do you think the lesson was helped your students? Is so, why or why not?
7. Does culturally responsive teaching instruction align to your teaching philosophy? If so, in what ways are they the same or different?

## **Appendix E**

### **Second Interview**

1. Do you have any experience teaching using culturally responsive teaching?
2. Describe your experience teaching the lesson?
3. Is there any part of your previous experiences personally or professional that you feel impacted the way you taught the lesson?
4. Do you think using CER impacted student's argumentation skills? If so, in what way?
5. Do you think the lesson impacted students understanding of human diversity? If so, in what way?
6. If you could change anything in the lesson what would you change and why?