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# A Holistic Approach to Culturally Relevant Education In Biology to Examine Student Engagement

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# A HOLISTIC APPROACH TO CULTURALLY RELEVANT EDUCATION IN BIOLOGY TO EXAMINE STUDENT ENGAGEMENT

by


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# DEDICATION

To my husband and love of my life, Paul Biery – your support and counsel is second to none. To my children, Paul and Lily, you are my world; stay curious and persistent. You all inspire me daily to be a better person and raise the bar. I feel so lucky to call you family and thank God that he gave you to me. Honey, thanks for all of your behind-the-scenes work to support our young family while I set out to achieve a lifetime goal.

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ABSTRACT

Recognizing that many students were disengaged in my grade-level biology class, this study sought to improve student engagement as a result of the implementation of CRE-enriched instruction and to describe themes associated with CRE and engagement. This qualitative action research study used a survey, exit tickets, and observations to discover emergent themes as a result of implementing CRE-enriched lessons. This action research study used member checking and disconfirming evidence to increase rigor and transferability. The results were that the use of CRE-enriched lessons increased the engagement of grade-level students in biology, and that engagement requires a two-pronged approach – cultural appeal to students and culturally appropriate support from the teachers.

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LIST OF ABBREVIATIONS

CP ........................................ College Preparatory

CRE ........................................ Culturally relevant education

CRP ........................................ Culturally relevant pedagogy

CRT ........................................ Culturally relevant teaching

DNA ........................................ Deoxyribonucleic Acid

EOC ........................................ End-of-Course

GPA ........................................ Grade Point Average

LOL ........................................ Laugh out Loud

MAP ........................................ Measures of Academic Progress

mRNA ........................................ Messenger Ribonucleic Acid

NCLB ........................................ No Child Left Behind

NGSS ........................................ Next Generation Science Standards

NRCNA ........................................ National Research Council of the National Academies

NSTA ........................................ National Science Teachers Association

RNA ........................................ Ribonucleic Acid

RTHS ........................................ Rocky Turtle High School

RTTT ........................................ Race to the Top

SCDOE ........................................ South Carolina Department of Education

TOSRA ........................................ Test of Science-Related Attitudes

WIHIC ........................................ What is Happening in this Class?

# CHAPTER 1

# INTRODUCTION

Finn (1989, 1993) defines *engagement* as concomitant active participation, a sense of belonging, and aligning identity with school goals. Disengagement in learning predicts reduced academic achievement and lifelong success (Finn, 1989, 1993; Henry et al., 2012; Wang & Fredricks, 2014). School disengagement often leads to dropping out of high school (Fredricks et al., 2016; Landis & Reschly, 2013; McFarland et al., 2018; Yazzie-Mintz, 2006). Students more likely to drop out of high school need early proactive measures (Henry et al., 2012). Levels of engagement decline as students progress through grades (Lepper et al., 2005).

Engagement is a significant concern in the secondary science classroom, which research has found suffers from some of the steepest declines in engagement (Gottfried, et al., 2009; Patall et al., 2018). In my practice, I have noticed higher levels of disengagement in grade-level biology compared to honors-level biology. Furthermore, there are disproportionate numbers of historically underserved groups and low SES students in lower-tracked academic courses (Betrand & Marsh, 2021; Oakes, 1985) and my grade-level biology classes. Thus, grade-level biology is highly likely to have a disproportionate number of students that may not complete high school with their cohort.

Disengaged students are more likely to drop out of high school, significantly lowering their quality of life and disproportionately affecting historically underserved groups (Henry et al., 2012). Orfield et al. (2004) claim that we are "losing our future," referring to students who drop out of school (p. 2). There are tremendous social, economic, and political consequences for those who do not complete high school, including incarceration and poverty or significantly lower lifetime wages compared to high school graduates (Henry et al., 2012; Howard, 2010). Early warnings and prevention of school dropouts have recently received more attention, and one attempt is to increase students' engagement early in their educational careers (Henry et al., 2012; Wang & Fredricks, 2014). As such, the disengagement in grade-level biology presents a considerable need to improve engagement to prevent poor outcomes.

In addition, the COVID-19 Pandemic has deepened "disparities in educational opportunity and achievement" (U.S. Department of Education, 2021, p. iii). In the state of South Carolina, all students must take and pass biology to obtain a high school diploma; biology also has an end-of-course (EOC) examination (South Carolina Department of Education, 2021). According to district data, the 2018-19 EOC biology 1 pass rate at my school (the last typical school year before the pandemic) was 99.1% for honors students. However, the pass rate for college preparatory (CP) biology was 71.1%. Both pass rates have been affected by the pandemic, but the CP pass rate has severely decreased in comparison. The 2021-22 pass rate for honors biology was 94.2% and CP biology pass rate was only 48.4%. Thus, an intervention in grade-level biology could help offset this widening gap by engaging more students in learning.

Several years ago, I began reading about culturally relevant education (CRE) and noticed that my instruction already included some of these tenets, although not entirely or intentionally. At the same time, I was participating in a Professional Development School

(PDS) focus group at my school. This focus group gave us the opportunity to regularly try strategies and discuss them at our monthly meetings (Biery, 2021). I began taking more of a leadership role in my school's PDS focus group and won a PDS fellowship as a result of this work and my dissertation focus. As part of the PDS focus group, we did a book study and planned school-wide professional developments around culturally relevant practices. This combination of events helped me develop a better understanding of CRE and with this study's decision to apply a holistic approach to the classroom.

It was within this group that I tried out different strategies to improve the engagement of grade-level students, and it seemed to help students be more engaged in biology. However, there was no formal study and no inquiry into what students thought of these strategies or whether they impacted engagement. Thus, my interest began in an intentionally designed unit using CRE to value all students' cultural backgrounds, interests, and lived experiences with an attempt to improve the engagement of grade-level students. Some things I noticed that were beneficial to the students at the time were prioritizing relationships, including student interests in lessons, and providing more student choice (Biery, 2021). Recognizing that all students have unique backgrounds and experiences by which they process and filter new information, it is vital to incorporate familiar experiences into lessons. CRE provides the most comprehensive view of how instruction and pedagogy can be interwoven as a holistic approach attempting to improve the engagement of all students in a grade-level biology.

The literature surrounding the use of CRE in science is positive and has demonstrated value in increasing engagement (Djonko-Moore, 2018: Milner, 2011), and providing a more "effective instructional environment" (Johnson, 2011, p. 170). Milner discusses how providing them second chances "motivated students to remain actively engaged in the classroom" (2011, p. 74). In addition, Johnson (2011) reports that using CRE provides more effective instruction for Hispanic students.

Engagement is not necessarily something a teacher can measure by looking at the student. A student can look engaged but be thinking about something entirely different. Although difficult to define, academic student engagement was the focus of this research. Academic student engagement was gauged by the degree of on-task student behaviors and active participation in the classroom (Harris, 2008) and determined by student and teacher perceptions. This study comprehensively described CRE-enriched lessons' impact on grade-level biology engagement.

**Problem Statement**

The problem of practice for this study is that the lack of engagement among grade-level biology students leads to lower academic success and limits their long-term opportunities. Throughout the world, policy-driven, high-stakes tests are distorting practical work in science, resulting in teacher-centered instructional strategies and teaching to the test that leaves students disengaged and lacking in the fundamentals of science (Childs & Baird, 2020; Erduran et al., 2020; Vogler, 2005, 2006a, 2006b). Many authors state that disengaged students tend to drop out of high school (Finn, 1993, Fredricks et al., 2016; Henry et al., 2012; Landis & Reschly, 2013; McFarland et al., 2018; Yazzie-Mintz, 2006). In addition, students in lower-tracked courses like grade-level biology are less likely to graduate (Oakes, 1992). Other factors contributing to disengagement in the classroom are the absence of students' cultures and interests (Baber, 2012; Howard, 2010; Tate, 1997) and unfair, inhibitory tracking practices (Domina et al., 2017; Oakes; 1992).

## Summary of Background Literature

Many students are not engaged in grade-level biology. In general, STEM (science, technology, engineering, and math) courses see the steepest declines in engagement (Gottfried et al., 2009; Patall et al., 2018). In addition, as students progress through grades, engagement declines (Lepper et al., 2005). Finally, high-stakes testing (Dianis et al., 2015), tracking practices (Oakes, 1992), and teaching practices (Erduran et al., 2020) affect engagement in science classrooms across the United States.

Teacher-led “cookbook” activities and investigations plague science classrooms with high-stakes tests where students follow directions without much thought to the underlying principles of science (Erduran et al., 2020). For example, many labs in biology have students following teacher-directed instructions for the students to discover a predetermined example of a phenomenon where there is highly likely to be a question on the EOC about the phenomenon. Erduran et al. (2020) say there should be less "mindless procedural engagement and more thoughtful consideration of practical science," where students are engaged in planning, conducting, and evaluating the phenomenon (p. 1544). Many authors posit that high-stakes testing perpetuates teacher-centered instruction that is more focused on the most effective use of time to cover the content, which reduces the active engagement of students (Au, 2008; Misco et al., 2011; Vogler, 2005). Some of the significant problems teachers report are that it limits the variety of instructional strategies and the ability to "respond to diverse learning styles" (Misco et al., 2011, p. 8).

Grouping students homogenously is called *tracking* or *ability grouping* (Atkos et al., 2004). While it can be beneficial for some higher-tracked students, it tends to harm lower-tracked students and continues to produce, maintain, and legitimize education inequality (Domina et al., 2017; Park & Datnow, 2017). First, low-tracked courses contain disproportionate numbers of students of color and students from the lowest income brackets. Second, these courses have unequal learning opportunities compared to high-tracked ones (Bertrand & Marsh, 2021; Gamoran, 2011). The unequal opportunities in ability grouping widen the achievement gap and persistently leave low-tracked students coming up short (Gamoran, 2011). Third, low-tracked courses contain reduced academic rigor and deficit orientations (Oakes, 1995). For example, teachers tend to have lower expectations for low-tracked students, and students begin to expect less of themselves.

Howard (2010) posits that "countless numbers of students who are classified as "low achievers" by traditional standards are often some of the most talented, intellectually gifted, creative and critical thinkers on school campuses across the country (p. 13). Discrepancies between achievement and opportunity are interwoven in the fabric of education so well that it becomes accepted as a standard expectation (Betrand & Marsh, 2021). Betrand and Marsh (2021) report that teachers often blame low grades and disengagement on familial or cultural factors. Researchers agree that the educational system perpetuates achievement gaps (Betrand & Marsh, 2021; Emdin, 2016; Howard, 2010).

Meanwhile, a disproportionate number of disengaged students sit in my grade-level biology classroom's high-stakes testing environment compared to the honors level.

This problem is embedded in my practice as a teacher, and it is a real-world dilemma. This action research study examined CRE-enriched lessons to engage more students in grade-level biology.

## Theoretical Framework

This action research study is grounded in constructivism and CRE theory to increase engagement. Constructivism provides a student-centered theoretical framework that values students' backgrounds and uses their own experiences upon which to build new learning (Abdal & Haqq, 1998). Constructivism is a broader theory that CRE states should be used to include students' cultural references to build new learning. Students need "cultural references to academic skills and concepts, building on the knowledge and cultural assets" they bring to the classroom (Aronson & Laughter, 2016, p. 262). The use of CRE theory will guide this study by examining effective pedagogical and instructional strategies to fit the needs of grade-level biology students better.

### Constructivist Theory

As a learning theory, constructivism makes new meaning by tying it to an individual's prior knowledge and experiences. Students involve themselves in the content through a student-centered approach that includes strategies of "active engagement, inquiry, problem-solving, and collaboration with others" (Abdal-Haqq, 1998, p. 2). Therefore, constructivists believe in valuing the background and experiences of all students in the classroom and using these experiences to filter and learn new material. As a result, learners develop their understanding, and rote memorization is discouraged (Omotayo & Adeleke, 2017). In constructivist theory, instructors design learning that allows students to utilize their knowledge and preconceptions to develop meaningful and compelling learning experiences (Texley & Rudd, 2017). Constructivists define learning as constructing knowledge through interactions with others, the community, and the environment (Harasim, 2012). Ertmer and Newby (2013) state that learners create meaning as "they build their own personal interpretations of the world based on individual experiences and interactions" (p. 55).

Although constructivism is not a new learning theory, it has recently seen a boost in popularity (Applefield et al., 2000; Bednar et al., 1991). The works of Dewey, Piaget, Vygotsky, and Bruner all have threads of constructivism (Applefield et al., 2000). Piaget first referred to his views as "constructivist" (Gruber & Voneche, 1977). Bruner used the term "constructionist" in describing discovery learning (1966). Vygotsky's social development theory also serves as a foundation of constructivism as he believed that social interactions with peers and teachers guide students in developing their understanding (Applefield et al., 2016).

Other contributions include generative learning (Wittrock, 1985), postmodern curricula (Hlynka, 1991), and educational semiotic (Cunningham, 1992). Although there is no single voice nor a single common point of view, all constructivists believe that making meaning through personal interpretations and experiences is where learning happens (Applefield et al., 2016). Constructivism fits this study because it allows a student-centered approach that values students' prior experiences and culture, utilizing them in learning.

**CRE**

Johnson (2011) suggests that when student interests are valued and used in lessons, there is a positive effect on learning. In addition, students see how their culture or past experiences are valuable to what they learn when they are allowed to be experts (Ladson-Billings, 1995b). Therefore, constructivist methods are the best for CRE (Aronson & Laughter, 2016; Johnson, 2011). They are the best because constructivism explains how students use their understanding to filter and attach new information. Further, the science standards framed by the National Academy of Sciences (NAS) in the *Framework for K-12 Science Education* outline a key principle to be "the linkage of science education to students' interests and experiences, and the promotion of equity" (National Research Council of the National Academies (NRCNA), 2011, p. 2-1). Therefore, the Framework for K-12 Science Education is based on constructivism and was used by the State of South Carolina to develop the science standards (SCDOE, 2022).

CRE (Dover, 2013) is a curriculum theory that draws from the work of two giants in this field: Gloria Ladson-Billings' theory of culturally relevant pedagogy (CRP) and Geneva Gay's theory of culturally responsive teaching (CRT). The combination of CRP with CRT then becomes an inclusive framework that includes both teaching and pedagogy (Aronson & Laughter, 2016). CRP outlines three criteria: "an ability to develop students academically, a willingness to nurture and support cultural competence, and the development of a sociopolitical or critical consciousness" (Ladson-Billings, 1995b, p. 483). Gay (2002) outlines CRT theory as "developing a knowledge base about cultural diversity, including ethnic and cultural diversity content in the curriculum, demonstrating caring and building learning communities, communicating with ethnically diverse students, and responding to ethnic diversity in the delivery of instruction" (p. 106). The four markers for CRE are delineations of these two theories (Aronson & Laughter, 2016).

The four markers of CRE, as outlined by Aronson & Laughter (2016), are "academic skills and concepts, critical reflection, cultural competence, and critique discourses of power" (p. 168). First, the authors define *academic skills and concepts* as constructivist methods that connect concepts and skills to students' cultural references. Second, *critical reflection* engages students in reflection about their lives and societies while it outlines that educators should utilize inclusive materials to analyze represented cultures (Aronson & Laughter, 2016). Third, *cultural competence* outlines that students should "both learn about their own and others' cultures" while developing pride in these cultures (Aronson & Laughter, 2016, p. 167). Finally, they indicate that the fourth marker, *critique discourses of power,* is about identifying and breaking down barriers associated with power in the classroom and school. My study is situated on these four principles and provides a comprehensive framework with the attempt to support every student in grade-level biology.

CRE is an appropriate choice for my study because it is an inclusive theory that outlines the shift in practice that I have come to believe will improve the learning experiences of grade-level biology students. Because CRE is inclusive of pedagogy and instruction, it will provide a comprehensive assessment of my stance and instruction. In addition, there is growing evidence that education using cultural references increases engagement in a science classroom (Aronson & Laughter, 2016; Johnson, 2011; Milner, 2011). Moreover, CRE is complementary to national science standards based on constructivist collaboration and inquiry methods (Aronson & Laughter, 2016; Johnson, 2011; NRCNA, 2011; NSTA, 2011).

An indicator of quality in any research study is the alignment of the theoretical framework with the purpose, the problem of practice, research question, and design (Grant & Osanloo, 2014). In this study, CRE is centered on the inclusion of students' cultural backgrounds, interests, and lived experiences in all teaching and learning combined with the nurturing of academic skills and building of quality relationships. Therefore, CRE is a comprehensive and practical model to design this study to determine the factors most effective at engaging grade-level biology students. The problem of practice is that instructional decisions fail to engage students in grade-level biology. This study aimed to examine whether implementing instructional activities that reflect the CRE characteristics increases student engagement.

## Research Question

### Purpose Statement

Lack of engagement in grade-level courses seems prevalent at my school based on my experience and the experiences of other teachers. I have recognized that many students in grade-level courses lack authentic engagement. When I first began reading about CRE, I realized some of what I was doing already aligns with CRE and benefits student engagement. As a result, I was motivated to engage in this research. The purpose of this study was to increase engagement by implementing CRE-enriched lessons. To serve this purpose, the following research question was developed:

1. How does the use of CRE-enriched instruction impact grade-level biology student engagement?

The focus of this research question was to identify how CRE-enriched instruction increases student engagement per student and teacher perceptions. In this study, *engagement* is defined as the degree of on-task student behaviors and active participation in the classroom (Harris, 2008). My students and I engaged in CRE together and together analyzed engagement experiences associated with learning biology. In a typical action research fashion, decisions were informed in the research cycle of planning, acting, observing, and reflecting (Herr & Anderson, 2015). The goal of this study was to improve my practice in engaging students in grade-level biology.

**Positionality**

I am passionate about teaching life science. It is my tenth-year teaching at a suburban high school. I have taught a range of sciences and had multiple roles in and out of the classroom before finding my niche teaching life sciences. There have been multiple experiences in my life that, had I not known a lot about science, my life or the life of a loved one would be gravely different. My overall goals for science instruction align with the National Framework for Science Education. I want students to be able to appreciate the beauty of science, to have a sufficient amount of scientific knowledge to engage in discussions, and to be able to filter new knowledge through their understanding so that they can make informed decisions (NRCNA, 2011). Aligning with these goals is a primary reason I want to design a highly engaging classroom for grade-level students. Everyone should understand the basics of biology. It does not get more relevant than the inner workings and makeup of a person's body. My goal is for students to leave my classroom very capable of understanding the underlying science of life so they can make good decisions about their health.

Positionality is how researchers position themselves regarding power relationships within a research study (Herr & Anderson, 2015). It is essential to be self-aware of the effect that "one's values, worldviews, and life experiences" can have on decisions made during research (Efron & Ravid, 2013, p. 57). Clarity about insider and outsider relationships is essential for validity, trustworthiness, and ethics in action research (Herr & Anderson, 2015). Because I was a subject in this study, I am an insider. However, I was an outsider regarding race and social class of many students involved in this research study. In addition, I held a position of power as the teacher of the students participating in this research.

Researcher positionality plays a vital role in qualitative research as the researcher is the primary instrument upon which results are collected, categorized, analyzed, and reported (Merriam & Tisdell, 2016). When I conducted my study, I was very aware that I was in a power relationship as the teacher researching my students. Although there are various ways to reduce a researcher's influence in a study, that influence can never be removed entirely (Merriam & Tisdell, 2016). In this study, I attempted to reduce the power relation influence by using anonymous surveys, providing explicit intentions and explanations, and encouraging students to be honest in their responses.

In addition, this study used member checking and disconfirming evidence to increase the credibility and reliability of the reported results. *Member checking* means taking results that the researcher has created and discussing them with the participants to "systematically check the data and the narrative account" (Creswell & Miller, 2000, p. 127). One of the most crucial steps for increasing the credibility of a study is member checking (Lincoln & Guba, 1985). In addition, searching for opposing themes in a research study is defined as d*isconfirming evidence* (Creswell & Miller, 2000). Constructivists believe that reality is both "multiple and complex," and including disconfirming evidence in this study will provide more credibility to the study (Creswell & Miller, 2000, p. 127). These added parameters increased the validity and rigor of my qualitative action research study.

## Research Design

### General Methodological Design

My qualitative action research study used an intervention of instructional strategies to improve student engagement. These instructional strategies were five CRE-enriched lessons spread out over a 5-week study. Student engagement was measured through initial and final surveys, exit tickets, and observations.

### Intervention: CRE-Enriched Lessons

I used CRE theory tenets of *academic skills and concepts, critical reflection, cultural competence*, and *critique discourse of power* to design the following five lessons:

- **Class DNA** (Appendix C) This lesson utilized the CRE tenets of *academic skills and concepts, critical reflection*, and *cultural competence*. Students obtained three pieces representing a nucleotide made up of a sugar, phosphate, and nitrogenous base. They decorated this nucleotide using their interests or cultural backgrounds, they chose someone to be their base pair, and their nucleotides were pieced together to make a giant class DNA that featured how we fit together as a whole. This giant DNA decorated the hallway around my room.
- **Rosalind Franklin Activity** (Appendix D) This lesson utilized the CRE tenets of *academic skills and concepts*, *critical reflection*, and *critique discourses of power*. In this lesson, students read about the life of Rosalind Franklin, a female

Jewish scientist. Students examined the controversy surrounding the discovery of DNA and gender inequality from the 1950s. They were prompted to build a scientific argument about who was the most unethical person in her life.

- **DNA Technologies** (Appendix E) This lesson utilized all four CRE tenets of *academic skills and concepts*, *critical reflection*, *cultural competence*, and *critique discourses of power.* In this activity, students examined ways that DNA technology is used and chose a DNA Technology that was interesting to them. They then researched the topic, organized information on a shared presentation, and presented their DNA technology to the whole class.
- **Protein Affirmations** (Appendix F) This lesson utilized CRE tenets of *academic skills and concepts* and *cultural competence*. Students worked in pairs to decode six DNA nucleotide sequences to discover the RNAs, amino acids, and affirmations associated with the DNA strands.
- **Eevee Epigenetics** (Appendix G) This lesson utilized CRE tenets of *academic skills and concepts*, *critical reflection*, and *cultural competence.* For this activity, students chose a partner, and the team obtained an Eevee (a Pokémon character). Each Eevee had six strands of DNA associated with six different expressed genes. The students had to transcribe and translate these strands to determine the RNA and amino acid sequences. Students then used the combination of amino acids to determine the proteins expressed, and used the expressed proteins to discover the Eevee type and what their character would morph into.

## Context

At Rocky Turtle High School (RTHS) (pseudonym), a large suburban high school, this year I taught 41 grade-level biology students divided into two different classes. Based on the enrollment database, my school's racial/ethnicity percentages were approximately 46% White, 38% Black, 5% Hispanic, 4% Asian, and 7% of all other races. My grade-level biology classes' demographics were 52% Black, 30% White, 9% Hispanic, 7% Asian, and 2% two or more races. This data demonstrates a typical overrepresentation of historically underserved communities in my grade-level biology classes.

## Participants

Any student in my grade-level biology classes who chose to participated in the questionnaires and exit tickets was considered a participant. In qualitative research, generalization is not justifiable, and therefore "nonprobability sampling is the method of choice for most qualitative research" (Merriam & Tisdell, 2016, p. 96). In addition, it is common for purposeful sampling to occur in qualitative research as the goal of the research is usually to "discover, understand, and gain insight and therefore [a researcher] must select a sample from which most can be learned" (Merriam & Tisdell, 2016, p. 96).

Merriam and Tisdell (2016) outline that researchers should consider ethical issues ahead of time, including "protection of subjects from harm, the right to privacy, the notion of informed consent and the issue of deception" (p. 261). In this research study, I sought to improve classroom engagement, which should not harm those who did or did not participate. I used pseudonyms for my school and participants to protect students' right to privacy. I sent home permission forms for parent approval that informed them of my intentions and provided a full explanation of the study. I was clear that participation was not mandatory and that there were no negative consequences if they did not wish for their child to participate.

**The Rationale for Action Research**

Action research is typically conducted by those in an organization where the actions are cyclical, including observation, planning, action, and reflection to address problematic situations (Herr & Anderson, 2015). Teachers are constantly bettering our craft through testing and discernment of practical solutions to problems of practice. Action research provided the best approach to conduct and document this research. Many adjectives have been used to describe action research, including *meaningful, useful, multifaceted, relative*, *readable, problem-solving, and positive feedback* (Efron & Ravid, 2013; Herr & Anderson, 2015). Action research creates a learning environment for those on the front lines of teaching our youth, thus empowering and motivating teachers.

This empowerment and motivation for this teacher research was the application of CRE in my grade-level biology classrooms to determine ways that improve student engagement. As an insider, action research allowed my substantive examination of these areas (Herr & Anderson, 2015). It was the best avenue for this type of research, where the "boundaries among theory, research, and practice are blurred" (Efron & Ravid, 2013, p. 5).

My interest in CRE began as I saw pieces of CRE in my lessons and noticed that those pieces seemed to empower grade-level students. That began my interest in conducting an intentional study on CRE-enriched lessons and their effect on engagement. Convery & Townsend (2018) state that action research is "a fluid and contestable research approach which needs to be justified according to the situations and settings in which it is adopted" (p. 507). Herr & Anderson (2015) say that action research is usually focused on improving a specific setting instead of "generating knowledge that can be shared beyond the setting" (p. 6). Efron & Ravid (2013) discuss a disconnect between research and practice that are often found in traditional research. My research used theory and other action research best practices to implement instructional strategies designed with CRE to investigate which are most engaging for students in grade-level biology.

Herr & Anderson (2015) describe one assumption of action research as the research spiral of planning, acting, observing, and reflecting. My qualitative action research study utilized this methodology. Initially, the design was primarily based on theory, multiple studies, and personal experience. As the study progressed, this knowledge base was combined with study data to make any adjustments and reflect on the study. Finally, all data was processed and analyzed, with all information gathered throughout the planning stages and completion of the study.

## Data Collection and Analysis

A qualitative study provided the best framework to conduct this action research study. Merriam & Tisdell (2016) describe qualitative research as "understanding the meaning people have constructed" (p. 15). This action research study sought to investigate whether using CRE strategies influences student engagement. Merriam & Tisdell (2016) indicate that qualitative research is an inductive process used by a researcher as the primary data collector focusing on meaning and understanding, resulting in detailed descriptions. This research was significant to my setting. I was the primary instrument in using an inductive process to discover the impact of CRE and recording detailed descriptions to document and share this qualitative action research study. Students who chose to complete the survey and exit tickets participated in the study.

**Student Surveys**

The initial and final survey was administered anonymously. One part was a Likert scale questionnaire, and the other part was an open-ended questionnaire. The survey allowed me to gauge student perceptions at the start and end of the study. The Test of Science-Related Attitudes (TOSRA) (Fraser, 1981) and What is Happening in this Class? (WIHIC) (Aldridge & Fraser, 1999) statements and questions were adapted and used in this survey.

**Exit Tickets**

Exit tickets were another data collection tool that students completed at the end of each of the five CRE-enriched lesson. The exit tickets contained Likert scale questions followed by open-ended portions where student could explain why they answered a certain way. The exit tickets had three two-part questions. First, the survey asked students to rank their engagement, on-task behavior, and active participation on a scale of 1-5. After each ranking, students explained why they answered the way they did.

**Observations**

Teacher observations were conducted during each CRE-enriched lesson. These observations sought to gather information about the big picture from the teacher perspective. The classes were recorded, and the resulting videos were transcribed digitally. This observation data was combined with other data sources to better understand the students' levels of engagement during the study and what factors contribute to engagement. Observations were most appropriate for this study to allow for continuous and further review of student engagement resulting from CRE-enriched lessons.

**Data Analysis**

The qualitative data was collected and analyzed using emergent themes for this qualitative action research study. In qualitative research, the researcher analyzes data generated and decides how to proceed (Merriam & Tisdell, 2016). Merriam and Tisdell (2016) recommend beginning data analysis as soon as data is generated so that classification and interpretation can start and inform future direction. The first round of data analysis began with the initial student survey and the first CRE observation. Next, I reviewed the data creating a document to capture my "reflections, tentative themes, hunches, ideas, and things… [I] want to ask, observe, or look for in the next round of data collection" (Merriam & Tisdell, 2016, p. 196).

Several rounds of data analysis were coded to identify emerging themes and trends that informed future directions. The second data set was compared to the first set and was used to inform future decisions (Merriam & Tisdell, 2016). This study began as an inductive process and transitioned to a deductive process (Merriam & Tisdell, 2016). Member checking and disconfirming evidence were used to improve this study's rigor.

## Significance of the Study

My students and I were the significant benefactors in this study as we learned what better educational experiences are. I gained valuable information on the application of CRE in my classroom and learned a great deal about grade-level student engagement. I think that students gained a love for science and education. As an extension, I hoped that sharing outcomes of my study could be responsible for a curriculum shift at my school in favor of grade-level students becoming more engaged in biology and other classes. I think the use of CRE can impact EOC scores, graduation rates, and general academic outcomes to alter student trajectory and improve lifelong success.

## Limitations

One limitation was that this study is situated in my classroom and therefore was focused on a single teacher's practice in one school. Another limitation was the initial survey had 34 participants, while the final survey only had 24 participants. I think this was because it was the end of the study and there was a bit of survey fatigue. Another limitation for this study was that it took place over 5-weeks. The influence of CRE on engagement should be a much longer study. Even though it took place over a short time period, there were positive outcomes associated with engagement. Another limitation is that there was no recording of a non CRE-enriched lesson. I think this would have supported the study even more and was not anticipated as needed pre-study. However, the themes that arose from this study are all tied to the literature surrounding CRE, and therefore supported by the literature.

### Organization of the Dissertation

The first chapter of this dissertation introduced the problem of practice and discussed related literature, the research design, and data collection methods for this research study. Chapter Two takes a deeper dive into the background of the problem, theoretical framework, and other related literature. Chapter Three discusses the methodology used in the study, and Chapter Four presents the findings, including data presentation, general results, and data analysis. Finally, Chapter Five discusses the implications of key findings and considers future directions to expand the study's implications further.

## Glossary of Terms

*Codon* - a sequence of three nucleotides which together form a unit of genetic code in a DNA or RNA molecule (Oxford English Dictionary (OED), 2022).

*Culturally Relevant Education* – a conceptual framework that recognizes the importance of including students' cultural backgrounds, interests, and lived experiences in all aspects of teaching and learning within the classroom and across the school (Ladson-Billings, 2009)

*CRE-enriched Lessons* – Lessons designed using several markers of CRE: *academic skills and concepts*, *critical reflection*, *cultural competence,* and *critique discourses of power* with the purpose of centering learning, normalizing diversity,

*Communal* - "A way of knowing and being that focuses primarily on interpersonal relationships, community and the collective betterment of a group as the fundamental tenet" (Emdin, 2007, p. 372).

*Relevance* – learning experiences that are either directly applicable to the personal aspirations, interests, or cultural experiences of students or that are connected in some way to real-world issues, problems, and contexts (Great Schools Partnership, 2013)

*Enacting Care* – A focus on high expectations through supports and positive input, allowing revisions and scaffolding to help students understand what a quality product is, and not letting students to get by with lacking or mediocre work.

*Engagement* as the degree of on-task student behaviors and active participation in the classroom (Harris, 2008).

*Sense of Belonging* – "the feeling of security and support when there is a sense of acceptance, inclusion, and identity for a member of a certain group" (Cornell, 2022, para 1).

*Transcription* - the process by which genetic information represented by a sequence of DNA nucleotides is copied into newly synthesized molecules of RNA, with the DNA serving as a template (OED, 2022)

*Translation* - the process by which a sequence of nucleotide triplets in a messenger RNA molecule gives rise to a specific sequence of amino acids during synthesis of a polypeptide or protein (OED, 2022).

*Quality Relationship* - A focus of this study on care and development of a quality relationship with students where the teacher is knowledgeable about student interests, backgrounds, and overall needs, serving as a responsible adult influence and coach.

# CHAPTER 2

# LITERATURE REVIEW

## Problem Statement

At my school, higher percentages of students are disengaged in grade-level biology compared to honors biology, both of which are high-stakes testing environments. There are various effects of high-stakes tests on classrooms worldwide, distorting practical work, leading to ineffective instructional strategies that disengage students (Childs & Baird, 2020; Erduran et al., 2020). Disengaged students are at a higher risk of dropping out of high school (Henry et al., 2012). In the US, lower-tracked courses contain higher numbers of students that may not graduate (Oakes, 1992). Some researchers blame the absence or devaluing of culture in schools and the classroom (Baber, 2012; Howard, 2010; Tate, 1997) and academic tracking practices (Domina et al., 2017). The problem of practice for this study is that there are disproportionate numbers of students that are disengaged in grade-level biology.

## Purpose Statement

Disengagement in grade-level courses, biology included, is a common problem for many at my school. Based on my professional experiential knowledge of my context and my students, I have recognized that many students in grade-level courses lack authentic engagement. While reading about CRE, I noticed elements of CRE that may work well to engage more students, which motivated me to engage in this research. This study aims to increase engagement in my grade-level biology classes by implementing

CRE-enriched lessons. In order to serve this purpose, the following research question guided my collection of data:

1. How does the use of CRE-enriched instruction impact grade-level biology student engagement?

This chapter presents a review of the literature surrounding CRE practices and how these practices could impact student engagement in a grade-level biology class. Machi and McEvoy (2016) state that a literature review associated with an intervention must be conducted to document current knowledge on the topic of study. Further, they outline a six-step process to be successful: “recognize and define the problem, create a process for solving the problem, collect and organize the information, discover the evidence and build findings, draw conclusions, communicate and evaluate the conclusions” (Machi & McEvoy, 2016). These were the steps that guided the creation of this review of the literature. Using these steps provided a deep understanding of the background of the problem of practice. This study sought to design CRE-enriched lessons and measure student engagement and the factors that influence this engagement.

In creating this literature review, I accessed databases through the Thomas Cooper Library at the University of South Carolina, including Dissertations and Theses Global, ERIC (EBSCO), Google Scholar, JSTOR, PASCAL, ProQuest, SAGE Reference Online, and Taylor & Francis Social Science and Humanities Library. In using these databases, I searched for keywords and topics including *culturally responsive, culturally responsive pedagogy, achievement of African American students, culturally responsive education, culturally responsive teaching, culturally responsive curriculum, engagement, cultural* *competency*, *culture in science*, *culturally relevant science*, *engagement*, *high-stakes testing*, *academic tracking*, and *culturally responsive science classroom*.

## Chapter Organization

This chapter begins with the purpose of the research and statement of the problem of practice, followed by barriers in grade-level biology. The section continues with a discussion of the theoretical framework of constructivism and CRE that guided this study. Finally, the chapter discusses research studies using CRE and engagement.

## Background on the Problem of Practice

The United States continues to fall behind other countries in science and mathematics, as determined by standardized testing (DeSilver, 2017). These deficiencies have prompted laws like No Child Left Behind (NCLB) (2002) and Race to the Top (RTTT) (2008) in recent years that have driven the era of standards-based teaching and high-stakes testing and accountability (Buxton, 2010). As a result, practical work in science is being distorted by policy-driven, high-stakes tests, resulting in ineffective instructional strategies that leave students disengaged (Childs & Baird, 2020; Erduran et al., 2020).

Biology is a science course ranked among the courses that have seen the steepest engagement decline (Gottfried et al., 2009; Patall et al., 2018). In addition, students typically lose engagement as they progress through grades (Lepper et al., 2005). As a result, engagement in the secondary science classroom does not look promising. Therefore, grade-level biology needed an intervention to help students engage more in science to understand life's inner workings better.

Several barriers to engagement that are distinct to secondary grade-level biology include high-stakes testing, tracking practices, and teaching practices. High-stakes testing results in ineffective instructional strategies that directly lead to disengagement (Childs & Baird, 2020; Erduran et al., 2020). Tracking practices affect the level of academic rigor (Bavis, 2016). The following section will discuss these areas and how they prevent grade-level biology students from being engaged.

**High-Stakes Testing**

A Nation at Risk, published in 1983, is credited with transforming schools in the United States toward standardization and accountability using high-stakes tests (Ravitch, 2010). High stakes refer to the number of accountability measures, or stakes, associated with a single summative test. As a result, many stakeholders are affected, including students, teachers, administration, schools, and districts, where significant decisions about policy and funds result (Polesel et al., 2014). More recently, NCLB (2002) and RTTT (2008), the current federal initiatives, are an attempt to ensure adequate education for K-12 students (Buxton, 2010). As a result of these federal initiatives, the South Carolina State Board of Education signed the Educational Accountability Act of 1998, which required EOC tests for benchmark courses (SCDOE, 2022). As a result, since the 2010-2011 school year, all students taking the benchmark course, Biology I, take the EOC, which is weighted as 20% of students' final grades (Education Accountability Act, 2016). In addition, these test scores determine school and district effectiveness in their regular reports to the federal government as an accountability measure for the State of South Carolina.

In a high-stakes testing environment, there is a relationship between changes to classroom practices that are induced by the test and the reproduction of inequalities in education (Au, 2008). Content coverage and teacher-centered instruction constrain these classrooms. Active student-centered learning is limited because it takes more time, which sets students up for failure (Calabrese Barton, 2001; Erduran et al., 2020; Misco et al., 2011). Significant themes associated with a class that is associated with a high-stakes test is that there are constraints in appropriate content, content delivery, and teacher pedagogy (Au, 2008). The content found on the test is the most appropriate topic in the classroom. The delivery methods chosen will be the quickest way to cover the content. In addition, teacher pedagogies are teacher-centered and lecture-based, focused on the rote-memorization of disparate facts solely determined by the content and conceptual understandings assessed by the test (Au, 2008). These render few opportunities for student-centered independent learning and practically eliminate opportunities for teachers to support students with diverse learning needs (Misco et al., 2011). Au (2008) makes the argument that there is a relationship between the constraints of high-stakes tests and the "reproduction of race-based and class-based inequalities in education" (p. 639).

Teaching practices can either contribute to or thwart student engagement. Culturally relevant practices can offset the superficial understanding that many educators have of culture and provide a space where all students feel their culture is valued (Ladson-Billings, 1995a & 1995b, 2009). In addition, culturally relevant practices have demonstrated improvements in engagement in the classroom (Milner, 2011; Johnson, 2011).

When teachers transition their teaching practices to be more equitable, they generally give up some control of the classroom. This transition demonstrates breaking corporate ideological structures often found in traditional classrooms (Emdin, 2007). One of the most revealing findings from Emdin (2007) is that the corporate structure of the classroom, not the content, may cause African American and Latino students to be disengaged. Communal structures are most closely aligned with CRP (Emdin, 2007) and were a pedagogical practice implemented in this research study due to Emdin's findings.

## Academic Tracking

Tracking, or ability grouping, separates students into homogenous groups according to their ability in different subjects (Atkos et al., 2004). Historically, there were three tracks: vocational, general, and academic; In the mid to late 20th century, this practice reduced tremendously (Chiu et al., 2008). Oakes (1985) first revealed the inequality of tracking practices. Several reports concluded that lower tracks do not prepare students appropriately for the current job market (Burris et al., 2008). As a result, many schools removed tracking practices to replace them with different categorizations of students based on ability (Burris et al., 2008). For example, grade-level, honors, or advanced placement courses would be available. These courses offer different levels of academic rigor (Bavis, 2016). For example, my school's grade-level course is termed *college preparatory*, commonly called *CP*. Nevertheless, homogenous grouping is a common ingrained practice in secondary schools across the United States (Chiu et al., 2008).

This level of tracking has been beneficial for some, but it is disadvantageous for lower-tracked students (Domina et al., 2017). Domina et al. (2017) describe five dimensions of tracking systems found within schools. They are

> (1) the degree of curricular differentiation, (2) the extent to which sorting practices generate skills-homogeneous classrooms, (3) the rate at which students enroll in advanced courses, (4) the extent to which students move between tracks over time, and (5) the relationship between track assignments across subject areas (p. 293).

Based on these dimensions, Domina et al. (2017) claim that schools are perpetuating inequity through the "production, maintenance, and legitimation" of organizational level tracking (p. 293). The research of Oakes (1992) reveals the particularly negative impact that tracking practices have on "low-income, African American, and Latino students" who are assigned disproportionately to lower-tracked courses (p. 12). These negative impacts on those in lower-tracked courses include widening achievement gaps between high and low ability groups and lower self-confidence, graduation rates, occupation status, and enrollment in gifted and talented programs (Oakes, 1992). Tracking reduces the opportunities for learning and involvement for lower-tracked students (Oakes, 1992).

In schools that have been de-tracked, Bavis (2016) reports that de-tracking has "provided greater access and opportunity for all" (p. 389). The outcomes were higher school-wide achievement scores, more robust learning environments, higher expectations, and greater access to honors and advanced placement courses for lower-tracked students.

### ***Deficit Thinking***

Education professionals often see grade-level courses through a deficit frame because there is a disproportionate number of historically marginalized and low socioeconomic status students in low-tracked courses (Betrand & Marsh, 2021). Betrand & Marsh (2021) state that teachers' typical excuses for low-tracked students' poor standardized test performance are disengagement, familial, or cultural factors. To perform poorly is the standard expectation of low-tracked students' performance (Betrand & Marsh, 2021). Milner discusses the effect of the interplay between social identity and schooling (Milner, 2009) and how negative signals can contribute to the disengagement of Black students. In addition, this belief is true for Hispanic populations (Hagiwara et al., 2011) and those who identify as LGBTQIA (Aronson & Laughter, 2020). It is not students' lack of ability that perpetuates these gaps but the educational system itself (Betrand & Marsh, 2021; Emdin, 2016; Howard, 2010). The system is not helping students found in lower-tracked courses.

The qualitative action research study herein attempted to neutralize the effects of the barriers described above through the use of CRE to improve engagement in the classroom. The research in this field is supportive of positive student outcomes through the use of CRE. Poor student engagement is a precursor behavior for students that drop out of school (Henry et al., 2012). Focusing on improving engagement through CRE may benefit lower-tracked biology students where there may be a disproportionate number of students that are disengaged, and therefore, at-risk of dropping out of high school (Betrand & Marsh, 2021; Finn, 1993; Oakes, 1995). The following section will describe the theoretical underpinnings of this study.

## Theoretical Framework

This qualitative action research intervention used CRE-enriched lessons to foster engagement in grade-level biology. *Constructivism* is the broader theory upon which CRE situates itself. Constructivism is grounded in the belief that learners construct new meaning by building on their prior experiences through social interactions and observation (Applefield et al., 2000). CRE theory is nested in constructivism and is an amalgam of CRT and CRP, where the learners can use their cultural references to learn new material (Aronson & Laughter, 2016).

CRE provides the most comprehensive, inclusive, and appropriate framework for a science classroom and outlines constructivist methods as a marker (Aronson & Laughter, 2016). Johnson (2011) claims there is a complementary nature between high quality science instruction and CRE. In addition, South Carolina State Science Standards align with constructivist methods (NSTA, 2014). Moreover, the framework by which the SC State Standards are derived outlines an equity component as a requirement (Pratt, 2012). This research project chose CRE because of its complementary foundations with SC Science Standards. In addition, the theoretical framework is vital in research as it provides the structural framework that grounds the study (Grant & Osanloo, 2014). This section describes constructivism's history and tenets and then does the same for CRE.

### Constructivism

*Constructivism* is a learning theory upon which this study situates itself. A theoretical foundation is essential as it provides a lens to view research. Aronson & Laughter (2016) suggest constructivist methods as the best methods for CRE. Constructivists believe "individuals seek understanding of the world in which they live and work" (Creswell, 2014, p. 37). Abdal-Haqq (1998) explains constructivism as a student-centered approach to learning in the classroom that includes instructional strategies of "active engagement, inquiry, problem-solving, and collaboration with others" (p. 2). These strategies are those that I believe best align with CRE and its use in the biology classroom.

Given the recent rise in the popularity of constructivism, it is not a new learning theory. Constructivism is built from the contributions of Piaget, Dewey, Vigotsky, and Bruner (Applefield et al., 2000), where students learn by actively constructing meaning instead of passively receiving the knowledge (Piaget, 1977). Bruner (1966) describes constructivism as a discovery type of learning. The construction of knowledge instead of mere transmission is the basis of constructivism (Applefield et al., 2000). Students filter what they are learning through their current knowledge and modify or construct their understanding of natural phenomena (Applefield et al., 2000).

A constructivist approach to classroom learning closely aligns with how scientists conduct research. Scientists discover natural phenomena, develop an understanding of them through prior experiences, and explain their findings in published research (Freedman, 2018). Applefield et al. (2000) report that there seems to be a shift in paradigm toward constructivist perspectives in the guidelines for math and science in the United States. The Framework for K-12 Science Education outlines active engagement in science as an overarching theme (Pratt, 2012), a key component of constructivist theory. In addition, the framework promotes "building on prior interests and identity, and leveraging students' cultural funds of knowledge" (Pratt, 2012). These examples demonstrate the complementary nature of the national standards and, therefore, the State Standards of South Carolina.

When students build their understanding, it yields more meaning and their understanding lasts longer (Texley & Rudd, 2020). Science class is the perfect place to enact a constructivist approach, as scientists do. Constructivism was appropriate for this study because it is a theory upon which the science standards originated for the State of South Carolina. In addition, there is reciprocity within CRE theory that delineates constructivist methods as most appropriate (Aronson & Laughter, 2016).

**CRE**

CRE is an inclusive and comprehensive theory that uses culture to influence teaching, pedagogy, and education (Aronson & Laughter, 2016). Teachers who use CRE employ cultural references to build *academic skills and concepts*, *critical reflection* of situated personal contexts, *cultural competence* to "develop pride in [students'] own and others' cultures," and *critiques of discourses of power* to pursue social justice (Aronson & Laughter, 2016, p. 167).

The use of culture to improve educational outcomes for ethnic groups has been documented well for the last four decades as a response to poor student achievement (Ladson-Billings, 1995a). Other works that discuss this type of work have used the following terminology: *culturally appropriate* (Au & Jordan, 1981), *culturally congruent* (Mohatt & Erickson, 1981), *culturally responsive* (Cazden & Leggett, 1981; Erickson & Mohatt, 1982), and *culturally compatible* (Jordan, 1985; Vogt, Jordan, and Tharp, 1987). Later, the work of Irvine (1990) was more comprehensive to include contextual influences and expectations termed *cultural synchronization,* which was important because its view was counter to deficit orientations. Much of this work was known for the flexibility it provided students from various cultural backgrounds to connect with classroom content which could prove to be of great value in a grade-level biology classroom.

Ladson-Billings (1995b) created the first pedagogical, theoretical model in the field, coined *CRP*. Her theoretical model addressed academic achievement and affirmed students' cultural identities in the educational setting (Ladson-Billings, 1995b). The theoretical model consists of three tenets outlined by Ladson-Billings (1995b): "an ability to develop students academically, a willingness to nurture and support cultural competence, and the development of a sociopolitical or critical consciousness" (p. 483). First, Ladson-Billings (1995b) discusses academic achievement as the belief that all students can learn. Second, cultural competence is valuing and utilizing the culture and background to drive instruction. Last, critical consciousness teaches students to challenge structural inequities in society within institutions (Ladson-Billings, 1995b).

Another scholar in the field of educating diverse students is Geneva Gay (2000) who published her theory of CRT in 2000. This theory is an instructional theory that outlines "developing a knowledge base about cultural diversity, including ethnic and cultural diversity content in the curriculum, demonstrating caring and building learning communities, communicating with ethnically diverse students, and responding to ethnic diversity in the delivery of instruction" (Gay, 2002, p. 106).

Aronson and Laughter (2016) delineate the essential elements of CRT, starting with *multidimensionality*, which encompasses the intricacies and wealth of knowledge associated with cultures, including perspectives, contributions, and general experiences of ethnically diverse students. They indicate that empowerment involves setting and maintaining high expectations, socially and academically, for all students with an unconditional commitment to their success. The authors indicate that CRT is transformative in utilizing students' strengths to guide curriculum and instruction, thus transforming schools from within the classroom. Gay (2000) defines *humanistic* as "concerned with the welfare, dignity, and respect of" all individuals (p. 44). *Normative* and *ethical* seek to normalize diversity and support students "socially, emotionally, and politically" (Aronson & Laughter, 2016, p. 165).

CRE draws from the work of Geneva Gay's ideas about CRT and Gloria Ladson-Billings' theory of CRP to become an inclusive framework that includes both teaching and pedagogy (Aronson & Laughter, 2016). Dover (2013) was the first researcher to coin *CRE* as a broad term. However, Aronson & Laughter (2016) delineated the theoretical underpinnings and markers of CRE: *academic skills and concepts, critical reflection, cultural competence,* and *critique of discourses of power* (p. 167).

### ***Academic Skills and Concepts***

Aronson and Laughter (2016) align "social and academic empowerment" and multidimensionality from CRT with academic achievement from CRP into one marker, which they term "academic skills and concepts" (p. 168). This study will focus on academic skills and concept development geared toward students disengaged in biology. Providing an inclusive environment focused on academic skills and concept development was significant in this study. Enacting care falls under this category as it is the unconditional support of students, not accepting failure as an option, and holding students to high expectations. Students' cultural references were valued and included in lessons as cultural assets. Aronson and Laughter (2016) explicitly state that constructivist methods help "develop bridges connecting students' cultural references" to the classroom (p. 167). An inclusive classroom environment views student culture as an asset or bridge to develop academically (Ladson-Billings, 1995a).

### *Critical Reflection*

CRE outlines critical reflection as an amalgam of cultural validation from CRT and cultural competence from CRP (Aronson & Laughter, 2016). They describe critical reflection as a vital component to any type of growth concerning creating an equitable classroom with inclusive curricula. This study will use critical reflection from the student and teacher perspectives to document and analyze changes in engagement. Critical reflection will occur from the stance that all student cultures are valued and accepted. Inclusive curricula encompassed building community, culture inclusion, and student choice in the classroom. This study also sought to value student voice as a vital component which is why so many data sources in this study are the voices of students. In addition, each CRE-enriched lesson has students analyzing their engagement, which supports students to become more aware of factors that impact their engagement.

### *Cultural Competence*

Aronson and Laughter (2016) outline cultural competence with the principle from CRT that serves to address "social, emotional, and political comprehensiveness" (p. 168). The goal of this marker is for students to gain confidence in their own beliefs and contribute to the broader culture. This confidence will help them to have the "chance to improve their socioeconomic status and make informed decisions" about their life (Ladson-Billings, 2006, p. 36). This tenet of CRE also encompasses quality relationships and building community because when students develop relationships with others, they are gaining competence in the culture of others and situating themselves within the classroom. I want students to be confident in their abilities and comfortable with their identity in my classroom and beyond.

***Critique Discourses of Power***

Aronson and Laughter (2016) outline critique discourses of power with sociopolitical consciousness from CRP and "school and societal transformations" and "liberation from oppressive educational practices and ideologies" with CRT (p. 168). Providing communal structures in the classroom is an example of an educational practice that critiques discourses of power. This tenet is about identifying and breaking down barriers associated with power in the classroom and school. Using CRE theory, this action research study will adapt teaching practices based on South Carolina State Standards to be more culturally relevant to the students in grade-level biology classes.

CRE and the standards for the state of South Carolina are complementary. In 2011, the NRCNA released *A Framework for K-12 Science Education,* leading to the creation of Next Generation Science Standards (NGSS) (National Science Teaching Association (NSTA), 2014). South Carolina is one of the states that created its framework guided by the NRCNA's Framework (NSTA, 2014). An entire section in the framework outlines a need for promoting equity in science classrooms with an asset-based view of student cultures and what they contribute to the classroom (Pratt, 2012). An example provided in the framework is that cultures that utilize storytelling would be an asset for engaging in argument-driven science inquiry (Pratt, 2012). Thus, the biology standards for the state of South Carolina arose from a framework created to promote equity in science education. CRE also delineates constructivist methods as the best way to promote the development of academic skills (Aronson & Laughter, 2016). Scientific inquiry provides a natural way for students to construct their meaning from science (Johnson, 2011). Therefore, science education, science and engineering practices, and state biology standards align well with constructivist methods because students construct knowledge using their interests.

CRE is an appropriate choice for my study because it is a comprehensive and inclusive theory that thoroughly defines what equitable education practices should be. Because CRE is an amalgam of a teaching and a pedagogical theory, this study used CRP to design the curricular framework and CRT to select the instructional strategies most appropriate for the curricular framework. As a result, CRE offered the most comprehensive framework upon which to base this study. Both pedagogy and instruction must be diverse and flexible to meet the needs of all students, or it is limited. Student learning and understanding are the greatest when both are well planned and catered to everyone in the classroom.

**Study Framework**

Within a framework of CRE and constructivism, I designed and analyzed CRE-enriched lessons to determine whether they were engaging from the teacher and student perspectives during this study. The methods used in this study were derived from both constructivism and CRE. Constructivism and CRE formed the study framework to answer whether CRE-enriched lessons impact engagement in grade-level biology.

## Related Research

Science influences and affects every aspect of life in the modern world (National Academy of Sciences Engineering Medicine, 2016). The National Academy of Sciences set out to promote equity in the science classroom by publishing A Framework for K-12 Science Education (NRCNA, 2011). Aronson and Laughter (2016) provide numerous examples of using CRE in various subjects to stimulate more research in the area of CRE. There are many calls for more research in the area of CRE in science (Johnson, 2011; Milner, 2009, 2011; Seriki, 2018). Aronson & Laughter (2016) call for more research that "documents connections between culturally responsive pedagogy and student outcomes" and "what CRP means and looks like in the classroom" because discourses surrounding educational reform have marginalized this type of work (2016, p. 164).

### CRE

This section contains many research studies that develop the conceptual and theoretical framework that situates my study. The following section will begin with a discussion about research found in general education using CRE, transition to research studies in science using CRE, and finally, discuss CRE and engagement.

#### *Engagement with CRP*

In a qualitative action research study, Cruse's (2019) dissertation reports a "disconnect between potential and performance" of middle school-age African American males using MAP reading scores as the basis for her interest in the effect of CRP on self-efficacy and engagement (p. 3). Her purpose was to increase the engagement or willingness to engage African American males through CRP. The teacher focused on three to five African American males in a grade level class and collected evidence through semi-structured focus group interviews, surveys, and observations. She states, "Assessment scores made it apparent that students possessed the needed skills, but their performance did not reveal these results" (p. 93). Her results indicate that there were no gains in self-efficacy. However, there was an increase in engagement.

### ***Culture***

McVee (2014) conducted a qualitative study on language, literacy, and culture professional development on 24 preservice and in-service teachers. The professional development helped teachers to incorporate culture into the classroom. One of the teachers in the professional development course, Jenny, had a "fair amount of skepticism" approach to the class and described many of the authors as "teacher bashing" (McVee, 2014, p. 6). Jenny's views changed throughout her professional development, not because of the readings, but because she would "try out" some of the suggestions. Jenny's stance slowly migrated toward that of Ladson-Billings' position as she developed a very successful month-long Puerto Rican themed unit. McVee (2014) discusses the importance of culture inclusion in the classroom and demonstrates that teacher reflection plays a vital role in the change in practice regarding culture and identity.

### ***Classroom as Family***

In an aim to understand how teachers' pedagogical relations can enact care in their classroom and community, Kathleen Gallagher (2016) writes about an eighth-grade teacher's use of the "metaphor of 'family'" in an urban classroom (p. 1). Mrs. Langley's pedagogy and teaching practices were used as an example to hone in and describe in detail what was involved in "care" and viewing interactions that occur in the classroom like that of a family. For Mrs. Langley, families are "a social grouping wherein we are bound to each other, must care for, and are accountable to one another," and relationships are essential (Gallagher, 2016, p. 23). Mrs. Langley took the metaphor of family to mean the bond of obligation, commitment, trust, the ability to start fresh every day, and absolute safety. She was careful that the family metaphor to not conflict with the home. The work of Mrs. Langley closely aligns with CRE.

### *Impact of CRP*

Langlie (2008) conducted a quantitative study using the National Education Longitudinal Study of 1988 in combination with CRP on "mathematics achievement of black and Hispanic tenth grade students" (p. 6). Her study aimed to understand CRP's impact on the mathematics achievement of Black and Hispanic high school students. Multiple variables have a positive relationship with mathematics achievement, including socioeconomic status, parent education, and the strength of the teacher community. Langlie's study also disaggregates the above factors by race, and the results have the mean family income for African Americans at 53% and Hispanics at 63% of White students. The statistically significant results of her study demonstrate a "multiplicative effect of Conceptions of Self and Others" on Black and Hispanic students. These results support CRE as an effective tool to improve educational outcomes.

## Engagement and CRE

Science education became more structured due to interest in the need for technological advances associated with the industrial revolution (Bybee, 2010). Progressive educator John Dewey recommended inquiry as a potent educational process of a natural discovery (Bybee, 2010). In the 1960s, Sputnik landed on the moon, and the United States was left scrambling to catch up with Russia (Schiro, 2013). Thus, the US launched the National Science Foundation, which focused on developing science curricula in schools across the United States (Schiro, 2013). However, gender and racial inequality in science have been a problem, so much so that Project 2061 seeks to correct the curriculum available (Flinders & Thornton, 2017). Many authors state that CRE is undertheorized in science and could help the US gain ground in the areas of science (Aronson & Laughter, 2016; Johnson, 2011; Milner, 2011; Seriki, 2016).

### *Culturally Relevant Science*

Djonko-Moore et al. (2018) used a week-long summer camp for elementary school students to enact culturally relevant science, hoping to improve urban students' understanding of nature, the environment, resources, and how human activities affect ecosystems. A qualitative study used pre-test/post-test data, focus group interviews, journals, and student documents. The findings were that engagement was positively influenced by CRE in this summer camp.

In a longitudinal qualitative case study, Johnson (2011) reports on two teachers of middle school students. This study aimed to examine the transformation in practice and beliefs of two teachers participating in a transformative professional development utilizing culturally relevant science pedagogy in low-performing, urban school districts with predominantly Hispanic English language learner populations.

One of the teachers, Ms. Fields, believed that relationships were essential to being a good science teacher. She integrated culture into her classroom and "attended many afterschool activities of her students" (p. 186). Mr. Roberts used mutual respect with demonstrated care, which translated into his students' success. Ms. Fields "provided multiple opportunities and a variety of activities for students to deepen their understanding of concepts grounded in the context of the real-world" (p. 182). In addition, she held them to high expectations and "cared enough to hold them responsible for learning" (p. 186). Ms. Field's and Mr. Robert's focus was high expectations and care.

Moreover, Mr. Roberts utilized a collaborative community which demonstrates relinquishing control of the classroom and valuing student culture. As a result, they became culturally responsive teachers and found a more effective instructional environment for Hispanic students. Further, they found that high-quality science instruction is complementary to components of culturally relevant instruction, such as the no one-right answer approach, scaffolding of learning, and organization of the classroom as a community of learners. Johnson's (2011) research supports collaborative learning, constructivist methods, communal structures, the importance of quality relationships, and enacting care. My study used these elements as a result.

### *CRP and Engagement*

In 2011, Milner conducted a qualitative research study investigating the efforts to build cultural competence in a White science teacher's ethnically diverse urban high school classroom. Through semi-structured and informal interviews, recursive, thematic processes, observations, and triangulation, Milner identified themes within Mr. Hall's pedagogy and teaching practices that allowed him to build cultural competence with his ethnically diverse students.

In this empirical work, Milner (2011) describes how Mr. Hall builds relationships, deepens his understanding of identity and race, and "implements a communal and collective approach" (p. 66). A key component to the success of Mr. Hall was providing students "with multiple opportunities for success" with classroom assignments and behavior modifications (p. 74). In addition, he built trust with students through the use of second chances, and this "motivated students to remain actively engaged in the classroom" (Aronson & Laughter, 2016, p. 183). Finally, Mr. Hall built cultural competence by using personal narratives as a key feature in his classroom to keep students engaged in learning. My intervention used these qualities described in Mr. Hall's teaching. The key findings were developing a relationship inside and outside the classroom, a family style of care geared toward the classroom, high expectations allowing multiple opportunities for success, and personal narratives improved student outcomes.

***Corporate and Communal Structures***

Emdin's (2007) work is unique in investigating corporate and communal structures in the science classroom. It describes the often overlooked and misunderstood doxa of students of color. The article's purpose was to report on the existence of varying ideologies and perspectives within urban science classrooms and uncover the importance of focusing on student and teacher practices to bridge disconnections. He specifically discussed the existence of corporate and communal ideologies and the dynamics that create misalignment between the usage of the two belief systems.

In this qualitative study, Emdin uses his classroom to describe communal and corporate structures, outline their differences, and examine why their implementation accepts some students while rejecting others. Emdin (2007) builds communal structures and student agency through cogenerative dialogues. He posits that corporate classroom structures are problematic for African American and Latino/a students who are "accustomed to communal practices" (p. 334). The structures in a corporate ideological classroom tend to dismiss student value as part of the community, so they become disinterested and tend to disengage. He concludes by saying it may be the classroom structure causing students to be disengaged and not the content. He reports that the classroom structures must be interrogated to ensure communal practices are present.

## Summary

This study investigated the influence of CRE on student engagement in biology. A few studies connected increased engagement with CRE in science, and these studies were small in scale (Aronson & Laughter, 2016). CRE has not been used as a holistic approach to engaging more secondary biology students. CRE-enriched lessons have also not been analyzed through student perceptions of engagement. The key components of CRE are academic skills & concepts, cultural competency, critical reflection, and critique discourses of power. Each of these areas has been associated with CRE and should positively affect student engagement.

# CHAPTER 3

# METHODOLOGY

## Overview of Study

The previous chapter reviewed the relevant literature and the comprehensive theoretical framework for this study: constructivism and CRE. Constructivism is a learning theory, and CRE is an amalgam of teaching and pedagogical theories. This comprehensive framework will support this action research intervention study where CRE-enriched lessons were used in grade-level biology to measure the impact on student engagement.

## Problem Statement

As I look at the students in my CP or grade-level biology classes, I see a higher number of disengaged students than at other levels (Honors, AP and STEM). Disengaged students are more likely to drop out of high school, significantly reducing their quality of life (Henry et al., 2012). A disproportionate number of students may not graduate in lower-tracked classes across the country (Oakes, 1992). Several things could be contributing to this disproportionality. First, high-stakes testing constraints could contribute to ineffective instruction (Au, 2008; Childs & Baird, 2020; Erduran et al., 2020). Second, tracking practices could also be to blame because they leave lower-tracked students disadvantaged and unchallenged (Oakes, 1992). Lastly, the absence of student culture and the use of interests in lessons could contribute to disengagement

(Howard, 2010). Biology classes may be the perfect place to set the stage to improve engagement through CRE-enriched lessons.

**Purpose Statement**

The purpose of this study was to increase engagement by implementing CRE-enriched lessons. Therefore, the following research question guided the data collection measures in this study.

1. How does the use of CRE-enriched instruction impact grade-level biology student engagement?

This chapter will discuss the data collection and analysis methodology used in this study. It will include a detailed description of the design elements, including the study type, constructs, data collection plan; participants and characteristics; and researcher positionality. I will also outline details of data collection parameters, instruments, and tools used to collect the data. Next, there will be a discussion of data collection tools and their use, how materials were kept secure, the transcription process, and all procedures followed during the research study. After this, the methods used for data analysis and justifications for their appropriateness are discussed. Finally, there will be a summary at the end of this chapter, a brief synopsis of all sections.

## Research Design

This qualitative study examined an intervention for grade-level biology classes using CRE-enriched instructional practices and measured the impact on student engagement. This study used CRE (Aronson & Laughter, 2016) in combination with constructivism as the theoretical framework that outlined the methods in this section. I was a teacher-researcher using an inductive process as the primary data-gathering instrument to discover the impact of CRE-enriched lessons on student engagement.

Qualitative research methodology provided the best method to conduct this study because it investigated the understanding and meaning-making that "individuals or groups ascribe to a social or human problem" (Creswell & Creswell, 2018, p. 4). This design was appropriate because it analyzed engagement through student perceptions, authentic voices, and my observations. Therefore, my data provided thorough descriptions of all participants, their responses, and my own to seek out themes in the data to shed light on the influence of CRE on student engagement. One of the markers for CRE is the use of constructivist methods, which Creswell & Creswell (2018) align with qualitative research.

The methodological framework for this study centered itself within CRE, combining two different perspectives: those of the teacher and the students. It is important to include student voices as students could look engaged but be thinking about something entirely different. Several tools generated data, including surveys, exit tickets, and observations.

Based on the 2021-22 school database, RTHS is a large suburban high school with over 1,700 students. The RTHS racial breakdown was roughly 46% White, 38% Black, 5% Hispanic, 4% Asian, and 7% all other. About a third of our students qualify for free or reduced lunch. Biology is a state-required course with a state-mandated end-of-course test.

This intervention used a variety of methods to address my problem of practice and research question. Initial and final surveys that included Likert scale and open-ended questions measured students’ perceptions of their engagement. In addition, exit tickets were administered directly following each CRE-enriched lesson. In order to gain students' perceived levels of engagement and the associated student voices, all exit tickets had the same three questions requiring students to rank their level of engagement and give an open-ended explanation for that ranking. In addition, each CRE-enriched lesson was recorded. This observation data was analyzed for themes, compared to student perceptions, and combined with other data sources. Throughout the study, I recursively coded data to find emergent themes from all sources, which drove decision-making as we moved forward.

Throughout this study, students had "choice" in decisions made in the classroom, allowing them to feel valued and like experts (Ladson-Billings, 1995b) and to provide communal structures (Emdin, 2007). In addition, throughout the study, constructivist methods were the primary method of instruction, as this is a tenet of CRE (Aronson & Laughter, 2016). The intervention occurred over five weeks and included the following CRE-enriched lessons designed by the researcher: Class DNA, Rosalind Franklin's activity, DNA Technologies, Protein Affirmations, and Eevee Epigenetics.

Action research provided the best approach to conducting this study because it is cyclical (Herr & Anderson, 2015). The cycles of observing, planning, acting, and reflecting were used in this study as a model that allowed the research study to evolve as needed. I reviewed data from the initial survey looking for any elements that warranted changes in the initial plans of the study. As I collected data, I made decisions to modify future research. Action research provides the best methodology for my research because this research was focused on improvement of my teaching practices.

## Participants

My study involved two different grade-level biology classes with a total of 41 students. Grade-level (called CP) biology is the most basic course level of biology offered at my school. The combined demographics of the students in my grade-level biology courses were 52% Black, 30% White, 9% Hispanic, 7% Asian, and 2% other races. Nine of these students failed the first quarter of this school year. In addition, there were three second-year ninth graders, and 17 of these students had GPAs below 2.0. In addition, there were five students with special accommodations in these classes.

I obtained parental permission before anyone participated in the study. This permission could have been withdrawn with no consequence throughout the study. Therefore, there was no penalty for not participating in the study. The participants in this study were minors, so extra care was taken to protect this vulnerable population by use of pseudonyms for our school and participants. In addition, all identifying data was generalized, and all surveys and exit tickets were anonymous.

I gathered data from all students in my grade-level biology classes through anonymous surveys, anonymous exit tickets, and observations. Many qualitative research methods use nonprobability sampling because they want to learn about a particular subject. Random selection may not produce a subject that would benefit that type of study (Merriam & Tisdell, 2016).

Researcher positionality is critical in qualitative research because the researcher is the primary instrument (Merriam & Tisdell, 2016). Therefore, when conducting research, I need to be aware of the power differential between my students and me. This study attempted to reduce the power relation influence by using anonymous surveys, providing explicit intentions and explanations, and encouraging students to be truthful with their responses. To reduce researcher bias, I employed member checking by running the themes and data analysis by students to see if they have the same conclusions or ideas as I had (Creswell & Miller, 2000). Additionally, I used disconfirming evidence by looking for any evidence that did not align with my study (Creswell & Miller, 2000). These additional measures of member checking and disconfirming measures increased the study's quality and rigor (Lincoln & Guba, 1985).

## Data Collection Measures, Instruments, and Tools

Merriam & Tisdell (2016) say, "data collection is about asking, watching, and reviewing" (p. 105). In order to carry out this purpose, this study used surveys, exit tickets, and observations as data collection tools to determine if the perception of engagement changed as a result of the implementation of CRE-enriched lessons in grade-level biology.

### *Pre-study and Post-Study Survey*

This study involved one two-part survey that was given at the beginning and the end of the study. The first part of the survey focused on student perception and feelings of engagement in biology and school, CRE, and learning using Likert scale questions (see Appendix A). The Likert scale portion of the survey was developed in part by the researcher and in part using the Test of Science Related Attitudes (TOSRA) and What is Happening in this Class? (WIHIC). TOSRA test-retest coefficients ranged from 0.69 to 0.84 with a mean of 0.78); this indicates "quite good test-retest reliability" (Fraser, 1981, p. 4). WIHIC has been used in many studies as a predictor of learning outcomes (Aldridge & Fraser, 1999). TOSRA questions focus on assessing attitudes toward science

(Fraser, 1981), and WIHIC has an equity component used in this study (Aldridge & Fraser, 1999). Researcher-developed questions were patterned after TOSRA and WIHIC but were based on student engagement.

The Likert scale portion of the survey allowed me to understand how my students feel about my class, learning, CRE factors, science, and school. For example, some of the statements on the Likert scale portion of the survey were "I would prefer to find out why something happens by doing an experiment than being told" and "biology lessons are fun." Students chose from Likert-style responses that included *strongly agree, agree, neutral, disagree, and strongly disagree*. This survey allowed me to compare change in students' feelings before the intervention and at the end of the study. I used Google Forms to gather this information for ease of comparison for each question.

The open-ended portion of the survey also gathered data about CRE and engagement. The purpose of this portion of the survey was to gather descriptive data from students. A few questions on this portion of the survey are:

1. Are your interests used when learning biology?
2. What factors do you think make biology easy to engage in? What factors do you think make biology easy to disengage in?
3. Explain how a relationship with your teacher could influence how well you do in that class.

These questions were essential for this study to provide qualitative data that gives student voice to the general Likert scale portion of the survey responses. Both sections of this survey gathered data about students' perceptions of their engagement and was given at the beginning and end of the study.

### ***Exit Tickets***

This study used a three-question exit ticket (see Appendix B) that had students rank their level of engagement, on-task behavior, and participation on a scale from one to five and then have them explain why they answered that way. The questions are the following:

1. How engaged were you in class today?
2. To what degree were you on-task today?
3. To what degree did you participate in class today?

For each question, students ranked themselves and then explained why they answered that way. This exit ticket allowed me to compare their behavior during observations with their perceptions. After the first exit ticket was administered, an additional question was added that inquired about if they liked the activity. Students were then prompted to explain their response. Analyzing the exit ticket data provided a great picture of the overall level of engagement for each CRE-enriched activity. In addition, it provided data for student enjoyment associated with CRE-enriched lessons. Administration of the exit ticket occurred after each CRE activity.

### ***Observations***

Observations were conducted during every class period that CRE-enriched lessons were conducted. For the two classes with 5 CRE-enriched lessons, there were a total of 10 recorded lessons that were transcribed and reviewed for emergent themes. Observation data helped me see the big picture of engagement associated with CRE-enriched lessons. In addition, the data created from observations were combined with the data from the exit tickets and surveys to support the impact of CRE on engagement.

## Research Procedure

This qualitative action research study investigated whether CRE-enriched lessons increased engagement in grade-level biology utilizing CRE and constructivism as the theoretical framework. The following section outlines my methods. This intervention study occurred during the fourth quarter of the school year and took place over 12 class periods in my school's A/B-day schedule (consequently, it lasted five weeks in total).

Developing quality and caring relationships is fundamental to cultural relevance (Howard, 2013; Gallager, 2016; Johnson, 2011; Milner, 2009, 2011). Milner (2009) outlines care, quality relationships, speaking possibility, and high expectations as essential components of cultural relevance. Howard (2013) suggests that the most impactful needs for marginalized students include personal relationships, culture inclusion, tailored pedagogy, and disruption of inferiority notions. Many of these themes found within the literature of CRP and CRT are interwoven into the four tenets of CRE: *academic skills and concepts, critical reflection, cultural competence, and critique discourses of power.* The CRE-enriched lessons and my approaches to the classroom were designed based on these theoretical underpinnings, and the alignment of the lessons with the tenets are outlined in Table 3.1.

### *Intervention: CRE-enriched Lessons*

Five CRE-enriched lessons occurred throughout this study on days 3, 5, 8, 10, & 12. On the other days, students were provided with content-related instruction and background knowledge to support the lessons. These CRE-enriched lesson class periods were recorded for observations and ended with the administration of the exit ticket (see

Appendix B). The alignment of CRE tenets is found in Table 3.1 with the specific documents provided in the appendices.

**Class DNA.** The Class DNA activity was the first CRE-enriched lesson. (see Appendix C) In this activity, each student was prompted to decorate their nucleotide (a monomer of DNA) with interests, culture or something they saw as valuable. A whole class DNA molecule was pieced together using these nucleotides and displayed in the hallway outside my classroom. Displaying the class DNA served to include each student's culture and to display something of theirs as valuable. As such, it promotes inclusivity which is part of the tenet *of critical reflection*. Aronson and Laughter (2016) state that a "classroom is a place where students both learn about their own and others' cultures and also develop pride in their own and others' cultures," and this is the development of *cultural competence* (p. 167). As a result, each student's contributions were deemed valuable. In addition, it allowed me to get to know my students better, build our relationships, and provide communal structures in the classroom. Therefore, this activity ranked as building *cultural competence* as each student expressed their own culture and saw how it fits the whole class. It was categorized using *critical reflection* because this is an inclusive activity. Last, it developed *academic skills and concepts* because they built the structure of DNA using constructivist methods that allowed them to connect their cultural references to the content (Aronson & Laughter, 2016).

**Rosalind Franklin Activity.** On day five, we began the class by reading the story of Rosalind Franklin, who was impacted negatively by sexism (Streissguth, 2017). Then, students worked in groups to make a claim and provide evidence and reasoning about the most unethical person in Rosalind's life (see Appendix D). This activity helped students *critique discourses of power* around the issues of gender inequality. It provided an avenue to discuss inequality from the 1950s, gender inequality today, and the internalization of social norms. We critically reflected on how this applies to their lives as students expressed how they felt about the injustice that occurred to Rosalind Franklin. We built *academic skills and concepts* because students developed skills in scientific argumentation, used constructivist methods, and were required to participate (Aronson & Laughter, 2016).

**DNA Technologies.** In this constructivist activity, students researched and learned about a specific type of DNA technology and then presented that DNA technology to the class (see Appendix E). This lesson was student-centered, and each student was an expert for the material they researched and presented to the class. Ladson-Billings (1995b) discusses the value of allowing students to be experts in the classroom as a stance for CRP. Viewing the students as an expert in the classroom is considered *critical reflection.* In the DNA Technology lesson, students got to pick the DNA technology they researched, making this inclusive of student interests. This activity served to provide choice in assignments (*critical reflection)*, maintain communal structures (*critical reflection*), and use student cultures to learn (*academic skills & concepts*). In addition, this activity sought to increase students' engagement as they were responsible for teaching the class the material they found interesting (*academic skills & concepts*).

One of the examples of the DNA technologies students chose was the Innocent Project, where people have been released from prison due to the use of DNA as evidence. This one presentation provided an opportunity to discuss the disproportionality of those wrongfully convicted of crimes (Innocence Project, 2022). Students found other notable DNA technologies students interesting, including Tutankhamun's health and identification of his parents, GMOs, and insulin production. This activity sought to help students *critique discourses of power* and engage in *critical reflection* through learning about the Innocence Project and other ways DNA technologies are used. In addition, students continued to develop pride in their beliefs and relate that to the classroom culture (*cultural competence*) and allowed students to build on the cultural assets they bring with them to the classroom and relate it to biology *(academic skills and concepts)* (Aronson & Laughter, 2016).

**Protein Affirmations.** In this activity, student groups used several DNA strands to transcribe and translate them into proteins and decode a message (see Appendix F). These messages were sentences of affirmations. This activity sought to build relationships with students (*cultural competence*), demonstrate care (*academic skills & concepts*), and engage them in using their transcription and translation abilities (*academic skills & concepts*). There were several ways this activity aligns with CRE. Complimenting students may help students become more comfortable with my class and me, and it helps to build better community within the classroom. In addition, this should help build *cultural competence* as students develop pride in themselves and others in our classroom community (Aronson & Laughter, 2016). This activity also aligns with the literature on the importance of building student relationships (Johnson, 2011; Milner, 2010). Finally, this activity also developed *academic skills and concepts* as students used constructivist methods to simulate transcription and translation processes (Aronson & Laughter, 2016).

**Eevee Epigenetics.** On this day, students learned about epigenetics and used their transcription and translation abilities to discover what genes were activated in their Eevee, a Pokémon character (see Appendix G). Students transcribed and translated six DNA strands into the protein sequence. Then, they used the information to determine the genes expressed and their Eevee type. Students worked in pairs for this assignment, and many divided the work. I categorized this assignment as CRE because it uses an interest of students as many of my students are fans of Pokémon and would be familiar with Eevee (*academic skills & concepts*). This activity also helped build *cultural competence* as it is a valued part of student culture and linked learning to the background of students. In addition, Eevee Epigenetics used *critical reflection* as it is an inclusive, communal structured activity that values student culture. Finally, this activity used *academic skills and concepts* because students are learning about epigenetics using constructivist methods to connect to student cultural references (Aronson & Laughter, 2016).

Table 3.1. *CRE-Enriched Lessons*

| Name | Synopsis | CRE Tenet |
|---|---|---|
| Class DNA | Students decorated a nucleotide with their interests and culture, and it was pieced together as part of a large strand of DNA. This DNA was displayed in the hall. | Academic Skills and Concepts, Cultural Competence, Critical Reflection |
| Rosalind Franklin Activity | Students read about the injustice surrounding the discovery of DNA and the lack of credit given to Rosalind Franklin. Students built an argument for who was the most unethical person in her life and completed a claim/evidence/reasoning chart. | Academic Skills and Concepts, Critique Discourses of Power, Critical Reflection |

| | | |
|---|---|---|
| DNA Technologies | Students chose a topic associated with DNA technology that interested them. They researched, organized the information into a presentation that they presented to their classmates. | Academic Skills and Concepts, Cultural Competence, Critique Discourses of Power Critical Reflection |
| Protein Affirmations | Students worked in groups to transcribe, translate, and decode three unique DNA sequences for affirmation messages. | Academic Skills and Concepts, Cultural Competence |
| Eevee Epigenetics | Student groups were each given 6 strands of DNA that were expressed in their Eevee, a Pokémon character. They had to transcribe, translate, determine the proteins expressed, and then determine what their Eevee would morph into. | Academic Skills and Concepts, Cultural Competence, Critical Reflection |

Note. Depicts the intervention plan including the name, synopsis, and the intervention category associated with CRE.

### *Likert-scale and Open-ended Surveys*

With a combination of Likert-scale and open-ended questions, this survey was administered once before any CRE-enriched lessons were used and once at the end of the intervention. Class time was devoted to completing the survey, which meant the rate of return for participants was high. After administering the survey, I immediately reviewed the surveys for notable items. I reviewed the data thoroughly at the end of week three and at the culmination of the study.

### *Exit Tickets*

I administered the exit tickets following each CRE-enriched lesson. Students used the time right after the activity to complete the exit tickets. The exit ticket data was reviewed after each CRE activity, and at the culmination of the study to examine student perceptions of their engagement for each CRE activity.

### *Observations*

Each CRE-enriched lesson was recorded for both classes to look for any trends and identify elements that are happening in a classroom that is implementing CRE. These classes were recorded from one position in the classroom. These videos were kept in a password protected Google Drive folder. Upon completion of the CRE-enriched lesson, the videos were transcribed. The transcripts were used to analyze the number of redirects that occurred during each CRE-enriched lesson to keep the lesson going which provided support to the exit ticket data. Transcripts were also analyzed for evidence of factors associated with CRE-enriched lessons that impact engagement.

## Treatment, Processing, and Analysis of Data

This qualitative study examined the construct of engagement, which I gauged through both teacher and student perspectives. I gathered data through student surveys, exit tickets, and observations to measure engagement. Pre- and post-intervention surveys were divided in their analysis by the type of statement, including statements about engagement, biology, CRE, desire to learn, and school. I analyzed the open-ended surveys, and coded and analyzed observation transcriptions for emergent themes of factors that impact student engagement. The data were processed initially and throughout to inform decisions in this study. An emergent design was the process by which this analysis was managed. As topics arose, they were used to code future data and adjust categories.

Typical of qualitative research, some of the "research cannot be tightly prescribed, and some or all phases of the process may change or shift after the researcher enters the field and begins to collect data" (Creswell, 2014, p. 235). Using Tesch's (1990) Eight

Step process, I reviewed and annotated transcripts as a whole group, then completed a deeper review of individual transcripts. Similarities were noted and clustered logically in a preliminary list of themes. Categorical titles were adjusted as needed to ensure appropriate wording and relationships. Next, I reviewed each document, adding coding and looking for additional themes.

Emergent coding was the method of analysis for this study. The analysis process was inductive at the beginning of the study and morphed into a divergent analysis. Later data tools were adjusted as a result of emergent themes. This analysis of emergent coding was used for all data sources, including surveys, exit tickets, and observations. Initial data sources aided in the generation of themes and categories. Then, the latter data sources were filtered through these themes to confirm and modify categories as needed.

The research question guiding the study was *how does the use of CRE-enriched instruction impact grade-level biology student engagement?* The answers for these questions were found by combining data outcomes from various tools: surveys, exit tickets, and observations. These methods are the most appropriate for this study because they provide both the teacher and the student perspective and various methods.

***Initial and Final Survey***

**Likert-scale Portion of the Survey.** The initial Likert-scale portion of the survey was used initially to identify any trends or anything interesting found in the results. The responses to the survey were coded with numbers to allow for averaging the responses to analyze shifts. For positive statements, like *I stay interested and engaged in most of my classes* strongly agree was coded as a five, agree was coded as a four, neutral was coded as a three, disagree was coded as a two, and strongly disagree was coded as a one. For negative statements, like the statement *School is boring,* reverse-coding was used and so strongly agree was given the code one, agree was given the code two, neutral was given the code three, disagree was given the code four and strongly disagree was given the code five. The differential in average responses on the initial and final surveys were compared to one another to identify any shifts in student perceptions. The initial survey was administered on day one of the study to serve as a baseline of student perceptions related to engagement, school, and my class. The post-survey was given at the end to gather comparison data. Once the study ended, the differential between the initial and final surveys was reviewed for any data that stood out, notes were made, and data was filtered through the categories that emerged with other qualitative data.

**Open-ended Portion of the Survey.** The initial and final open-ended portion of the survey was analyzed for differences between student answers from beginning and end. The initial survey was one of the first bits of data reviewed as it was administered after IRB approval but before any treatment had taken place. This portion of the survey was repeated after all other data had been collected and the intervention had been completed, making it the last data collection tool. Consequently, the initial portion of the survey was analyzed in the initial data analysis, and the post-survey was analyzed as a final data tool. Data from these surveys provided an opportunity to compare authentic student perceptions about engagement, factors associated with CRE and general thoughts about biology and school before and after the intervention took place.

***Exit Ticket***

The exit tickets were given after every CRE-enriched lesson; their purpose was to gauge how engaged students were in the CRE-enriched lesson. The Likert-scale portion was analyzed by averaging student responses and comparing CRE-enriched lessons across the study. The open-ended portions were used to provide authentic student voices to the study and support or negate other trends in the data.

### *Observations*

The observations were conducted during the five CRE-enriched lessons for each class. This data was transcribed, and transcripts were analyzed to search for evidence related to the impact on engagement in CRE-enriched lessons. I reviewed transcripts several times, adding coding and comments in the margins. These transcripts were combed through to find the number of redirects to support student perception of engagement, and to identify factors about CRE-enriched lessons that contribute to engagement.

All documents, videos, and transcripts with identifiers were kept confidential and destroyed upon completion of the study. All data was collected electronically through google forms, allowing it to be kept secure in a password-protected Google Drive folder on the school's server. Notes from data analysis and coding were kept in the same electronic folder. Data from the surveys, exit tickets, and observations were stored in the Google Drive folder. All data, videos, transcriptions, and notes were destroyed upon completion of the study and successful defense of the resulting dissertation.

## Summary

This qualitative action research study used an intervention of CRE-enriched lessons to measure changes in engagement in grade-level biology. The data collection tools are a Likert-scale and open-ended survey, exit tickets, and observations. First, the data were analyzed, looking for general trends to determine if CRE-enriched lessons impact student perceptions of engagement. Next, the data were processed throughout the study using emergent codes/categories and guided decision-making and adjustments. Next, the data were analyzed and coded using Tesch's (1990) eight-step process. Finally, the categories that arose were used to describe how CRE-enriched lessons impact perceptions of student engagement.

# CHAPTER 4

## FINDINGS

Long-term opportunities and academic success are limited by the low levels of engagement found in my grade-level biology courses. Several factors reduce engagement in biology, including high-stakes testing (Childs & Baird, 2020; Erduran et al., 2020; Vogler, 2005, 2006a, 2006b), tracking practices (Domina et al., 2019; Oakes, 1992), and the absence of students' cultures and interests (Baber, 2012; Howard, 2010; Tate, 1997). After reading about CRE, reflecting on my practice, and trying a few strategies, I saw improved student engagement in biology, which motivated me to examine the effects of CRE strategies on student engagement. Therefore, the purpose of this study was to determine whether engagement increased through implementation of CRE-enriched instruction.

This intervention used five lessons designed using the theories of constructivism and CRE. The four tenets under CRE are *academic skills and concepts*, *cultural competence*, *critical reflection*, and *critique discourses of power*. DNA Technologies was the only lesson that used all four tenets (see Table 3.1). Others like Class DNA, the Rosalind Franklin activity, and Eevee Epigenetics used only three, and Protein Affirmations used only two. All the activities sought to give students more choice and allow them to be experts (Ladson-Billings, 1995b).

## Methodological Framework

This qualitative action research study sought student and teacher perspectives to determine if implementing CRE-enriched lessons improves student engagement in grade-level biology. The study was guided by the following research question:

1. How does the use of CRE-enriched instruction impact grade-level biology student engagement?

I used surveys, exit tickets, and observations to gather data, and the study was guided by a theoretical framework that merged constructivism with CRE. Constructivism and CRE are centered on learners' making meaning by interacting with content (Abdal-Haqq, 1998; Aronson & Laughter, 2016). CRE further emphasizes that students' cultures are valuable in this process (Aronson & Laughter, 2016). This study used an inductive process to make meaning of the influence of CRE-enriched instruction on student engagement through student perceptions and authentic voices and my observations.

The Likert scale portion of the survey was numerically coded and averaged. The Likert scale portion of the exit tickets were averaged. The open-ended portion of the survey and exit tickets, and the observations were analyzed for emergent coding. All of these factors support my research question about the impact of CRE-enriched lessons on student engagement.

## Chapter Overview

Chapter four discusses the findings from this study, beginning with results of a comparison of the pre- and post-intervention surveys. Next, the exit ticket data Likert-scale averages are discussed, followed by a synopsis of engagement in each CRE-enriched lesson. Finally, discussion of data from observations of CRE-based lessons will further demonstrate results about student engagement in a grade-level biology classroom.

## Participants

I administered the anonymous questionnaires in two grade-level biology classes with combined demographics of 52% Black, 30% White, 9% Hispanic, 7% Asian, and 2% two or more races. Of the 41 students from these classes, 34 volunteers took the initial survey, and 24 took the final survey. In addition, classes engaging in CRE-enriched lessons were video recorded for later transcription, and students completed anonymous exit tickets after each lesson. The number of volunteers that completed the exit tickets varied as follows: 29 for Class DNA, 26 for Rosalind Franklin Activity, 33 for DNA Technologies, 24 for Protein Affirmations, and 28 for Eevee Epigenetics.

## Data Presentation & Interpretation

The results of each data set are presented separately in the following order: survey, exit ticket, and observation. First, the data from the Likert scale portion of the survey is organized by the following delineated categories: biology, CRE, natural desire to learn, and school—to gain student perceptions about these topics. This data was numerically coded and averaged to identify general shifts in perception. Second, the data from the open-ended portion of the survey were categorized based on commonalities and emergent themes. This is followed by a discussion of data from the Likert scale portion of the exit ticket (which was averaged) and the open-ended portion (which was analyzed for emergent themes). Next, observations data is organized based on emergent themes associated with the impact of CRE-enriched lessons on engagement.

## Survey Results

The purpose of the initial and final surveys was to gain student perceptions of their engagement before and after the intervention. The Likert scale portion allowed me to gather a general idea of what the students thought about engagement in school and my class, CRE, and learning. The open-ended portion of the survey allowed me to capture and report student voice as related to the same topics. These results are discussed separately followed by a combined summary.

There were 34 students that completed the initial survey and only 24 that completed the final survey, and the surveys were completely anonymous. There was no way to match the responses on the initial survey with those on the final survey. Therefore, the overall averages are reported in the table below. Those that did not respond to the post-survey could have had differing perceptions. Although, the averages of many statements that this study should not influence remained the same when comparing initial and final responses.

### *Likert-scale Portion*

The Likert scale portion, administered on day one and at the culmination of the study, was used to gather student perceptions of engagement, biology, CRE, learning, and school. The survey combined Likert-style statements from the WIHIC (Aldridge et al., 1999) and TOSRA (Fraser, 1981), along with researcher-created statements about engagement. The most significant results are discussed in four categories, including statements about biology, CRE, students' natural desire to learn, and school. There were seven statements about biology, eight statements about CRE, three statements about a natural desire to learn, and five statements about school.

The first seven statements on the Likert-scale portion of the survey were intended to compare students' perceptions of biology before and after the implementation of CRE-enriched lessons (See Table 4.1). For every statement about biology, students' perceptions changed for the better when comparing the initial and final survey averages. The most notable changes were *that Biology lessons are fun*, which increased by over a half point, and *I stay interested and engaged in biology*, which increased by almost three-quarters of a point. In fact, this statement showed the greatest positive shift in student perception when comparing initial and final surveys. Not a single student disagreed or strongly disagreed with either statement in the final survey responses. Responses to *I really enjoy going to biology class* showed a similar shift, increasing by over one-third of a point. Finally, student perceptions for the statement *I am engaged in biology class* improved after the intervention. In addition, no students disagreed with this statement where five students disagreed or strongly disagreed with this statement on the initial survey. These results indicate that students' perception of their engagement did increase in grade-level biology after the implementation of CRE.

The highest average response related to biology measures came from responses to the statement *I feel accepted in Biology class.* On the initial survey the average response was 3.87, indicating the average student was neutral or agreed with this statement. For the final survey, the average increased to 4.24, which indicates that the average student agreed or strongly agreed with this statement. Out of 24 student responses on the final survey, a total of 19 (eight agreed and 11 strongly agreed) positively responded to this statement. On the initial survey, five students disagreed with this statement, but no students disagreed or strongly disagreed with it in the final survey. The responses to *I feel accepted in biology class* indicate that students felt more accepted after the intervention.

Table 4.1. *Likert Scale Biology Measures Initial and Final Surveys Means*

| Statement | Initial Survey | Final Survey |
|---|---|---|
| Biology lessons are fun. | 3.24 | 3.84 |
| I really enjoy going to biology class. | 3.45 | 3.81 |
| I am engaged in biology class. | 3.34 | 3.72 |
| I stay interested and engaged in biology. | 3.11 | 3.84 |
| I feel accepted in Biology class. | 3.87 | 4.24 |
| Mean for positive phrased statements | 3.27 | 3.68 |
| Biology lessons bore me. | 2.82 | 3 |
| The material covered in biology lessons is uninteresting. | 3.08 | 3.34 |
| Mean for negatively phrased statements | 2.95 | 3.17 |

Note. Some statements are derived from the TOSRA (Fraser, 1981) and WIHIC (Aldridge et al., 1999). Positively phrased statement responses were given the following codes: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). Negatively phrased statement responses were reverse coded with the following codes: Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), and Strongly Disagree (5).

The next eight statements on the survey were on measures associated with CRE (See Table 4.2). They are delineated in the table based on factors that are within the teacher's control and student preferences. Interestingly, many of these measures remained relatively the same. For the statement *my work receives as much praise as other students'* work, there was an increase from 3.55 to 3.73 indicating a shift toward more students agreeing with this statement as a result of the study. There were a few small shifts in student perceptions about the statements *positive comments motivate me to do my work* and a *relationship with your teacher makes a difference in how you do in a class*. The most notable increase in this category was in *the acceptance of my culture in the classroom is important to me*, which increased from 3.68 to 4.07. This indicates that the average student agreed with this statement. In the initial survey just over half of the students responded they agreed or strongly agreed with this statement. After the study three-quarters of the students agreed or strongly agreed with this statement. There was also a decrease in the perception for the statement *science teachers should use student interests to develop lessons*.

Table 4.2. *Likert Scale CRE Initial and Final Survey Means*

| Statement | Initial Survey | Final Survey |
|---|---|---|
| My work receives as much praise as other students' work. | 3.55 | 3.73 |
| Science teachers should use student interests to develop lessons. | 3.95 | 3.75 |
| Positive comments motivate me to do my work. | 3.84 | 3.95 |
| Relationship with your teacher makes a difference to how you do in a class. | 3.95 | 4.04 |
| Mrs. Biery gives me as much attention as others. | 3.79 | 3.78 |
| Means for what teacher can control | 3.82 | 3.85 |
| Acceptance of my culture in the classroom is important to me. | 3.68 | 4.07 |
| I have the same amount of say in this class as other students. | 3.82 | 3.83 |
| When my interests are discussed in class, I pay more attention. | 3.97 | 3.92 |
| Means for Student Preferences | 3.82 | 3.94 |

Note. Some statements are derived from the TOSRA (Fraser, 1981) and WIHIC (Aldridge et al., 1999). Positively phrased statement responses were given the following codes: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). Negatively phrased statement responses were reverse coded with the following codes: Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), and Strongly Disagree (5).

Three statements from the Likert-scale portion of the survey inquired about students' perceptions of their natural desire to learn (See Table 4.3). Interestingly, student perceptions dropped on the statement that *I would prefer to find out why something is happening by doing an experiment than being told*. At the start of the study, the average was 4.42 indicating that most students agreed or strongly agreed with this statement. At the culmination of the study, the average was 4.06 indicating that the average student agreed with this statement. Perceptions improved for *Learning new things is fun* from the average response of 3.68 to 3.95 when comparing the initial and final survey results. This means the average student agreed with this statement post-study. One notable characteristic of this Likert-scale data category named *natural desire to learn* was that it contained the highest average perceptions compared to all other categories (school, biology, and CRE), demonstrating that these students have a natural desire to learn.

Table 4.3. *Likert Scale Natural Desire to Learn Initial and Final Survey Means*

| Statement | Initial Survey | Final Survey |
|---|---|---|
| I would prefer to find out why something happens by doing an experiment than being told. | 4.42 | 4.06 |
| I am curious about the world in which we live. | 3.97 | 4.00 |
| Learning new things is fun. | 3.68 | 3.95 |
| Means for all Natural Desires to Learn Measures | 4.02 | 4.00 |

Note. Some statements are derived from the TOSRA (Fraser, 1981) and WIHIC (Aldridge et al., 1999). Positively phrased statement responses were given the following codes: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). Negatively phrased statement responses were reverse coded with the following codes: Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), and Strongly Disagree (5).

Five statements assessed students' perceptions of engagement associated with school (See Table 4.4). Many of the survey responses associated with school had the worst perceptions of any other category in the Likert-scale data. However, the one category with the most students that agreed or strongly agreed was that *Getting an education is important,* and this score stayed the same when comparing the initial and final survey results. In addition, it was the highest ranked perception on the final survey for the whole survey. The most notable changes in school perceptions were from the statements that *I love going to school* and *School is boring*. *I love going to school* began with an average of 2.37 and ended with 2.81. *School is boring* was reverse-coded and began at 2.11 and perception improved to 2.60. Interestingly, there was also a slight shift for the statement I am engaged in school. These results demonstrate a benefit to school enjoyment and engagement due to implementing CRE-enriched lessons.

Table 4.4. *Likert Scale School Initial and Final Survey Means*

| Statement | Initial Survey | Final Survey |
|---|---|---|
| I love going to school. | 2.37 | 2.81 |
| Getting an education is important. | 4.29 | 4.30 |
| I am engaged in school. | 3.42 | 3.60 |
| I stay interested and engaged in most of my classes. | 3.18 | 3.26 |
| Means for all School Measures | 3.31 | 3.49 |
| School is boring. | 2.11 | 2.60 |

Note. Some statements are derived from the TOSRA (Fraser, 1981) and WIHIC (Aldridge et al., 1999). Positively phrased statement responses were given the following codes: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). Negatively phrased statement responses were reverse coded with the following codes: Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), and Strongly Disagree (5).

Several statements in the Likert-scale portion of the survey were similar so that they could be used for comparing student perceptions of biology and school (See Table 4.5). For example, *I love going to school* paired with *I really enjoy going to biology class.* For these statements, the students favor biology a lot more in comparison to school as their average scores for biology were in the neutral-to-agree range, whereas the average scores for *I love going to school* were in the neutral-to-disagree range. Interestingly, even though the intervention was applied only to biology, student perceptions of their fondness for biology and school improved from the comparison of initial and final survey responses. The perception for *I love going to school* increased slightly more in comparison to *I really enjoy going to biology class* after this intervention of CRE-enriched lessons. These results indicate students' enjoyment of biology and school improved after the intervention.

Student perceptions of their engagement in school and biology improved on the final survey in comparison to the initial survey. The statement that *I am engaged in biology class* improved more than *I am engaged in school* (Table 4.5) because it began with a lower perception and ended with a higher average perception. Biology began with the average of 3.34 and ended at 3.72, where school engagement began at 3.42 and ended at 3.60. Although, the intervention was only applied to biology engagement in school did increase. These results indicate that students were more engaged in school and biology due to this study.

To compare biology with other classes, the statements *I stay interested and engaged in most of my classes* and *I stay interested and engaged in biology* were used. A similar trend was found in that biology began with a slightly lower perception compared to other classes but ended with a much higher average perception of engagement and interest. For the initial survey, most of the respondents responded neutral to the statement about biology. However, in the final survey, the majority agreed with this statement. In addition, no student disagreed with this statement post-study. Interestingly, there was a slight shift in perception of whether students remained interested and engaged in most of their classes when comparing the initial responses with the final responses.

Table 4.5. *Likert Scale School vs. Biology Initial and Final Survey Means*

| Statement | Initial Survey | Final Survey |
|---|---|---|
| I love going to school. | 2.37 | 2.81 |
| I really enjoy going to biology class. | 3.45 | 3.81 |
| I am engaged in school. | 3.42 | 3.60 |
| I am engaged in biology class. | 3.34 | 3.72 |

| | | |
|---|---|---|
| I stay interested and engaged in most of my classes. | 3.18 | 3.26 |
| I stay interested and engaged in biology. | 3.11 | 3.84 |
| School is boring. | 2.11 | 2.60 |
| Biology lessons bore me. | 2.82 | 3 |

Note. Some statements are derived from the TOSRA (Fraser, 1981) and WIHIC (Aldridge et al., 1999). Positively phrased statement responses were given the following codes: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). Negatively phrased statement responses were reverse coded with the following codes: Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), and Strongly Disagree (5).

Another thing that stands out about this data that compares student perceptions of school and biology is that adding student interests to the statement about engagement resulted in a positive shift in student perception. In addition, boredom in school and biology also saw a positive shift. These responses were reverse-coded, and both perceptions improved after the intervention. However, perceptions of school saw a greater shift beginning at 2.11 and ending at 2.60. Data from this study on the intervention of CRE-enriched lessons demonstrate an improvement in students' enjoyment and engagement in biology and school, an improvement in students' interests in biology, and a reduction in boredom associated with school and biology.

**Open-Ended Portion**

The open-ended portion of the survey was designed for students to share their voices about biology and some commonalities associated with CRE, including interests, identity, and relationships. Many common responses pertained to thoughts about biology, activities that were engaging or disengaging, whether interests were used in biology, whether a relationship with the teacher influences how well they do, and whether seeing someone with the same identity is important in education.

On the initial survey, half of the students responded positively about their thoughts on biology, making comments like “It’s an amazing class” and “I love it.” Another central idea that emerged from coding on the initial survey was that students find interesting and interactive activities engaging; for example, one student commented, “I think it is easy to engage in when there are interesting activities.” Comments like “it’s easy to engage in interactive assignments,” highlighted the idea that the nature of activities is important to engagement. On the flip side, one student’s comment that with “note taking it's easy to get distracted” reflected a frequently held view of note taking as disengaging. Other negative trends included that less than a quarter of students responded positively about using their interests in biology.

Overwhelmingly, students indicated that having a good relationship with their teacher can influence how well they do in a class. Comments that reflect the student-teacher relationship can impact engagement included, “It could get me more engaged” and “better engage[d] into the class.” Other common comments were about being more comfortable and having a better connection, as the following comments indicate:

- “Having a better relationship with my teacher makes me want to learn a little more and makes me feel comfortable in my surroundings.”
- “If you have a good relationship with your teacher, you feel more comfortable with them, so you don't have to be scared to ask for help.”
- “You feel more connected to your teacher and trust them to help you with your work.”

In addition, the initial survey had about a quarter of students respond that seeing someone with the same identity as them mattered in education. Some student comments that exemplify this topic were, “Yes, because you feel confident that if they can do it then you can do it too” and “Yes because I get to talk to someone who knows about the things that I want to hear.”

On the final survey, 19 out of 24 students responded positively about biology. Their comments were, “I loved taking this class this year and it was very fun and memorable,” “I think biology is great,” “I love learning the things that I do,” and “Biology is fun!” In addition, many students responded that they found activities engaging and note-taking disengaging. Comments like “The activities help make biology easier to engage with!” and “Lessons that are engaging and for disengaging notes all class period” highlighted this idea. In addition, there was more variety in the responses on the final survey. Several other comments were made that aligned with emergent codes from this study. The positive comments about what engages them more were “taking tiny steps at each lesson,” “when I’m working with other people,” “seeing how the biology fits into our day to day lives,” and “Learning something you want to learn or think is important.”

For the final survey, most students responded positively about the use of their interests in biology. The final survey also had an overwhelming response to the importance of having a relationship with your teacher. Some of the responses on the final survey were that having a good relationship with your teacher increases comfort, paying attention, and motivation. Comments that reflect the importance of the relationship between the teacher and students are as follows:

- “Because you might be more comfortable to ask questions”

- "It could influence students because people pay more attention to people they respect more. If the teacher is viewed as a friend then they are most likely to be listened to"
- "It can impact a student greatly and may motivate them even if they're upset from something else."

The final survey had more than half of the 24 students responding that seeing someone with the same identity as you were important. A few positive comments were, "Yes, they can relate to you in one or more ways than you think," "Yes, because y'all are alike," and "Yes because it doesn't make you feel lonely and helps you learn." A few negative comments were, "no because it doesn't matter what my identity is we should all get the same education" and "no because it doesn't matter what you look like."

When comparing the initial survey with the final survey, there was a shift in students' perceptions of biology. Half of the students responded positively in the initial survey, and this shifted to 19 out of 24 that responded similarly in the final survey. When comparing the initial with the final survey, there were not many differences in the responses of what students found engaging and disengaging. The final survey contained more of a variety of responses than the initial one, and the number of students that responded positively about using their interests in biology increased. The initial survey had about a quarter of students respond positively about using their interests; for the final survey, most students responded positively about using their interests.

Overwhelmingly, in both surveys, students responded that having a relationship with the teacher can influence how well they do. General responses to both surveys were that it made the class more engaging, increased student comfort levels, and improved motivation. In addition, more students felt that seeing someone with the same identity was influential in the final survey compared to the initial survey. In the initial survey, most students said it did not matter if they saw someone with the same identity in education. However, in the final survey, most students said that seeing someone with the same identity did matter in education.

**Exit Ticket Results**

Students responded to an exit ticket after every CRE-enriched lesson to self-report their level of engagement, on-task behavior, and participation. Being on-task and participating are part of the definition that Harris (2008) gives for academic engagement, and the exit ticket tool was designed with this in mind. As such, many of the responses to the participated and on-task behaviors were used to support the responses of engagement and to dig a little deeper to understand why students responded a certain way. In addition, participation and on-task behavior are both student-friendly terms. Within this section, the main discussion arose from the responses to the question *how engaged were you today?*

On each exit ticket, students ranked their level of engagement on a scale of one to five, with five being the highest. In addition to Likert-scale self-reported rankings, students were prompted to explain why they responded this way. After the first CRE-enriched lesson, Class DNA, I decided to add questions to the exit ticket to discover whether students liked or disliked an activity and why. As such, this section is divided by categories I coded for engagement and enjoyment. The category engagement had the following emergent codes: *engaged*, *completed work*, *understood*, *interesting*, and *fun*.

The codes associated with the category of enjoyment are *use of interest*, *learning*, *practice*, and *fun*.

## Engagement

Engagement was a broad category under which I nested codes from the exit ticket question *how engaged were you today?* Students used a combination of phrases to explain why they ranked themselves on their self-reported level of engagement. Several codes emerged from this data tool, and are discussed below.

### *Completed Work*

Overwhelmingly, students equated completed work with engagement. For every single CRE-enriched lesson, students either used terms like *finished work* or *got my work done* which I coded as *completed work*. Students that ranked themselves highly engaged on the Likert scale said, “I got my work done and on time,” “I finished all my tasks and paid attention,” “I completed my work,” and “I finished early.” The code *completed work* was used the most for the activity DNA technologies; within that lesson alone, it was used 10 times to describe why students ranked themselves at the high end of the scale. Specific student comments from DNA Technologies included, “I completed my assignment and even presented,” “I finished all my tasks and paid attention,” and “I got my work done.” The lesson with the fewest references to *completed work* was Rosalind Franklin, where only one student said, “I finished all my work while being focused.”

### *Engaged*

When asked whether the CRE-enriched lesson was engaging, many students responded with phrases using the word *engaged*. The highest use of the word engaged was in the first activity, Class DNA, where it was used seven times. All of these students ranked themselves high on the engagement Likert-scale question and followed the high ranking with the following reasons: “It was fun and engaging,” “I found the lesson very engaging,” and “I was really engaged and interested in the activity.” Other activities, although not as commonly as Class DNA, did have students use the term *engaged*. For instance, some of the students responded, “I was engaged in class today,” “I stayed engaged,” and “I was very engaged.”

### ***Understood***

This code understood appeared in three of the five CRE-enriched lessons: Class DNA, Protein Affirmations, and Eevee Epigenetics. One student responded, “I understood the instructions to the project,” and this was tallied under the *understood* code. The other two activities, Protein Affirmations and Eevee Epigenetics, had quite a few responses that were coded as *understood,* including “I understood the assignment and got it done,” “I actually understood what we were doing,” and “I finished and understood my work.”

### ***Focused***

Four of the CRE-enriched activities had the code *focused* used as a code for phrases students used to describe why they responded highly on the rankings for engagement. Rosalind Franklin had one student respond that they were focused. DNA technologies had the highest number of phrases that were coded *focused;* four students choose phrases that used *focus* to describe why they were engaged. Protein Affirmations and Eevee Epigenetics had two students each that used the term focus in their phrase to explain why they self-reported high scores for engagement. Some of the responses from students were, “I finished all my work while being focused,” “I stayed focused and remained on task," "I stayed focused I didn't have any distractions," and "I focused and did my work."

### *Interesting*

There were four CRE-enriched lessons where students responded with terms that were categorized under the code *interesting.* Class DNA, Rosalind Franklin, DNA Technologies, and Eevee Epigenetics each had two responses that were coded as *interesting.* Students used the following phrases to explain why they ranked themselves highly on their level of engagement: "It was very interesting, especially because I grew up with Pokémon," "It was easy and it was interesting," "I was really engaged and interested in the activity," and "I paid attention and found the lesson interesting."

### *Disengaged Comments*

Some students did not rank themselves at the high end of the scale for their level of engagement on the CRE-enriched lessons. Some common comments were made about why students ranked their level of engagement low. Many were categorized as *disinterested*. Sometimes students said "The lesson wasn't all that interesting," "It got boring," and "It do be a little boring." Another common response for students explaining why they ranked their levels of engagement low was also they were tired. The activity with the least references to disengagement was the Protein Affirmations lesson, and the activity with the most references to disengagement was the Rosalind Franklin lesson.

### *Summary of Engagement*

Students seem to equate *completed work* with a high level of engagement. In fact, to describe their high level of engagement across all CRE-enriched lessons, they used phrases that were nested under the code *completed work* 33 times. Students also use other terms to describe a high level of engagement: engaged, understood, focused, and interesting. However, none of them were used at the frequency of *completed work*. For all CRE-enriched activities, *engaged* was used 17 times, *understood* was used 9 times, and *focused* and *interesting* were both used 8 times.

### Enjoyment

After reviewing early data sources, an additional set of questions were added to the exit ticket that asked the students whether they liked the activity or not. This choice was made in response to the Likert-scale survey question on enjoyment and the response from a student on the exit ticket for Class DNA: "I liked it was easy and I was engaged in it too because it was important." The addition occurred right after the Class DNA lesson. Students were only allowed to respond yes or no to whether the liked the activity or not. Then, students were prompted to explain why they answered that way. In this section, I will discuss the codes associated with the student responses followed by a summary of enjoyment across the last 4 CRE-enriched lessons.

#### *Use of Interests*

The use of interests seemed vital to enjoyment in the exit ticket data. There were several comments made during different CRE-enriched lessons pertaining to enjoyment because of the use of interests. In the Rosalind Franklin activity, one student commented, "I love to see women empowerment." In the DNA Technology lesson, one student expressed that they liked the activity "because I like research." In the Eevee Epigenetics lesson there were many comments expressed about student's enjoyment of their interests being used. Comments like "Because Eevees are cool in their own right," "I did because I like Eevees for one and two it wasn't boring" and "It was really fun. I enjoyed it a lot because I grew up watching Pokémon with my siblings." The Eevee Epigenetics and the DNA Technology lessons were the two lessons that used students' interests and almost every student that took the survey responded that they liked the activity. In fact, only one student out of 28 said they did not like the Eevee Epigenetics lesson and two out of 33 said they did not like the DNA Technology lesson.

***Learning***

Learning was a code that emerged from the responses about why students liked the activity. There were so many comments that used learn as the main reason why a student responded that they liked the activity. For Rosalind Franklin, students responded "I learned new facts," "Got to learn a side of a story I never heard of before," "It was interesting to learn about Rosalind Franklin," and "It was nice to learn about it." The same trend was found in the DNA Technologies lesson a lot of comments about learning were expressed. One student said "I liked it because I learned a lot of things about DNA I won't remember them but it was interesting to listen to," Other students made the following comments "It was fun learning about my subject" and "It was kinda interesting because you learn new things." For the Eevee Epigenetics activity, students said "I liked it because you got to use the things you learned in bio to be able to do the assignment" and "because it's fun and easy to learn."

***Practice***

Practice stood out as a code in the data on enjoyment of CRE-enriched lessons. The following student comments relate to the importance of practice contributing to enjoyment. Two comments about the Protein Affirmations lesson were "It was easy and help with practice of this lesson" and "I think it's pretty interesting. It's hard at first, but it got easier." The Protein Affirmation activity served as a scaffolding activity and so it is interesting that students noticed they were practicing. Even more interesting is that another student on the Eevee Epigenetics activity made the following comment: "I liked it because you got to use the things you learned in bio to be able to do the assignment." This demonstrates student enjoyment of being given practice learning skills. Other notable comments from the Eevee Epigenetics activity. This demonstrates students recognizing that practice built their skills and that skills learned in prior lessons build on each other.

***Fun***

Fun was an unexpected code that emerged from the responses about why students liked the activity. Fun was not used at all for the Rosalind Franklin activity. Fun was used a lot for DNA Technology and for Eevee Epigenetics lessons. However, it was only used once for the Protein Affirmations lesson. In the DNA Technology lesson, students responded with the following reasons why they liked the activity: "It was fun learning about my subject," "very fun and interesting," and "It was fun and I liked doing the research." One student noted that "it was fun to decode the words and the proteins" for Protein Affirmations. Eevee Epigenetics had the following comments "I liked it because it was very interesting and fun," "because it's fun and easy to learn," "I thought it was fun because it was easy," "I found it very fun and interesting," and "I enjoyed it a lot because I grew up watching Pokémon with my siblings."

***Dislike***

Comparing the four CRE-enriched lessons, there were only a few negative responses to the question about whether students liked the CRE-enriched activity.

However, there was a common response of “boring” from those who responded they did not like each activity. The Rosalind Franklin lesson had six students out of 27 that responded negatively. A few of their comments were “It was boring,” “It was basic and we had to read a lot,” and “Really did not like history.” The Protein Affirmations activity had 5 students respond negatively with the following comments “It was too much work” and “tedious.”

Table 4.6. *CRE Activities and Average Student Self-Assessment*

| Activity (responses) | Engaged | On-task | Participated |
|---|---|---|---|
| Protein Affirmations (24) | 4.41 | 4.33 | 4.54 |
| Eevee Epigenetics (28) | 4.36 | 4.39 | 4.32 |
| DNA Technologies (33) | 4 | 4.36 | 4.33 |
| Class DNA (29) | 3.97 | 4.24 | 4.31 |
| Rosalind Franklin (26) | 3.38 | 3.76 | 3.76 |

Note. Students ranked their performance on a scale from one to five with five being highest.

Protein Affirmations had the highest average self-perceptions in engagement and participation (see Table 4.6). Eevee Epigenetics had the highest average self-perceptions of on-task behavior, and it was the students’ favorite activity. For these two activities the average student ranked their level of engagement for the activity at a 4 or a 5 indicating high levels of engagement associated with these CRE-enriched lessons. For the DNA Technologies lesson and the Class DNA lesson, the average student ranked their level of engagement at a 4. However, the participation and on-task levels were greater. This indicates that the average student was engaged in these CRE-enriched lessons.

Students ranked their levels of engagement the lowest by far for the Rosalind Franklin activity. Class DNA scored second lowest in all categories, and there was a perception gap in the averages when comparing the Rosalind Franklin activity scores with Class DNA as Rosalind Franklin scores were 0.59 less than that for engaged, 0.48 less for on-task behavior, and 0.55 less for participation. This indicates that the Rosalind Franklin activity was not as engaging as the other activities because many more students gave themselves a 3 for their level of engagement.

The exit ticket data was essential to understanding what it was about each CRE-enriched lesson that was engaging. Overwhelmingly, students equate completed work with engagement. In addition, many students responded they liked the CRE-enriched lessons because they learned and had fun.

## Observation Results

A total of 10 observations occurred, one for each of the two classes for the five CRE activities. Three themes emerged from the observation results: teacher mediation, guided learning, and sense of belonging. The teacher mediations were tallied based on the number of redirects and served to support the degree of engagement for each CRE activity. Guided learning and a sense of belonging also emerged as categories of data within the observations. The sense of belonging included codes of *acceptance*, *support*, and *inclusion*, where guided learning emerged from the many interactions that occurred in the classroom to move students to greater engagement. The observation data also provided evidence of *relationship building*, which was nested under a sense of belonging. Transcripts were combed through and examples of teacher mediation, sense of belonging, and guided learning were documented and are presented below.

### *Teacher Mediation*

Teacher mediation was a broad category that emerged in this study as a vital component that supports student engagement. This category included behavioral corrections attempted by me to help students stay engaged. The data demonstrated the need for teacher mediation to respond to students to keep them on task and support them in completing work.

Behavioral corrections were needed throughout all activities to ensure students stayed engaged in the CRE-enriched lessons. These were gentle reminders and redirections to the task at hand. Examples of behavior that needed to be corrected were any actions by a student that prevented them from moving forward and remaining engaged in the activity. I coded the transcripts with redirects and the reasons.

The reasons for the redirects were off-task conversations, being too loud, distracted, or disagreements. An example of off-task conversations happened during DNA technologies when the ladies in front of me would not stop talking when Madison was presenting. Sometimes the whole class would need to be redirected due to their noise level. I would ask them to quiet down. This type of off-task behavior was classified as being too loud. I noticed that the louder the noise level the more students were getting off-task. Other examples are when students got distracted during the CRE-enriched lessons. Redirects were classified as such when I caught students individually on their phones or when I locked the screens during the DNA Technology presentations because so many students were playing games or watching videos rather than paying attention. An example of a disagreement was when two students could not agree on who was right on how to proceed. They argued for quite some time because it began when I had just started helping another student across the room. Also, when Nolton was mad that David wasn't cutting his nucleotide out, I tallied it under the code disagreement in the observation transcripts.

In addition, I tallied the number of redirects needed for each CRE-enriched lesson. The most redirects for disengagement were found in the Rosalind Franklin activity, with 20 different behavioral corrections over the two classes. Class DNA had 17 corrections, followed by Protein Affirmations with 11 and DNA Technologies with 10 corrections. The least number of redirects per the observations was in the Eevee Epigenetics lesson, with five corrections occurring over the two classes.

Rosalind Franklin had the most corrections for students to get started and remain on task, with 20 corrections during both classes. Many of these corrections were to help students get started. Some students decided they did not want to do the assignment, so I kept checking in with them. For instance, I asked one student, “Are you working on it” and touched base with another student several times over the class. It took great effort to get some students to complete the assignment.

***Guiding Learning***

Guiding learning was a category that arose after the intervention when I noticed the many ways teacher feedback supports student engagement. There are many feedback techniques that I used to guide learning in my classes when engaging in the CRE-enriched lessons. Many times, it is directing next steps because students are unclear on how to proceed. Sometimes it is the scaffolding that seems to affect students’ level of engagement in completing the CRE-enriched lessons. Other times, storytelling helped to engage students. Lastly, guiding learning also included the many ways that I assessed and corrected misunderstandings while engaging in CRE. Teacher feedback and interaction were critical to keeping students engaged in the CRE-enriched lessons.

**Directing Next Steps.** Directing students' next steps was common practice to help students remain engaged in the CRE-enriched lessons. During Class DNA, this was letting them know they were ready to cut out their nucleotides and paste them down. Sometimes students needed help with positioning the parts of the nucleotide so their design made sense. For example, when Monroe asked, "How do I put these together?" He wanted to make sure his design would be displayed the way he wanted it. During other CRE-enriched lessons, much of this occurred when I checked in with students as they were working. I walked around and some students had finished all they knew how to finish and just needed to be told what the next task was.

For DNA technology, much of this directing next steps is present in helping students pick their topic. I walked around to every student individually to see if they were engaged. The most common need to remain engaged for this CRE activity was to help students pick a topic. For example, Asia had not picked a topic when I got to her desk, and I started listing different topics. Then I said "designer babies" and she said, "I want that one." Hadley had claimed the Innocence Project first during the introduction. However, she later decided that making bacteria glow was what she wanted to research. This opened up the Innocence Project for others, and Jake quickly claimed that one. These were examples of helping students remain engaged as they got to pick a topic they were interested in which helped them to continue engaging in the CRE-enriched lesson. In addition, to help them remain engaged in the lesson they were allowed to choose a different topic if they wanted to at any point in time.

In Eevee Epigenetics, students needed my assistance in starting or moving from transcription and translation to locating materials needed. For example, students needed to know the locations of the resources to help them progress through the CRE-enriched lesson. Immediately after receiving the materials, Kelsey asked, “Do we start with the codon wheel?” indicating that she needed direction. I told her to begin with transcription. When she finishes that she said, “Once I get finished, I go to the codon wheel?” To which I respond yes and explain she will use those amino acids to determine the protein and show her where to find that information. Engagement seems to be tied to knowing what to do and guiding learning was vital to help students begin or to move to the next part. For example, Brittany asked, “how do I do the amino acid one,” and once I showed her, she was good until the next transition. I helped many students to locate materials within the Eevee Epigenetics and move to the next steps. After finishing, Alani said she liked the activity “once I figured out what to do.”

**Scaffolding.** Scaffolding really seemed to be vital to helping students get started and remain engaged in CRE-enriched lessons. It was very apparent from the observations which CRE activities had scaffolding and which did not. Scaffolding seemed to improve engagement because students were comfortable and sure of themselves while working through the lesson.

In Rosalind Franklin activity, there was an obvious scaffolding issue with understanding the vocabulary. The class began with me reading through several documents to explain what happened. Then I prompted the students to answer the question *who was the most unethical person in Rosalind Franklin’s life?* Many students did not know what unethical meant, such as when Hadley says “I don’t understand what that means though” and Chris said, “what does unethical mean?” There were so many students that were stuck because they did not know what unethical meant. In addition, students seemed to have a hard time understanding and application of the vocabulary claim, evidence, and reasoning. I had to ask many questions for clarification and guide students to a quality response. For example, when Maya presented her claim, I had to prompt her to get her to accurately respond with evidence and reasoning.

Another guided learning example can be found in helping students to understand who was whom during the Rosalind Franklin activity so that they could build their best argument. Many students mixed up the names of the scientists like when Lainey says that Watson worked in the same lab as Rosalind Franklin. Other students made similar mistakes. This activity was also missing scaffolding in sharing the story of Rosalind Franklin in a manner that was easy to differentiate between everyone involved. This also points to a scaffolding problem, which negatively affected student engagement in this CRE-enriched lesson.

Alternatively, Protein Affirmations lesson happened before the Eevee Epigenetics lesson and was the scaffolding for the Eevee Epigenetics lesson. Both lessons had students beginning with transcribing a DNA sequence and then translating that sequence using a codon chart to determine the amino acid sequence. The Eevee Epigenetics had students taking the amino acid sequence and identifying the proteins expressed and then using the combination of proteins to determine what Eevee would morph into.

There were considerably fewer students with questions about transcription and translation for the Eevee Epigenetics lesson compared to the Protein Affirmation lesson. The observations of the Protein Affirmation had 38 different inquiries from students for help with transcription and translation skills. Half of these inquiries were about transcription and the other half were about translation skills. The Eevee Epigenetics only had 17 inquiries pertaining to transcription and translation. Two of these were about transcription, five were about using the codon chart for translation, and the other 10 were about a new skill to learn, knowing where to start. The Protein Affirmations activity did not have students starting at AUG, which is the sequence where protein synthesis begins. This demonstrates that students learned the basics of transcription and translation from the Protein Affirmations activity.

Students used these same skills in Eevee Epigenetics but continued to use the product of translation to determine the proteins that were expressed and what that meant for what their Eevee would morph into. This activity had the fewest teacher redirects and it is likely because it was properly scaffolded. In addition, Eevee Epigenetics was the most engaging CRE-enriched lesson per the observation data and it is highly likely because Protein Affirmations served as scaffolding.

**Storytelling.** Storytelling was important to help increase student engagement for several CRE-enriched lessons. Storytelling allowed students to better understand various content in a way that was more relevant. This helped students engage more as they better understood the elements needed. The two activities that used storytelling as part of CRE was Rosalind Franklin and DNA Technologies. The Rosalind Franklin activity yielded a few examples of storytelling as an interaction to increase student engagement. To attempt to get students' attention, I said, "Here is where the story gets a little juicy" and "Are y'all ready to hear the scoop?"

Many students did not quite understand what *claim, evidence,* and *reasoning* meant. For example, Britany got held up and asked, "what is a claim?" I tell her that it is a statement about something and I made a claim, "Mrs. Biery is the best," and explained how that is a claim. I explained that I would then need to support it with evidence, to which she said, “because she is a baddy.” However, about 10 minutes later, I returned to check on her, and she still did not have a claim written down. I tried a different explanation a bit more relevant to teen culture. I made the claim “Your man is cheating on you.” I followed it with evidence that can be found in pictures, and “he didn’t return my calls and my girlfriend saw him walking down the road with this girl.” Kelsey chimes in “oh, and his location said he was there 35 minutes ago, and he was at the girl’s house.” Many students were paying attention at this point, and so I explained the vocabulary of claim, evidence, and reasoning relating to this story.

Ten minutes later, Brittany has completed everything and is ready to share her work along with many other students. She picked Wilkins as the most unethical person in Rosalind Franklin's life and said, “because he stole it from her and he took all the credit.” She then started talking about how “he was probably watching her in the lab, taking pictures of everything she was doing.” Kelsey chimes with “stalker status.” Brittany continued saying, “he probably killed her. He poisoned her.” Many students in the class giggle or look surprised. Instead of discounting her claim, I asked her if she had evidence to support these claims. She says, “no, not yet, but I’m going to be researching it.” Storytelling and incorporating something that was more relatable to teen culture was valuable to helping students understand the vocabulary associated with this activity.

For DNA Technology, storytelling was essential to help students understand a little bit about the technology before they committed to researching the topic. Mostly I told the short version of interesting stories about DNA so students would be interested. This helped students to pick topics and engage in learning quickly. I used storytelling to open up the lesson by sharing the story of Hank the Tank and Genghis Kahn. Hank the Tank was a news article where a bear was blamed for many break-ins, but DNA evidence proves he did not work alone, nor was he responsible for all that he was blamed for. Storytelling in this lesson helped students to determine different DNA Technologies that they may be interested in as their topic. They were allowed to pick any topic that interested them. The only requirement was that it needed to pertain to the use of DNA. This activity used storytelling from the students too as each student summarized and told the story of their DNA Technology.

This allowed them to select a topic that was valuable to them and then share that topic. Jake chose the Innocence Project after my quick overview of it and another student had decided she did not want to research it. Jake, a 14-year-old black male, told the story of a black male who, at 19 years old, was beaten and threatened until he confessed to a crime he did not commit. DNA evidence freed this man about 20 years later, but he had spent half of his life in prison (Innocence Project, 2022). His presentation presented the opportunity to discuss how the Innocence Project has freed close to 200 people, and that there is an overrepresentation of African Americans who were wrongfully accused (Innocence Project, 2022).

Storytelling was also valuable in helping students stay engaged and lift the veil on modern-day authority and to discover the truth about how DNA databases have been used to identify criminals. DNA databases are kept from the many people who voluntarily give their saliva to determine their ancestral backgrounds. Among other uses, it has been used to identify persons of interest and to solve crimes. However, many people do not realize this technology can be used this way. During this activity, Tiffany had the realization that

DNA technology could result in someone in her family being arrested. She said, “I don’t want to be the reason why somebody goes to jail.” Storytelling helped Tiffany to engage in the lesson and see how DNA could be used in a different way that is not advertised. Later the Golden State Killer’s case was presented, and he was found as a result of several of his family members being in the ancestral DNA database. Irregular DNA fingerprinting patterns found in his family's DNA narrowed the search, and the police went through all the relatives and identified him (Chamary, 2020).

In addition, there are ethical issues associated with DNA technologies. As a result of students not having a great understanding of the term *unethical* in the Rosalind Franklin lesson, we discussed the ethics of the use of DNA technologies. We talked about who we would not want having access to that database, like health and life insurance companies. The DNA Technologies lesson provided opportunities to have conversations that opened students' eyes up to the different uses that could result from DNA technologies. These stories were valuable for my student to engage in the DNA Technologies lesson.

**Assess and Correct.** Assessing and correcting misconceptions was a central feature of supporting engagement in a CRE-enriched classroom. This category emerged from the data after noticing the many ways I assisted students to remain engaged in the lesson by assessing and correcting misconceptions. In addition, I taught students how to determine ways to assess and correct their own mistakes.

For the Rosalind Franklin activity, I assessed and corrected students on applying the vocabulary claim, evidence, and reasoning. For example, when Hadley said, “He stole her work” as evidence. I corrected her saying the evidence was the picture in their report.

In Protein affirmations, I regularly assessed and corrected mistakes with transcription and translation skill development. I would mostly point out what was incorrect and ask if they could look this up again. Sometimes, I heard students say “A turns into U” to which I would respond with A binds with U letting them know it does not turn into anything. This was a common phrase in both classes at the beginning.  Another mistake that students made was they used T instead of U in their mRNA. I found myself correcting many students letting them know there are no Ts in RNA. Helping students correct misconceptions helps them to continue to be engaged in the lesson.

In many CRE-enriched lessons, I walked around the room and helped students move to the next step by checking they had done the previous steps correctly. When learning the codon chart several students asked about how to read the chart. David asked, “Does it matter which way it goes,” and I showed him how to find the correct amino acid for the sequence. Other times I help students identify where they made the mistake. Such as Beth when she says, “this thing says I am perfect and amazing just the help I am,” then she laughs. I tell her she must have done something wrong and it is obviously in the last part of her sentence. Then I ask her “what does this codon give you?” and she figured out what she has done wrong and giggled saying “LOL Mrs. Biery.” To which I reply “LOL” back.

With Eevee Epigenetics, some students would make simple mistakes by writing the wrong letter and that would end up meaning they got the wrong amino acid sequence. I would go back to the initial sequence to help students determine where they went wrong. This helped students to remain engaged as they learned how to double-check behind themselves so that they could correct their own mistakes. For Tiffany, she had read the chart wrong and had isoleucine which should have been something else. I pointed to that one after showing her the combinations from the proteins and said go back and look at that one. She figured out it should have been something else and that combination was right for a specific protein.

### ***Sense of Belonging***

A sense of belonging includes acceptance, inclusion and identity alignment (Cornell, 2022). This section will describe the observations that provide evidence for sense of belonging that arose in this study. A sense of belonging arose from the definition of engagement and the noticing that much of the data from the observations could be categorized as unconditional support and acceptance.

A significant portion of sense of belonging found in the observations of CRE-enriched lessons that support engagement was an acceptance of students with a focus on supporting learning. There are several examples that stand out as acceptance that happened within the observations. For example, Brittany’s ideas were accepted when she claimed that Wilkins probably killed Rosalind Franklin. Instead of discounting what she said, I linked it right back to the lesson by asking her if she could provide evidence for that.

Another example was when Jake answered the phone from his dad, who does not call but every few weeks and was incarcerated at the time. Jake was allowed to talk to his dad as long as he wanted in the hallway. I discretely checked on him, and he was allowed to take as much time as needed. Brittany also commented during the DNA Technology lesson, "do you think when police officers catch serial killers, they be having parties.” I said, “probably.” When I agreed with her I let her know her contribution to the class was valuable.

Acceptance from the observations is also demonstrated in the situation that arose where Jada and Tiffany had the correct answers for someone else's sheet in Protein Affirmations. I let them know that I knew they did not do that work. However, they were not in trouble, as my purpose was to get them to complete the work so they could learn the skills. I let it slide so they would have the opportunity to correct their mistakes. They did precisely that because they erased their answers and did the work themselves demonstrating that they could transcribe and translate the DNA on their own.

In the class DNA, students were allowed to personalize their nucleotides in any way they wished. They knew their nucleotide would be displayed in the hallway, so many put much effort into designing and implementing their DNA. An example of this was Monroe, a big fan of Billie Eilish decorated his nucleotide with many of her song lyrics. His interest was accepted as valuable and so were others.

Creating an environment that is accepting means honoring students' requests that may not come at the most opportune time. An example is when Mary wants to plan a time she can take her test right in the middle of class. Then Brittany realizes she has to do the same. I accept their request and make the time to plan it so that we can move back to learning. Another example is when Taylor asked about my favorite songs at the very beginning of a lesson. I had listened to two of them that morning, so we talked about those songs. Taylor said one of the songs I suggested, *Can’t Stop the Feeling* by Justin Timberlake, was a classic, and others agreed. Harry said that my other favorite song, *The Champion* by Carrie Underwood, was “alright.” This what coming from a student that is a composer. In these off-topic conversations, students learn a little about me as the teacher, but I also learn about them. In this way, we are building a classroom climate that is accepting which contributes to engagement.

Inclusion is very apparent in the conversations that happen within the observations. One example is when Tiffany who is best friends with Brittany and Alani tells us all about when Brittany waited up all night for superpowers after a social media platform posted that all Black people getting would get superpowers that night. Brittany stayed up all night waiting to get her superpowers. Alani is half Black and half White, and she was supposed to get them part-time. Participating in the conversation and accepting this conversation sends the signal that this is valuable and therefore promotes inclusion.

Brittany sharing about her crystals is another example of students' contributions to the classroom being seen as valuable and included. She brought crystals to the class, and I asked about them. She shared that she uses them to cleanse her house. They did provide a bit of a distraction during Eevee Epigenetics, and I had to ask her to put them away. However, they were allowed before they prevented several students from staying on-task.

When Sofia, a student from Guatemala, was allowed to present her DNA technology presentation in Spanish, her culture was accepted and included as valuable. Upon my request, another student who is fluent in Spanish and English, translated her presentation for the class. Allowing her to present in her native language included her culture because it made her culture valued in the classroom. In addition, it allowed the student fluent in Spanish and English to use his knowledge as a valuable skill in the classroom. This seemed to contribute to both students' engagement.

Sometimes students may bring up off-topic ideas that the lesson makes them think of and normalizing these types of inquiries is an inclusive practice demonstrated in the observations. For example, during the DNA technologies presentations, a student presented on stem cells used as a medical intervention. I bring up a case that I read about years ago in the early days of stem cell therapy when a lady used it to attempt to correct+ macular degeneration. One day, her eyes started clicking because the cells injected were turning into bone. Beth asks, "is that like when you go outside, and it is cold outside, and you blink, and your eyes start clicking?" I said no and explained that she had undifferentiated cells injected into her eyes to correct her vision, but those cells somehow got a message that they were supposed to be bone cells. Accepting these inquiries as valuable contributions is an inclusive practice. Often, these conversations are tied to topics that we have learned this year or that students need to know for the EOC in the same way this lesson was.

The alignment of identity with school is part of the definition of active engagement in the classroom (Finn, 1989, 1993). It is also part of the definition of a sense of belonging (Cornell, 2022). In the observations, examples of this alignment of identity with school occur within the relationships and personal conversations, and much of this is developed because of communal structures. Communal structures can be found within all CRE activities as they are all student-centered where students have choice in the operations of the class. In the observations, I make many suggestions to students, but it is up to them to decide what to do. An example of this choice and ownership is found in the

DNA Technologies lesson, where students pick their technology and choose what order they want to present it. Students were given editing rights to the Google Slides presentation that everyone would use to present so they could move their slide to the lineup to indicate when they wanted to present.

Sometimes aligning identity with school is seen in students getting to use their interests in lessons. One example is found in the exchange between me and Arden. Arden was one of the students who was off task during the presentations on DNA Technologies because he was watching anime. At the start of Eevee Epigenetics when he realized we were using Pokémon to learn epigenetics, he had the biggest smile on his face. He worked by himself and was the first one to turn in his work. His answer, Umbreon, for what his Eevee will morph into, was the correct answer. I asked if that was a good one. He said, “yeah, that’s the best one.” Arden got to use an interest of his toward learning a biological concept, and was very engaged in the lesson.

Other examples of ways that CRE facilitates students aligning their identity with the school are highlighted in the personal and professional conversations that are happening in many of the observations. When students work in groups, there is this back-and-forth conversation that is about the lesson and about things that are not associated with the lesson. This happens regularly in the observations of Class DNA and Protein Affirmations. Another way these conversations combine identity with schooling is in the example of when Asia suggested I make one of the codes “LOL for Brittany” because she always says “LOL.” For the Class DNA lesson, you see this when Nicole and Cal are discussing emojis and then Cal wants to put one on his nucleotide for Class DNA or when Asia and Mary use their personal pictures as a collage to decorate their nucleotide, they are allowed to align their personal identity with the lesson.

**Relationships Building**. Another major category of data that arose from this intervention from the observations is the constant attention to relationship building as an influence to engagement. In the observations, students are comfortable in my class. There were several examples of this category. For example, students have my telephone number, Mary and Lisa texted me their images instead of emailing them to me for the Class DNA lesson. Harry came by during his homeroom time, being in the near-daily habit of visiting my class during his lunch or homeroom time. Taylor exemplified this topic when, at the beginning of class, he fist-bumped me and said, “I’m going to be paying attention today, Mrs. Biery.”

Sometimes relationships can be viewed in the actions of students such as when students volunteered to distribute materials to the whole class. This shows their eagerness to contribute to our class and that is relationship focused. Another example of the relationships focus is when Mary commented about bringing me “fancy water” if I end up in a nursing home, demonstrating she knows me well. In DNA Technologies, I allowed off-the-wall topics that sometimes arise to be discussed, as I sought to accept all contributions to the class.

In the Protein Affirmations activity, the interactions with Tiffany demonstrated my support for her engagement and learning with a focus on building relationships. She was not working on her assignment. When she did not move to a different seat as requested, I did not get mad. Instead, I reminded her of my rationale by complimenting her grade on the last test and suggested it was because she paid attention. Then I explicitly tied my current request to helping her to accomplish the same for this unit.

There is also a relationship focus between students and the class as a result of CRE-enriched instruction as seen in the observations. Students who complete assignments early seem to be eager to help others. During the Protein Affirmations lesson, this can be seen when Several students are helping others learn how to transcribe DNA and translate mRNA. In addition, one student was attempting to settle differences between a group that was disagreeing on how to proceed. I was helping someone else and the student noticed this and went over to try to help settle their confusion.

The observation data was essential to gaining teacher perception and comparing it to that of students' perceptions. Much of the observation data demonstrate how CRE-enriched lessons support student engagement through interactions that happen in the classroom to help students feel as though they belong, have relationships with others at school, and reduce distractions.

## Findings

My research question was *how does the use of CRE-enriched instruction impact grade-level biology student engagement?* This study used many student voices to measure active engagement by the degree of on-task student behaviors and participation in the classroom (Harris, 2008). However, Finn (1989, 1993) defined *engagement* as concomitant active participation, a sense of belonging, and aligning identity with school goals. The latter definition seems to align with engagement concerning CRE and this study.

Students perceived that their levels of engagement increased in biology and school after the implementation of this study, where five CRE-enriched lessons were the intervention. The CRE strategies improved the levels of engagement in biology as supported by the differential in initial and final survey data, exit ticket data, and my observations. In addition, the implementation of CRE-enriched lessons increased students' interest levels in biology. One interesting result from this study is that by implementing CRE-enriched lessons, students' levels of perceived engagement increased for school.

**Emergent Themes**

Connectedness and supportive pedagogical practices were the two major themes related to how CRE-enriched instruction positively impacted student engagement (see Table 4.7). Connectedness arose from combining two major categories of data: connecting interests to biology and making connections between stakeholders. Making connections between stakeholders arose from developing a sense of belonging and building relationships within the classroom as a result of codes like acceptance, support, and inclusion. Supportive Pedagogical Practices emerged from the secondary themes of guided learning and teacher mediation. Categories that fell under guided learning were focusing on learning, completing work, and interacting which emerged from codes like directing next steps, scaffolding, learning. Teacher mediation arose from the need to correct behaviors that lead to disengagement where the teacher is intentional about preventing any distractions. To examine the codes associated with themes and associated categories, see Table 4.7.

Table 4.7. *Themes Associated with the Findings of this Study*

| Themes | Secondary Themes | Associated Categories | Associated Codes (Tool) |
|---|---|---|---|
| Connectedness | Connect Interests to Biology | Use of Interests (S, ET) | Biology (S) Enjoyment (S & ET), fun (ET), Engaging (S, ET), Interesting (S & ET), Aligning Identity with School (OB) |
| | Connections between Stakeholders | Sense of Belonging (OB), Relationship Building (S, OB) | Acceptance (S, OB), Support (OB), Inclusion (OB), Culture (S, OB), Conversations (OB) Relationship (LS), Aligning Identity with School (OB) |
| Supportive Pedagogical Practices | Guided Learning | Focus on Learning (S, ET, OB), Completing Work (ET), Interacting (OB) | Scaffolding (ET, OB), Learning (S, ET), Understanding (ET), Directing Next Steps (OB), Storytelling (OB), Assessing & Correcting (OB) |
| | Teacher Mediation | Behavioral Corrections (OB) | Loud (OB), Off-task (OB), Distracted by media (OB), Disagreements (OB) |

Note. This table contains the themes, secondary themes, associated categories, and codes used in my study. In addition, the tool from which each code emerged is abbreviated and labeled with parentheses. The survey data is abbreviated S, exit ticket data is ET, and observation data is OB.

### *Connectedness*

Connectedness emerged as a theme that improved student engagement in my classroom due to the implementation of CRE-enriched instruction. This theme splits further to connect interests to biology and make connections between stakeholders. Connecting interests to biology resulted in increased engagement, enjoyment, and assisting students with aligning their identity with school. Making connections between stakeholders resulted in students feeling a sense of belonging and being allowed to develop quality relationships in the classroom with me and their classmates.

**Connect Interests to Biology.** Every measure on the Likert-scale portion of the survey improved as a result of this study. This demonstrates that CRE-enriched lessons improved students' perceptions of biology and their engagement in biology. The use of interests emerged as valuable to student engagement from the survey and the exit ticket data. In addition, student enjoyment of biology improved as a result of the implantation of the CRE lessons. Based on the survey and exit ticket data, students found the lessons interesting, and it seemed to influence student alignment of their identity with school per the observation data.

**Connection Between Stakeholders.** Making connections between stakeholders was a secondary theme associated with the development of a sense of belonging and a relationship focus as a result of implementing CRE-enriched lessons in biology. There were many codes that aligned with this theme including, acceptance, support, inclusion, culture, conversations, relationship, and aligning identity with school. These codes emerged from the survey and observation data.

***Sense of Belonging.*** Cornell University (2022) defines a sense of belonging as "the feeling of security and support when there is a sense of acceptance, inclusion, an identity for a member of a certain group" (para 1). As a result of implementing the CRE-enriched lessons, a sense of belonging emerged as a valuable component of how engagement is impacted. Students' perception of acceptance from the survey data combined with the teacher observation data demonstrates the improvement of a sense of belonging in this study. The additional codes of support, inclusion, and alignment of identity with school further substantiate that these CRE-enriched lessons positively impacted students' sense of belonging, and therefore positively impacted their engagement (Finn, 1989, 1993).

***Relationship Building***. Overwhelmingly, students note the value of a relationship with how well they do in a class per the survey data. CRE-enriched lessons seem to promote authentic conversations between stakeholders that facilitate relationship development per the observation data. Within these relationships is where students develop cultural competence as they are learning about each other's cultures.

### ***Supportive Pedagogical Practices***

This theme arose from every data source demonstrating the influence a teacher has on the classroom that supports engagement associated with the implementation of CRE-enriched lessons. These teacher practices guide student learning and reduce distractions so that learning can be the focus and students can successfully complete the work, which they highly equate with engagement.

**Guided Learning.** Every data source from this study supports the emergence of this category that when a teacher focuses on student learning, student engagement increases. In this study, CRE-enriched lessons focused on student learning. Whether it was through scaffolding or high expectations, students were guided to completing the work which increased student understanding and learning, per survey and exit ticket data.

***Scaffolding.*** A significant factor that arose from the results as a needed element of CRE that supports engagement is the need for scaffolding. The most disengaging activity was the Rosalind Franklin activity, and scaffolding was missing. Further, the Protein Affirmations activity served as the scaffolding for the Eevee Epigenetics activity, which per the observations and exit ticket data, had the most on-task behavior. In addition, Eevee Epigenetics had the highest references to completed work compared to all other activities, was the class's favorite activity, and was most engaging with the fewest number of teacher redirects. Based on exit ticket data, students overwhelmingly equate completing their work with engagement.

***High Expectations.*** Every CRE-enriched lesson held students to high expectations because students were required to complete the assignment and supported to be successful in this completion. Students stayed on-task due to my constant presence around the room, catering to their needs by directing their next steps, telling stories to help them understand what was needed, and correcting any misconceptions. It was within these many interactions that students are held to high expectations. Holding students to high expectations seemed to build student confidence in their abilities and led to students continuing to engage in the CRE-enriched lessons.

**Teacher Mediation.** This secondary theme emerged from the observation data as a needed element to impacting student engagement. This theme was important to determine which activity was the least engaging from my perspective and that was the Rosalind Franklin lesson. In addition, this theme provided data to support that Eevee Epigenetics lesson was the most engaging as it needed the least redirects. The behavioral corrections needed were directed toward students being loud, off-task, distracted, or in disagreements.

## Analysis of Data

These results sought to connect the implementation of CRE-enriched lessons with student engagement, and describe what it looks like in the classroom. The research question for this study was *how does the use of CRE-enriched instruction impact grade-level biology student engagement?* These results demonstrate that grade-level biology engagement increased due to implementing CRE-enriched lessons because CRE-enriched lessons make connections between student interests in biology, make connections between stakeholders while guiding student learning and reduce distractions. The most important elements that impact student engagement as a result of the implementation of CRE are using student interests in lessons, developing a sense of belonging, and always focusing on learning. Finn (1989) defined *engagement* as concomitant active participation, a sense of belonging, and aligning identity with school goals. In this study, CRE-enriched lessons improved student engagement as Finn (1989) defines it.

**Summary**

Chapter four illustrated the impact of a CRE intervention on student engagement through teacher and student perceptions. The significant findings were that student engagement improved due to implementing CRE-enriched lessons in grade-level biology. In this study, the major ways CRE-enriched lessons impact student engagement was by connecting biology content to student interests, building connections between stakeholders, guiding learning, and reducing distractions. I will discuss these findings in a broader context, recommendations, and the plan for sharing outcomes in more detail in Chapter 5.

# CHAPTER 5

## IMPLICATIONS

Lack of engagement in grade-level courses seems prevalent at my school based on my experience and the experiences of other teachers. As such, the purpose of this study was to increase engagement by implementing CRE-enriched lessons. In order to serve this purpose, the following research question guided the study:

1. How does the use of CRE-enriched instruction impact grade-level biology student engagement?

Underpinned by constructivism and CRE theories, this research examined student and teacher perceptions of engagement resulting from implementing CRE-enriched instruction and described factors that impact engagement. The study took place over a 5-week period with two grade-level high school biology classes. The intervention was the implementation of five lessons embedded with the CRE tenets of *academic skills and concepts, critical reflection, cultural competence*, and *critique discourses of power.* Through surveys, exit tickets, and observations the study used student and teacher perceptions of engagement to examine whether the CRE-enriched lessons positively impacted student engagement. The significant findings discussed in Chapter 4 suggested that the perception of engagement in grade-level biology improved after implementing CRE-enriched lessons.

This chapter will discuss the implications of the above findings while reflecting on the most valuable information from Chapter 4. Theoretical research associated with

CRE supports these findings. Afterward, I will reflect on action research, occurrences, constraints, and unanticipated challenges, including how I would handle it differently if given a chance to do it again. Finally, I will discuss the implementation of this data into my practice and how I intend to share my results with others before drawing the chapter to a close by discussing the resulting generation of new knowledge from this intervention.

## Conclusion

This research sought to link CRE to student engagement benefits and describe associated practices. The key finding from this research was that student engagement in grade-level biology improved after implementing CRE-enriched lessons. In addition, CRE provides a two-pronged approach that supports student engagement – a cultural appeal to students and culturally appropriate support from the teacher. This two-pronged approach emerged from the two themes connectedness and supportive pedagogical practices.

Connectedness is inclusive of the ways that CRE connects biology to student interests, makes connections between students, and makes connections between the teacher and students. CRE creates and supports this trifecta of connections that is most beneficial to student engagement. Connectedness involved the categories: use of interests, sense of belonging, and relationship building. These categories contained the following codes: biology, enjoyment, fun, interesting, alignment of identity with school, acceptance, support, inclusion, culture, conversations, and relationships.

Supportive pedagogical practices were essential features of CRE-enriched lessons that guided student learning and reduced distractions. The secondary theme of guided learning featured a focus on learning, high expectations, learning, understanding, scaffolding, directing the next steps, completing work, and assessing and correcting misconceptions. In addition, teacher mediation pertained to reducing distractions, and so it was associated with behavioral corrections and reducing noise and distractions.

## Engagement Results

This study addressed the need to implement CRE-enriched lessons regularly in grade-level biology. I altered the molecular genetics unit by interweaving CRE elements into five lessons. Student perceptions of their engagement in biology and school improved due to implementing the CRE-based lessons, as measured by the differential in initial and final surveys, exit tickets, and observation data. Previous academic literature supports the improvement of engagement due to implementing CRE (Djonko-Moore et al., 2018; Johnson, 2011; Milner, 2010).

King (2015) heavily ties engagement to academic achievement. Further, the Framework for K-12 Science Education identifies improving active engagement in science as a central theme and purpose for developing national standards (Pratt, 2012). Therefore, having CRE-enriched lessons for each unit would greatly benefit biology, and increase student engagement and academic achievement (King, 2015).

Djonko-Moore et al. (2018) found that engagement improved in a week-long environmental science summer camp influenced by CRE. In a longitudinal qualitative case study, Johnson (2011) reported that the classrooms became a more effective instructional environment for Hispanic students due to teachers transitioning their practices to be more culturally relevant. In addition, Johnson reports that culturally relevant and high-quality science instruction is complementary in the following ways: scaffolding of learning, the classroom as a community of learners, and the no-one-right approach. Finally, Milner (2010) reports the use of culturally relevant practices promoted students' active engagement. The key findings from Milner's (2010) study show the importance of relationships, high expectations, second chances, and personal stories on student outcomes.

Many authors report that boosting student engagement could help reduce the at-risk population (Fredricks et al., 2016; Landis & Reschly, 2013; McFarland et al., 2018; Yazzie-Mintz, 2006). As such, CRE could be an essential support to narrow the achievement gap at my school. My results indicate that student engagement in school improved due to one class altering one unit to use CRE-enriched lessons. These results support the influence of one class positively affecting student perceptions of the school, which supports my initial thoughts of using biology as a course to boost student engagement in school.

The major conclusions from my study are:

- The CRE-enriched lessons improved student engagement.
- CRE supports student engagement holistically through a cultural appeal to the student and culturally appropriate support from the teacher.

**Connectedness**

The CRE element of connectedness encompasses the use of interests, a sense of belonging, and relationship building. This section has two themes: connecting interests to biology and making connections between stakeholders. There must be a cultural appeal to students to have the greatest impact on student engagement.

### *Connect Interests to Biology*

When lessons used student interests, there was an increase in engagement and enjoyment. Using student interests to learn biology content increased their enjoyment of the activity. The original purpose of developing the Framework for K-12 Science Education was to tie student interests to learning, explicitly stating the need for classrooms to leverage "students' cultural funds of knowledge" (Pratt, 2012, p. 29). Further, many authors discuss the absence of student interests to be disengaging (Baber, 2012; Howard, 2010; Tate, 1997).

### *Connection Between Stakeholders*

CRE facilitates teacher-to-student(s) and student-to-student connections that are essential to engagement. Two categories within this theme were a sense of belonging and relationship building. Both of these categories were valuable for the students in this study to engage more in learning.

**Sense of Belonging.** Developing students' sense of belonging in the classroom is similar to developing their bond with school. These students' feelings of acceptance increased significantly across my study due to implementing CRE. However, a sense of belonging is more than just acceptance. It also includes security, inclusion, and support (Cornell University, 2022). I supported students learning needs constantly by directing their next steps and correcting misunderstandings while making inclusion a priority. Gallagher (2016) describes obligation, commitment, and creating bonds as vital to enacting community in a classroom which aligns with the development of a sense of belonging.

My study sought to build a community among students and between the students and me. I saw that unconditional support nurtures students' feelings of acceptance due to CRE-enriched lessons. Finn (1989) includes a sense of belonging in the definition of engagement. A sense of belonging developed from my study because students felt accepted per the survey data and included per the observation data. I was explicit in my support for student learning as I catered to the needs of students progressing through each CRE-enriched lesson. I accepted any contribution to the discussion as valuable and attempted to turn it into a learning experience. In addition, I allowed second chances, like Milner (2010). Emdin’s (2007) work also contributes to this category by providing communal structures in the classroom. Communal structures break down barriers of control in the classroom giving students more power to make decisions for their learning which contributes to their sense of belonging.

**Relationships.** The academic literature on CRE heavily ties building relationships with increases in student engagement (Gallagher, 2016; Johnson, 2011; Milner, 2010). My students said they pay closer attention to the teachers with whom they have better relationships because they "feel more comfortable," desire to do better, or "want to impress them." Communal structures (Emdin, 2007) and constructivist methods (Applefield et al., 2000) allow classrooms to be social by facilitating relationship development and improving learning experiences. In addition, my study thinks the development of student-to-student relationships is highly valuable, as it seems to help students prioritize attendance and develop academic friendships. Additionally, fostering relationships between students may be a major reason why engagement increases due to CRE. When students have friends in the classroom, they experience more academic-associated interactions and social connections which allows them the opportunity to tie who they are with the classroom.

Constructivist methods facilitate these interpersonal relationships by providing students with opportunities to collaborate and talk (Applefield et al., 2000). In my study, each CRE-enriched lesson used communal structures where students took more control of their learning (Emdin, 2007). Students were allowed to have on- and off-topic conversations throughout each activity because “students will learn more readily from having dialog with each other about significant problems” (Applefield et al., 2000, p. 3).

## Supportive Pedagogical Practices

This study revealed that students in my grade-level biology class want to learn, but the school may not meet that need in the classroom. Several authors blame ineffective instructional strategies (Childs & Baird, 2020; Erduran et al., 2020). Others blame tracking practices that leave grade-level classes void of academic rigor (Bavis, 2016). Aronson & Laughter (2016) suggest that part of CRE is setting and maintaining high expectations with an unconditional commitment to student success. In my study, *supportive pedagogical practices* emerged as a theme that had a positive impact on engagement because these pedagogical practices provided culturally appropriate support from the teacher.

### *Guided Learning*

My study supports guided learning of students as a *supportive pedagogical practice*. The Likert survey revealed that students value learning, as indicated by my study, but the school does not seem to capitalize on this. Guided learning was a way to help students to be successful in completing the work associated with assignments. In my study, students equate engagement with completed work. Students enjoyed learning with many of the CRE-enriched lessons per the exit ticket. Ladson-Billings (1995b) discusses centering academic achievement with the belief that all students can learn, and that teachers must have the “willingness to nurture and support students” (p. 483). In my study, I constantly tended to the needs of students to nurture and support their academic growth. Guided learning means the teacher is just as engaged as the students. The teacher is not a passive participant in the classroom, but an active participant that is constantly interacting with students to develop their academic skills and conceptual understandings. Aronson & Laughter (2016) discuss this as *academic skills and concepts* where teachers enact care so that students receive unconditional support to meet high expectations.

**High Expectations.** Setting and reaching high expectations benefits student empowerment and confidence in their abilities (Gay, 2000; Ladson-Billings, 1995b). Johnson (2011) discusses high expectations as a way of caring for students and “holding them responsible for learning” (p. 186). In my study, I enacted care in my classroom by setting high expectations for the students and cultivating their growth toward meeting this achievement.

Rivera-McCutchen (2012) states that teachers providing care in the classroom empowered poor and minority students to meet high expectations. Many of these CRE-enriched lessons were honors-level assignments. Therefore, I nurtured and encouraged students learning, and corrected student misconceptions to help them meet high expectations. Additionally, I taught them how to assess and correct their own mistakes.

**Scaffolding.** Scaffolding was very important in the development of student understanding. Ladson-Billings (1995a) states as one of the conceptions of knowledge that “teachers must scaffold, or build bridges, to facilitate learning” (p. 481). Scaffolding emerged from my study after the lesson that was missing it had the lowest levels of student engagement. Further, the lesson with proper scaffolding was the most engaging and was the student-favored activity. Scaffolding was essential for grade-level students to meet high expectations.

**Practice Recommendations**

Outcomes from this study will tremendously impact my practice as I continue to develop into a culturally responsive educator:

1. I plan to expand CRE into every biology unit.
2. I will facilitate more student-to-student conversations in my classroom. These conversations demonstrate that students are getting the chance to develop bonds within the classroom, potentially providing a bridge to developing a bond with school (Finn, 1989).
3. I hope to foster students' sense of belonging with unconditional support and acceptance in the same manner as I would for my children.
4. I will continue to incorporate constructivist methods by giving students choice and voice as a way to increase engagement and learning in the classroom.
5. I hope to use students' interests as much as possible to improve their enjoyment of school and my classroom.

I hold several leadership roles at my school where I can share my results. First, I am the biology professional learning community leader at my school. I hope to influence others in the group to utilize or create their own CRE-enriched lessons. Second, as a PDS Fellow, the PDS structures at the University of South Carolina connect me to multiple opportunities to share my results with various levels of educational professionals. Within this capacity, I plan to share at state and national conferences, to preservice teacher classes, and other local meetings as opportunities arise. Third, I have a leadership role at my school in the PDS focus group that meets monthly. I plan to share my results within this group and influence my peers to use culturally responsive practices as a holistic approach to the classroom.

In addition to sharing my results, I will continue my own investigations into the effects of CRE on my classes. I will begin by examining data at my school going forward regarding the impact of using CRE-enriched lessons. For example, these classes had a 12% higher EOC pass rate than the average of all other grade-level biology classes. This is interesting because my study used CRE in one unit, and that one unit could have been responsible for this difference. Continuing to examine, analyze, and share data about student outcomes is one way I plan to expand the use of CRE.

Action research provides a framework by which I am continuously improving my practice. I plan to create CRE-enriched lessons for all biology units so that the students in biology are constantly supported by culturally appropriate methods. I think CRE is inclusive to meet the needs of many more students in the classroom. It normalizes diversity as valuable to learning, thus improving relationships and sense of belonging. My study has provided a glimpse of how a unit with CRE-enriched lessons can impact student engagement positively. I want to continue implementing CRE and linking it to student outcomes.

Action research was chosen for this study because I was interested in generating knowledge for my practice as a classroom teacher. As such, I created CRE-enriched lessons that would benefit my classroom. This research can inform the practice of other biology teachers as a possible way to increase student engagement. The research on CRE supports increased engagement due to its implementation (Johnson, 2011). I believe the results of this study might be of interest to other suburban high school science settings. Action research provides the framework by which I will continue to develop CRE-enriched lessons, as it is a recursive process.

**Implementation Plan**

The results of this study could inform teachers on ways to design more engaging lessons. I plan to share my research in as many avenues as possible. First, I plan to share it with my peers in my content area, with my school-based professional learning community, and with the faculty as a whole. In addition, I have been invited to share my work with several university classes of pre-service teachers after my defense. Lastly, I want to share my results at district, local, state, and national conferences. As a PDS fellow, there are structures in place that I have become aware of that I will use to share my results. I will ensure my study and results are put into action by continuing to collect and share student stories that exemplify the impact that CRE has had on me and my students.

**Reflection on Methodology**

This study sought to improve grade-level biology engagement by using 5 purposefully designed CRE-enriched lessons. As with all action research, this study will not be the final workings of implementing CRE in my classroom. The cyclical nature of plan, act, observe, and reflect (Herr & Anderson, 2015) attracted me to action research as an avenue to improving my practice. This study aimed to assist me in generating new knowledge about CRE and then applying that to my practice.

There were several expected and unexpected outcomes from this study. First, I expected some of the outcomes of CRE to be positive. I expected students to feel closer to me and for us to have a better relationship. In addition, I expected students to feel comfortable in my classroom and to want to do the assignments. There were many things in this study I did not expect, including the potential value of the student-to-student relationship as a possible contribution to developing a sense of belonging. In addition, I did not expect the emergent theme of *sense of belonging* to be part of the definition that Finn (1989) gave for engagement. Lastly, I did not expect students to enjoy learning as much as they did. It requires a significant amount of effort to get some grade-level students to participate. Another unexpected element from my study is that overwhelmingly, grade-level students want to learn but various classrooms are not meeting this need.

I would make several changes or additions if I were to do this study again. First, I would have recorded a non-CRE class to use as a baseline. Second, I would have added a question about whether students were interested in Biology, specifically leaving out the word engagement. For Class DNA, students could have used a visual for how the nucleotide pieces go together. Providing a visual orientation of the parts of the nucleotide would have helped many students to plan their design better. For Rosalind Franklin, I would have provided scaffolding and chunked the reading.

In addition, there could have been a sheet for the DNA Technologies activity where students wrote a statement about each technology while presentations were going on. Afterward, they could create an overarching DNA technology definition and choose two or three examples to include. I think this would increase the academic rigor of the DNA Technology lesson. In addition, it would have helped students' engagement while presentations were going on. Also, providing expectations for their participation during presentations could benefit this assignment, as many students thought they did not have to do anything.

I learned so much more about the use of culture and relevance in my classroom. I learned that grade-level students love learning, and I intend to capitalize on that by developing more CRE lessons that center on student learning. I learned that students want to fit in to feel like they belong. When a teacher facilitates belonging in the classroom, engagement should increase because a sense of belonging is part of the definition of engagement.

The goal of this study was for me to improve my practice continuously, where the significant benefactors are me and my students, and we are all learning what better education experiences are as we make connections in the classroom. However, connections were not solely occurring within my classroom. There was another layer of connectedness that was associated with this study because it was conducted at a PDS site. This layer of connectedness was between me and my peers at my school, and between me and multiple arenas to share my results. The PDS structures at my school allowed me to monthly discuss many CRE strategies and to gain a holistic understanding of what CRE looks like in the classroom. In addition, PDS structures provided me with avenues to share my progress locally at monthly meetings, regionally at quarterly meetings, and annually at a national conference. These experiences have helped me to build confidence in my understanding of CRE, and to have intelligible conversations with other educational professionals about culture and its use in the classroom.

Another valuable element for me as a teacher that resulted from this study was using the exit ticket not only to gain students' feedback, but also to help students see that they are an essential part of their learning experience. Students were thinking about their contributions by reflecting on their participation. They started to see the behaviors preventing them from engaging and participating more in the classroom. Implementing a regular exit ticket throughout the year where students assess their engagement and behavior may help students recognize behaviors that impair their engagement and reduce their academic achievement.

My experiences designing these lessons will serve me well in the future as I design more CRE-enriched lessons and share my work with others. Action research has allowed me to reflect on this study and improve my practice. As such, I better understand the theoretical underpinnings of CRE practice and what that looks like in a classroom. I can now clearly see the areas I need to grow to be even better for my students. This research has empowered me to learn as a teacher and teach students to expect more. I plan to share this work at various conferences and continue to grow as a practitioner-researcher.

## Limitations

This study is limited to my context, which is my grade-level biology classroom. My grade-level biology classes had an overrepresentation of racially and ethnically diverse students, and we engaged in CRE. This study was about improving my practice as a classroom teacher in a suburban secondary school, which is why action research provided the best framework. Many of the findings in this study align with the research on CRE.

One of the design limitations was that my study did not record a class as a baseline for the observations. Recording a class not engaging in CRE would have provided a baseline to compare with the CRE observations. Many interactions in a classroom engaging in CRE are also present in a classroom not engaging in CRE. Having a documented typical observation day could have substantiated the results even more. However, I think the literature on CRE substantiates many of the themes in this study.

The Rosalind Franklin activity not having the proper scaffolding was an error on my part as the teacher, and limited this study. However, I think it supports the need to scaffold learning and *academic skills and concepts*, as that lesson was the least engaging. If this lesson were scaffolded or if the reading was chunked, I think students would be more engaged, and not need as many teacher redirects.

As with any study, unanticipated occurrences could affect the results. One was the difference in the number of students that completed the initial and final surveys. The initial survey had 34 participants, while the final survey only had 24 participants. The surveys were not a requirement for students, and they were anonymous. It could have also been that some students were absent. To avoid this in the future, I could walk around and ask students several times if they had completed the survey or if they would complete it for me. Several Likert-scale statements results remained the same when comparing the initial and final results. These statements likely validate the data that changed significantly during the same period. For instance, the results for the statement that *I am interested and engaged in biology* changed tremendously. However, the results for the statement that *I am interested and engaged in my other classes* remained relatively the same when comparing the initial to the final survey.

## Recommendations for Future Research

I suggest several avenues of future research:

1. Longitudinal studies that link achievement scores and student outcomes with the use of CRE tenets would be highly beneficial to add to the literature.
2. Additional research on the influence of fostering more student-to-student conversations in the classroom to help students align their identity with school would be highly beneficial. I think it contributed to the positive engagement outcomes associated with my study.
3. Many of the literature's elements of enacting care and CRE align heavily with mothering. Since becoming a mother, I cannot help but other-mother many of these students. I look at them like they could be my own, and that makes enacting CRE a natural approach to the classroom.
4. I think comparison studies of the achievement scores of teachers that enact CRE and those that do not could demonstrate academic outcomes and link them to CRE.

## Conclusion

This 5-week intervention study aimed to answer the research question *how does the use of CRE-enriched lessons impact grade-level student engagement*? My problem of practice was that there is a lack of engagement among grade-level biology students, which leads to lower academic success and limits their long-term opportunities. My study sought to improve the engagement of grade-level biology students through the intervention of 5 CRE-enriched lessons to measure their impact. The overall conclusions were that CRE-enriched lessons improved student engagement and that engagement requires a two-pronged approach – cultural appeal to students and culturally appropriate support from the teachers. This study demonstrates a benefit to engagement in a grade-level biology classroom, and that engagement could potentially help students with developing a sense of belonging associated with school so that their long-term opportunities are not limited.

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APPENDIX A

SURVEY

Please respond to the questions by gauging whether you Strongly Agree (SA), Agree (A), Not sure (NS), Disagree (D), or Strongly Disagree (SD) with the statement.

| | Statement | SA | A | NS | D | SD |
|---|---|---|---|---|---|---|
| 1 | I would prefer to find out why something happens by doing an experiment than being told. | | | | | |
| 2 | Biology lessons are fun. | | | | | |
| 3 | Biology lessons bore me. | | | | | |
| 4 | I really enjoy going to biology class. | | | | | |
| 5 | The material covered in biology lessons is uninteresting. | | | | | |
| 6 | I love going to school. | | | | | |
| 7 | School is boring. | | | | | |
| 8 | Learning new things is fun. | | | | | |
| 9 | Getting an education is important. | | | | | |
| 10 | I am engaged in school. | | | | | |
| 11 | I am engaged in biology class. | | | | | |
| 12 | I stay interested and engaged in most of my classes. | | | | | |
| 13 | I stay interested and engaged in biology. | | | | | |
| 14 | Positive comments motivate me to do my work. | | | | | |
| 15 | Relationship with your teacher makes a difference to how you do in a class. | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16 | Acceptance of my culture in the classroom is important to me. | | | | | |
| 17 | I feel accepted in Biology class. | | | | | |
| 18 | Mrs. Biery gives me as much attention as others. | | | | | |
| 19 | I have the same amount of say in this class as other students. | | | | | |
| 20 | My work receives as much praise as other students' work. | | | | | |

21. What do you think about science?
22. What do you think about Biology?
23. What factors do you think make biology easy to engage in? or what factors do you think make biology easy to disengage in?
24. Are your interests used when learning biology?
25. What positive comments do you get from your teachers?
26. Explain how a relationship with your teacher could influence how well you do in that class.
27. Do you think seeing those with the same identity as you is important in education? Why?

This Likert Scale portion of the survey has been adapted from the Test of Science-Related Attitudes (TOSRA) (Fraser, 1981) and What is Happening in this class? (WIHIC) (Aldridge & Fraser, 1999). These questions were used to analyze student beliefs on various measures associated with engagement and CRE. They fit this study to gather data on cultural relevance, perceptions of school, sense of belonging, and engagement.

## APPENDIX B

## EXIT TICKET

1. (engagement) How engaged were you in class today? (1-5)

   - Why did you answer that way? (open responses)

2. (on-task) To what degree were you on task today?  (1-5)

   - Why did you answer that way?  (open response)

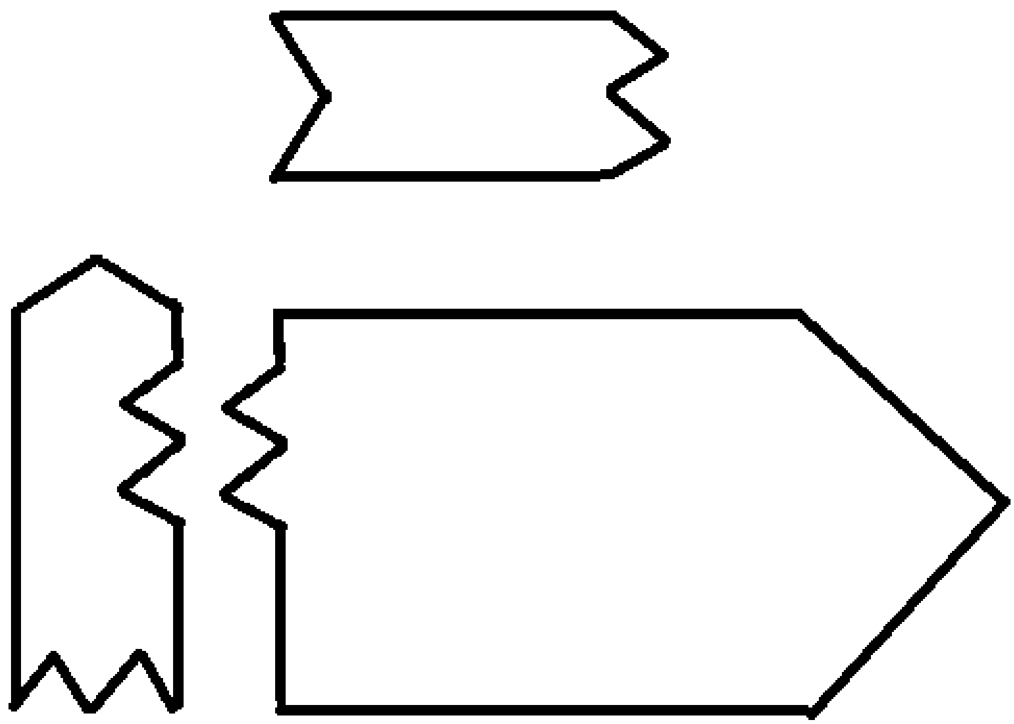
3. (active participation) To what degree did you participate in class today? (1-5)

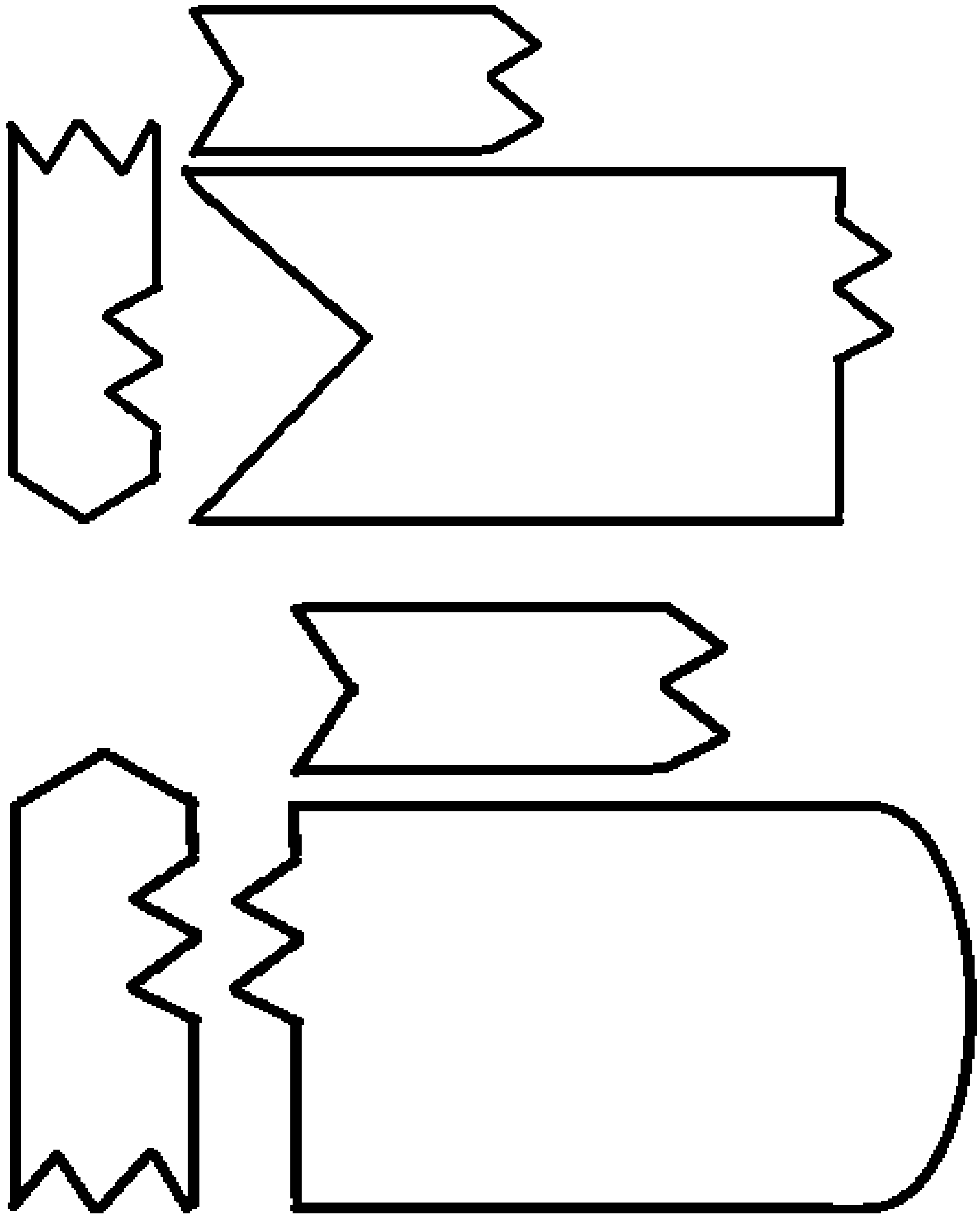
   - Why did you answer that way? (open response)

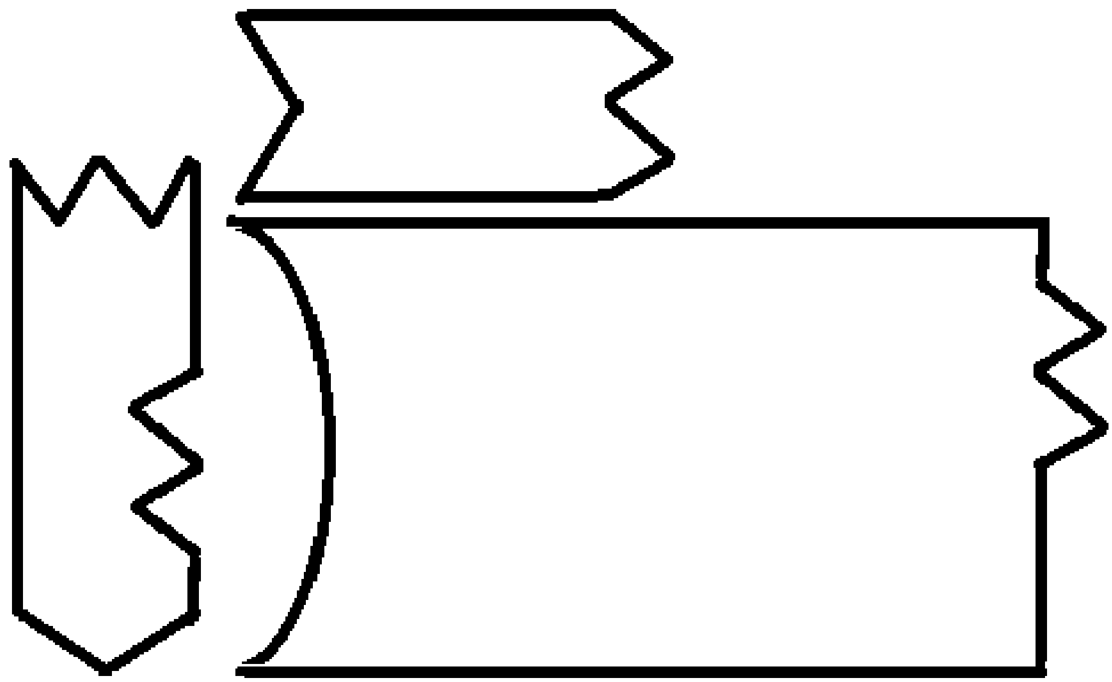
APPENDIX C

CLASS DNA LESSON

This DNA has been shrunk to fit into this dissertation. The actual size will result in strands of DNA that are 2-3 feet wide and many feet long depending on the number of students in the class.







APPENDIX D

ROSALIND FRANKLIN LESSON

Rosalind's story will be reviewed through several articles:

- Time Magazine - https://time.com/5793551/rosalind-franklin-100-women-of-the-year/
- Plagiarism - https://sites.psu.edu/magdaliapassionblog/2018/02/08/watson-and-crick/
- Compiled documents - https://drive.google.com/file/d/1Lly9q0bQv4onb_rwwwKM__oy8LquGg4D/view

Students was put into groups and complete a claim, evidence, and reasoning document about who was the most unethical person in Rosalind's life.

APPENDIX E

DNA TECHNOLOGIES LESSON

Students will research and present interesting uses of DNA technology. Students will help generate the requirements for the presentation based on what they think was interesting to learn about DNA technologies. Each student will claim a topic to present. Students were given 30 minutes to research and put together a presentation on an interesting use of DNA they have chosen. The latter portion of the class was used to present their technology. If students need help finding a topic, some links are found below to help them.

https://www.cnn.com/2012/09/28/justice/louisiana-inmate-exonerated
https://www.nytimes.com/2018/10/16/us/20-years-exonerated-dna-prison.html
https://innocenceproject.org/dna-exonerations-in-the-united-states/
https://www.cnn.com/2013/02/03/world/europe/richard-iii-search-announcement
http://www.cnn.com/2010/TECH/science/05/07/neanderthal.human.genome/index.html
https://www.huffpost.com/entry/bigfoot-dna-controversy-science-journal_n_2711676
https://www.nationalgeographic.com/culture/article/100216-king-tut-malaria-bones-inbred-tutankhamun

# APPENDIX F

## PROTEIN AFFIRMATIONS LESSON

Students were given the following DNA sequences that they will have to transcribe and translate to determine the affirmation within that code.

Examples:

DNA sequence: TAC GGC GGA TCC GCA GTA CGG CAT GAA AGG ACT

Codon: AUG CCG CCU AGG CGU CAU GCC GUA CUU UCC UGA

Affirmation Translation: There is no one better to be than myself.

DNA sequence: TAC TAT TTC GTA GTT CCT TTT ATT

Codon: AUG AUA AAG CAU CAA GGA AAA UAA

Affirmation Translation: I get better every single day.

List of Some of the Affirmations:

I am a beautiful and amazing person.

All of my problems have solutions.

My challenges help me grow.

I am perfect and amazing just the way I am.

Today is going to be the best day ever

I have people who love and respect me

I stand up for what I believe in

I believe in my goals and dreams

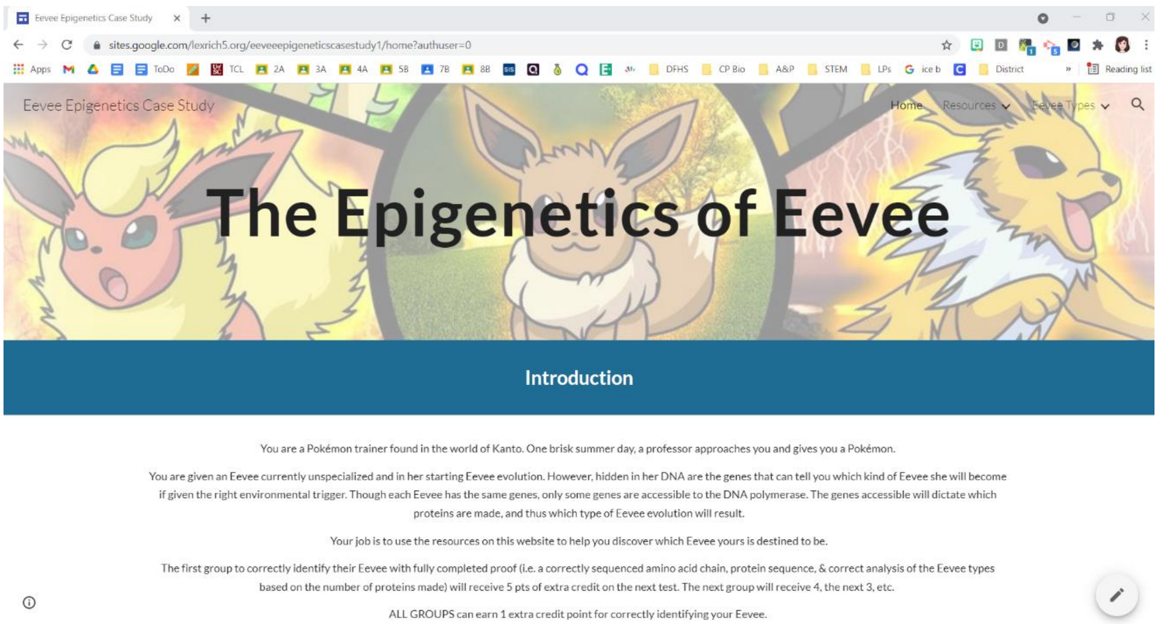
Today I choose to think positive.

I can do anything I put my mind to
Codon Chart for this activity:

UAG - Stop (period
CCG - There
CGC - stand
AUG - Start codon
CCU - Is
CGG - can
AAA - day
CGA - anything
CGU - one
AAC - power
AAG - get
AAU - problems
ACG - challenges
ACC - a
ACU - in
ACA - and
AGA - the
AGG - no
AGU - me
AGC - people
AUA - I
AUC - person
AUU - love
CAA - every
CAC - perfect
CAG - respect
CAU - better
CCA - up
CCC - am
CUA - think
CUC - today
CUG - going
CUU - than
GAA - choose
GAC - my
GAG - help
GAU - way
GCA - goals
GCC - to
GCG - believe
GCU - solutions
GGA - single
GGC - dreams
GGG - who
GGU - best
GUA - be
GUC - beautiful
GUG - of
GUU - mind
UAA - Stop (period)
UAC - for
UAU - grow
UCA - put
UCC - myself
UCG - just
UCU - positive
UGA - Stop (period)
UGC - what
UGG - have
UGU - amazing
UUA - ever
UUC - do
UUG - all
UUU - is

APPENDIX G

EEVEE EPIGENETICS LESSON




In this activity, students were assigned an Eevee case upon which they must use their skills in transcription and translation to determine genes that are being expressed. They will then use this information to determine what Eevee will morph into as a result of the epigenetics.

Student Worksheet to accompany this activity:

Eevee Epigenetics Worksheet

Directions: Use the website to help you discover what type of Eevee yours is going to evolve into if given the right environmental trigger. Follow each step below!

Eevee Unknown # _________

STEP 1: Transcribe

- You need to **transcribe** each of the 6 genes into the correct mRNA sequence. Remember, in RNA U's are going to pair with A's unlike in DNA! For example, TAC's corresponding mRNA will be AUG
- Put a space in between each codon (three letters) ex. AUG AAA CAG GGG UAU

Gene #1 mRNA:

Gene #2 mRNA:

Gene #3 mRNA:

Gene #4 mRNA:

Gene #5 mRNA:

Gene #6 mRNA:

STEP 2: Translate

- After you have turned your DNA message into RNA, you need to use the above mRNA sequences and translate them into amino acids. You do this by reading one CODON (three letters) at a time and using the codon wheel! Begin in the center, then move outwards.

Gene #1 Amino Acid Sequence:

Gene #2 Amino Acid Sequence:

Gene #3 Amino Acid Sequence:

Gene #4 Amino Acid Sequence:

Gene #5 Amino Acid Sequence:

Gene #6 Amino Acid Sequence:

STEP 3: Determine Proteins

- Using your newly generated amino acid sequences, analyze the order to determine what overall protein will be made from those given amino acids.
- Remember, in your body the START codon (AUG or Met) is what will always begin your amino acid sequence and the STOP codons (UAA, UAG, UGA) will always STOP it.
- The Met amino acid signifies the beginning of the amino acid chain!

Gene #1 Protein:

Gene #2 Protein:

Gene #3 Protein:

Gene #4 Protein:

Gene #5 Protein:

Gene #6 Protein:

STEP 4: Determine Eevee Type!

- Now that you have all 6 of your proteins, use the Eevee Type Chart to determine what type of Eevee yours will Evolve into!
- When you think you've cracked it, let me know and I will check it to tell you if you are right!

Eevee Type: ____________________