Black Girls Are Scientists: Science Identity Development and the Role of Culturally Sustaining Pedagogy in an Urban Science Classroom

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Black Girls Are Scientists: Science Identity Development and the Role of Culturally Sustaining Pedagogy in an Urban Science Classroom

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The racial, gender, and class disparities of science self-efficacy among middle school students create an equity barrier in middle school science students. Despite the research supporting the need for inclusion, the STEM education community has a long history of eliminating culturally diverse topics and people from the science curriculum. There are various long-standing challenges and future opportunities and recommendations for better serving the 6-8 science/STEM education needs of urban schools and communities. Teachers must prioritize students’ learning by actively identifying scientists and inventors of various racial and ethnic backgrounds, incorporating diverse scientists into their everyday curriculum, and learning the importance of students seeing themselves in the science curriculum to increase students’ science self-efficacy and the likelihood of pursuing a STEM-related career.

Through a pre-post survey and empathy and semi-structured interviews, this project examined identity development using classroom observations, note taking, looking at student work, and interviews to gain a deeper understanding of the science identity development of African American girls within an urban school setting in the Midwest.

Keywords: Black girls, Critical Race Theory (CRT), science identity, culturally relevant teaching (CRT), culturally sustaining pedagogy (CSP)
# Table of Contents

Dedication .......................................................................................................................... xvi

Land Acknowledgement ..................................................................................................... xvii

Acknowledgements ........................................................................................................... xviii

1.0 Introduction ...................................................................................................................... 1
  1.1 Importance of Diversity in STEM Fields ................................................................. 3
  1.2 Conclusion ................................................................................................................... 4
  1.3 Organizational System ............................................................................................... 4
    1.3.1 Stakeholders .......................................................................................................... 5
        Science Department ........................................................................................................ 5
        Administrators .............................................................................................................. 6
        Students. The majority of students at the school identify as Black/African American or Hispanic .......................................................................................................................... 6
        Interconnected Relationships ....................................................................................... 7
        Positionality Statement ................................................................................................. 7
  1.4 MySci Curriculum Implementation .......................................................................... 8

2.0 Chapter 2: Literature Review ...................................................................................... 11
  2.1 Culturally Relevant Teaching .................................................................................... 11
    2.1.1 Practical Implications of Culturally Relevant Teaching ....................................... 12
    2.1.2 Culture and Curriculum ....................................................................................... 13
      2.1.2.1 Community Cultural Wealth ........................................................................... 14
      2.1.2.2 Student Culture ............................................................................................. 16
2.2.3.2.2 Science Identity

2.2.3.2.3 Transitions

2.2.3.2.4 Structural Barriers

2.2.3.3 Guiding Question 3: What are the best practices to develop science self-efficacy in Black girls?

2.2.4 Gaps in the Literature

2.2.5 Conclusion

2.3 Critical Race Theory

2.4 Identity Development

2.5 Racial Identity Development

2.6 Ecological Systems Perspective

2.7 Implementation Plan

2.8 Driver Diagram

2.9 Driver Descriptions

2.10 Driver Measures

2.11 Process Measures

2.12 Balancing Measures

2.13 AIM Statement

2.14 Change Ideas

2.14.1 Science Curriculum Intervention

Concept 1

Concept 2

Concept 3
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept 4</td>
<td>51</td>
</tr>
<tr>
<td>Performance Task</td>
<td>51</td>
</tr>
<tr>
<td>2.14.2 Teacher Reflection Journal</td>
<td>54</td>
</tr>
<tr>
<td>2.14.3 Conclusion</td>
<td>55</td>
</tr>
<tr>
<td>3.0 Methods &amp; Measures</td>
<td>57</td>
</tr>
<tr>
<td>3.1.1 Research Methods</td>
<td>57</td>
</tr>
<tr>
<td>3.2 Research Questions</td>
<td>58</td>
</tr>
<tr>
<td>3.3 Participants</td>
<td>58</td>
</tr>
<tr>
<td>3.4 Data Sources, Collection, and Analysis</td>
<td>58</td>
</tr>
<tr>
<td>3.4.1 Qualitative Interviews</td>
<td>59</td>
</tr>
<tr>
<td>3.4.2 Quantitative Pre and Post Survey</td>
<td>61</td>
</tr>
<tr>
<td>3.4.3 Educator Reflection Journal</td>
<td>63</td>
</tr>
<tr>
<td>3.4.3.1 Use of Pseudonyms</td>
<td>64</td>
</tr>
<tr>
<td>3.4.4 Conclusion</td>
<td>64</td>
</tr>
<tr>
<td>3.5 Ethical Considerations</td>
<td>65</td>
</tr>
<tr>
<td>4.0 Results</td>
<td>66</td>
</tr>
<tr>
<td>4.1 Overview</td>
<td>66</td>
</tr>
<tr>
<td>4.1.1 Growing Science Identity - Participant Profiles</td>
<td>67</td>
</tr>
<tr>
<td>4.1.1.1 Kay</td>
<td>67</td>
</tr>
<tr>
<td>4.1.1.2 Jeniyah</td>
<td>68</td>
</tr>
<tr>
<td>4.1.1.3 Jenae</td>
<td>68</td>
</tr>
<tr>
<td>4.1.1.4 Marie</td>
<td>68</td>
</tr>
<tr>
<td>4.1.1.5 Kahleia</td>
<td>69</td>
</tr>
</tbody>
</table>
4.2.1.3 Conclusion: .......................................................................................... 78

4.2.2 Research Question Two ........................................................................... 79

4.2.2.1 Increase in Science Identity ................................................................. 79

4.2.2.2 Hip Hop Pedagogy .............................................................................. 81

4.2.2.2.1 Breakdancing .................................................................................. 81

4.2.2.2.2 Knowledge ...................................................................................... 81

4.2.2.2.3 Graffiti ........................................................................................... 82

4.2.2.3 Role Playing ......................................................................................... 83

4.2.2.4 Emceeing ............................................................................................ 83

4.2.2.5 Writing affirmations .......................................................................... 85

4.2.2.6 Multimodal Instruction ...................................................................... 86

4.2.2.7 Relevant and meaningful learning ...................................................... 86

4.2.3 Research Question Three ...................................................................... 89

4.2.3.1 Teacher Support ................................................................................ 90

4.2.3.2 Experiential Learning ....................................................................... 92

4.2.3.3 Community Cultural Wealth ............................................................. 92

4.2.3.3.1 Cultural Capital ............................................................................ 92

4.2.3.3.2 Aspirational Capital ................................................................. 93

4.2.3.3.3 Familial Capital ........................................................................... 95

4.2.3.3.4 Social Capital .............................................................................. 96
5.4.1 Whiteness as Dominance ................................................................. 109
5.4.2 Intersectionality of Race and Gender ............................................ 110
5.4.3 Counter Storytelling ................................................................. 109
5.4.4 Knowledge of Self ................................................................. 111
5.4.5 Inclusive Learning Spaces .......................................................... 112
5.5 Limitations ................................................................................. 112
5.6 Implications for Science Educator Practice ....................................... 113
  5.6.1 Cultivate Inclusive Learning Spaces .......................................... 113
  5.6.2 Embed Culturally Relevant Content .......................................... 114
  5.6.3 Promote Hands-On and Experiential Learning ......................... 114
  5.6.4 Continuous Professional Development ...................................... 115
  5.6.5 Teacher Education Programs .................................................. 115
5.7 Implications for All Educators ...................................................... 116
5.8 Conclusion ................................................................................. 117
Appendix A Educator Reflection Journal Prompts .................................. 119
Appendix B: A Single Item Measure for Assessing STEM Identity .......... 120
Appendix C: Empathy Interview Questions ............................................. 121
Appendix D: Semi-structured Interview Questions ................................. 122
Appendix E: Concept 3 Session 1 Culturally Relevant Teaching Strategy Alignment ..... 123
Appendix F: Concept 3 Session 2 Culturally Relevant Teaching Strategy Alignment ..... 125
Appendix G: Concept 3 Session 3 Culturally Relevant Teaching Strategy Alignment ..... 126
Appendix H: Concept 3 Session 4 Culturally Relevant Teaching Strategy Alignment ..... 128
Appendix I: Concept 3 Session 5 Culturally Relevant Teaching Strategy Alignment ...... 129
Appendix J: Concept 3 Session 6 Culturally Relevant Teaching Strategy Alignment...... 130

Appendix K: Observation Quotes from Participants .......................................................... 131

Appendix L: Educator Reflection Journal Part 1 .................................................................. 132

Appendix M: Educator Reflection Journal Part 2 .................................................................. 134

Appendix N: Educator Reflection Journal Part 3 ................................................................. 135

References .................................................................................................................................. 136
List of Tables

Table 1: Teacher Demographics.............................................................................................................. 6
Table 2. Summary of Culturally Relevant Teaching Strategies......................................................... 10
Table 3. Hip Hop Pedagogy and Science Education Alignment......................................................... 20
Table 4. Research Study Questions, Data Sources, and Analysis Alignment................................. 59
Table 5. Interactive Activities by Session .......................................................................................... 73
Table 6. Participant Responses to Teacher Impact on Science Identity ......................................... 91
Table 7. Participants’ Career Aspirations............................................................................................. 94
List of Figures

Figure 1. Driver Diagram ................................................................................................................. 46
Figure 2. Modified Version of Single Item Measure ........................................................................ 61
Figure 3. Science Identity Growth .................................................................................................. 80
Figure 4. Building Science Identity in Black Girls .......................................................................... 103
Dedication

This dissertation is dedicated to my nieces Aleathia Dove, Nalani Dove, and Naomi Denise. You are loved beyond measure. May you carry the strength of your ancestors with you wherever you go.

To Elle Marie, Layla Iman, Kaylin Raye, and Kamille Joy. Never let anyone tell you what you can and cannot do when you Black girl rock.

To my paternal grandmother, Cora Sue Ward and my great aunt Marilyn Black…thank you for loving me unconditionally.

To my brother, Adrian Jordan. Thank you for telling me that I’m smart. I promise…no one has ever been able to tell me anything different ever since.

This dissertation is dedicated to the 7 generations who came before me. Those who worked, thought, and prayed for this moment before it came. For it is not about the things that I have done, but about the people that we belong to and who belong to us.

To the Black girls who shared their voices and made this dissertation possible…thank you for helping me become a doctor. I hope that I can return the favor one day.

To all Black girls everywhere…I see YOU.
Land Acknowledgement

This dissertation was written on Native land. The University of Pittsburgh occupies the ancestral lands of the Seneca (Sen-uh-kuh) in Pittsburgh. The middle school where the research was conducted occupies the lands of the Osage, Shawandasse Tula (Shawnee), and Monongahela (Muh-naang-guh-see-luh) peoples.

I honor my ancestors as the original caretakers of multiple regions where this dissertation was brought to life and to completion. I uplift the historic relationship with the land and the ancestral territory. I pay my respects to my Elders and their past, present, and future. I commit to continue my gratitude, appreciation, and respect for my fellow people of past, present, and future generations.
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1.0 Introduction

“Authentically equitable means a science education…that disrupts and transforms the very foundation on which oppressive ideas are based.”

Jennifer D. Adams

There is an underrepresentation of African American and Black females in STEM fields, with inequity and systematic racism as the culprits of said underrepresentation. The intersections of race and gender create a space where Black girls are undereducated and intentionally excluded from higher-level STEM courses and access to qualified teachers. Within the K-12 classroom, factors such as science self-efficacy, student achievement, and access to opportunity and resources often leave Black girls with a negative view of themselves as scientists. Consequently, these factors often deter Black girls from pursuing STEM careers post-graduation.

The topic of science identity and the underrepresentation of Black women in STEM fields is important because it points to bigger issues that need to be addressed within the educational system. Research suggests access to qualified teachers (Taylor, 2010; Flores, 2007; Palardy, 2015), science academic achievement (NAEP, 2019), and science identity and science self-efficacy (Britner & Pajares, 2006; Lofgren et al., 2015) contribute to persistence in STEM such as taking college-level courses and entering a STEM career field. Approximately 75% of American scientists and engineers are White, and only 10% of STEM professionals are women of color (Young et al., 2017). According to the Nation’s Report Card (2019), results show that a more significant percentage of Asian and male twelfth-grade students have taken courses in biology as compared to other racial and gender groups.
If students do not see themselves as scientists or do not see scientists that look like them, they are less likely to pursue a career in a STEM-related field. According to McGee (2023), STEM has been designed for Whiteness by White men. Institutions have become complicit in placing constraints on Black and Brown peoples’ access to STEM related opportunities. Diversity and inclusion often address the numerical problem. However, it does little to address the need for cultural and structural changes to learning spaces (Cole, 2020; McGee, 2023).

These institutional barriers trickle down into curriculum where Black students do not learn or see Black scientists and inventors. According to Pringle (2013), science teachers’ bias perpetuates the idea that the image of the White male represents a scientist. This ideology marginalizes students of diverse racial backgrounds. “Students of color, primarily from underrepresented groups are rarely able to see themselves in science or see how science is relevant to their daily lives in science classrooms” (Pringle, 2013, p. 3). Representation in the curriculum and an engaging learning environment are ways to ensure that students see themselves in STEM and as scientists. When more Black students see themselves as scientists, they are more likely to enter a STEM-related field post-graduation. There is a need for culturally relevant pedagogy in the science classroom–especially in diverse schools. Teachers need to move away from pedagogy that lacks opportunities for diverse students to engage in science practices (i.e. observations, inference, and evidence) and towards practices where students can be situated as scientists in the classroom (Buck et al., 2009).

Students seeing themselves as scientists with potential for a future in the field, could be pivotal in shifting health disparities and making technology more culturally responsive. McGee & Bentley (2017) highlight the importance of implementing elements of social justice into STEM as it aligns to the collectivist mindsets of Black and Brown individuals and communities (p. 28). The
deficit perspective—often used in curriculum and instruction—leaves students at a loss (at no fault of their own). This mindset results in low academic achievement and low academic self-efficacy.

The purpose of my research is to use culturally sustaining teaching strategies to engage Black girls in science classes as a way to ensure that they develop a positive science identity. My research study will focus on my professional context—a predominantly African American school district in the Midwest. My current problem of practice (PoP) statement is that my middle school Black students do not see themselves as scientists within the middle school science classroom. As the literature suggests, Black girls often do not feel welcomed in the science classroom (King & Pringle, 2017) and are not viewed as scientists (Morris, 2007; King, 2022; Pringle, 2012).

The lack of diversity in STEM-related career fields is a result of these factors.

1.1 Importance of Diversity in STEM Fields

According to Tan et al. (2013), women represent less than 30% of total STEM field degrees. In the medical field, racial bias is present in pain assessment where White doctors believe Black Americans can tolerate more pain. This ideology results in under prescribing in Black populations for pain management (Hoffman et al., 2016). Black women have the highest mortality rate in the United States. In 2021, Black women mortality rates were three times the rate for White Women. This is caused by the comorbidities that disproportionately affect women of color. These include but are not limited to hypertension, obesity, and diabetes (Bond et al., 2021)

In technology, diversity is important in data where a widespread view of a data set can eliminate bias in tech systems such as Artificial Intelligence. For example, a person’s bias could be embedded in an AI system—creating a large-scale space for harmful biases (i.e. credit scores
based on race) (Lutkevich, 2022). A diverse workforce leverages different backgrounds, experiences and points of view. Cultural diversity and equity are vital to ethically sound companies and organizations. They support creativity and ensure innovation in ways that benefit a range of people.

1.2 Conclusion

In conclusion, the importance of representation in STEM cannot be overstated. Diversity within the fields of science, technology, engineering, and mathematics not only fosters innovation and creativity but also ensures that a broader range of perspectives are considered in problem-solving and decision-making processes. By actively promoting and supporting diversity and inclusion, we can create a more equitable and prosperous future where everyone, regardless of their background or identity, has the opportunity to contribute to and benefit from the advancements of STEM.

1.3 Organizational System

My problem of practice and research inquiry is in my work place. The school district is an urban school district in the Midwest. The middle school houses both 7th and 8th graders. In 2021, 100% of students (n=724) were eligible for a free/reduced lunch. According to the State Department of Elementary and Secondary Education, 89.8% of students are Black; 3.4% are
Hispanic, and 2.8% are White. Demographics by gender are 51.80% male and 48.20% female. In 2021 and 2022, all school administrators were Black.

### 1.3.1 Stakeholders

**Science Department.** The science department at the middle school includes six full-time science education teachers. There are three science teachers for each grade level (seventh and eighth). All teachers identify as Black. The eighth-grade team consists of all female teachers, while the seventh-grade team is one female and two males (Table 1).

All the seventh and eighth-grade science teachers in the school identify as Black and have substantial knowledge of culturally sustaining pedagogy. However, they are often left out of curriculum decisions and district-wide science initiatives. Instead, those decisions are left up to those with power and a lack of knowledge on how to move the district forward in providing equitable science education.

Science teachers are impacted because it is their pedagogy that has an impact on students’ sense of belonging and science identity development. Teachers who teach subject areas outside of science are impacted in the sense that students’ confidence in a subject matter can go beyond the science classroom. During empathy interviews, six out of eight students explained how being challenged in my science classroom gave them the confidence that they could do “hard things” in other classes as well. One student said, “In science, even if I fail, I am still a scientist. Everything won’t always be perfect. I can mess up in math and still be good at math.” This level of building self-efficacy can be beneficial for students in every content area—not just science.
Table 1: Teacher Demographics

<table>
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<th>Teacher By Highest Degree Earned</th>
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</tr>
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<td>Bachelor’s</td>
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<tr>
<td>Master’s</td>
<td>2</td>
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<tr>
<td>Doctoral</td>
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**Administrators.** Administrators are often held accountable for students’ engagement and achievement in the classroom. At the middle school level, students need to be prepared for the rigor of high school-level science courses. Further, principals, assistant principals, and instructional support leaders are held accountable for benchmark test scores. Even though these scores are incorporated into teachers’ summative evaluations, administrators are evaluated on how teachers perform in this area.

The demographics of the school’s leadership team are a Black male principal with a doctoral degree and background chemistry, a Black male assistant principal, a Black female assistant principal, and a White female ISL.

**Students.** The majority of students at the school identify as Black/African American or Hispanic. There is a lack of representation of Black scientists and inventors present in science curriculum. Based on my empathy interviews, students want to learn about different scientists, especially those that look like them. Further, they want to engage in more hands-on learning experiences, such as experiments. They also want to do more experiential learning, such as field trips, guest speakers, and going out into the community. Students’ commentary during interviews concluded that they wanted and needed more than what was being offered in their current science classroom.
**Interconnected Relationships.** The relationship between the district, Board of Education, families, and community members is difficult given that many families do not feel heard. Parents and families have many concerns around safety and academics in the school district. Many families feel the district is not doing enough to keep students safe and provide opportunities for students to reach their potential. Further, many families are against the work that the district has been doing with incorporating anti-racist and anti-bias standards. Other families feel we are “behind the times,” while others are grateful for this recent push from the district.

**The Community.** Also, the school district is in the middle of racial trauma. On August 9, 2014, Michael Brown Jr was murdered by a White police officer in Ferguson, Missouri. Riots and protests occurred in Ferguson and spread across the country. The protests and continuing activism led to an evaluation of the prison and educational system. From these efforts, the Ferguson Commission was born. Their mission was to “conduct a ‘through, wide-ranging and unflinching study of the social and economic conditions that impede progress, equality, and safety in the St. Louis Region (Bone, 2019; Forward Through Ferguson 2015).”

The relationships between teachers and students/families are inconsistent. Some teachers use their power to conform and force students to comply, while others share power within the classroom by empowering students to use their voices and providing choices.

Additionally, I would argue that I am missing the perspective of community organizations, community members, and curriculum writers. One way to gain this perspective is to do empathy interviews with those individuals and groups. Also, there needs to be more research on how these individuals are impacted and the historical relationships between communities and schools.

**Positionality Statement.** I was able to address my problem of practice as a Black woman who was raised in similar neighborhoods that my students reside in. This positionality impacted
the lens through which I view my students and how I related to their vast experiences of racism and sexism. My current position as a certified science teacher placed me in a position of power over the Black female students. My sphere of influence included the science course I teach, my advisor position of the STEM Club, and my professional views that equity, justice, and cultural relevance should serve as a foundation for teaching and learning.

As a Black female who studied biology in college, I understood the obstacles that my students face when they do not learn about Black scientists and do not see images of Black girls in science on a consistent basis. This experience can feel negative and creates a barrier between self and the desired identity of a scientist. I was able to share my own experiences to better give my students purpose in learning while also leveraging my personal experiences to address the gaps that exist.

1.4 MySci Curriculum Implementation

The school district utilizes MySci as a science curriculum resource. MySci utilizes the 5E model which includes engage, explore, explain, extend/elaborate, and evaluate. During the engagement phase, the teacher assesses students’ prior knowledge. Students may engage in brainstorming activities which help to motivate students to engage in the content. In the exploration phase, students engage in skills such as observations, investigating, and hypothesizing. During the explanation phase, the teacher serves as a “facilitator and ask[s] the students to describe and discuss their own explanations” (p. 53). In the elaboration phase, students develop a deeper understanding of the concepts. They also apply their skills while integrating technology. Finally, the evaluation phase involves informal or formal assessment (Duran & Duran, 2004).
The curriculum divides each unit into concepts which are broken into cycles. Each cycle is made up of sessions/lessons. The first cycle focuses on night and day while the second cycle focuses on the seasons. For this study's purposes, the researcher looked at the third concept of the Space unit. This concept was chosen by the researcher because students develop models, utilize simulation, and engage on a science field trip during this part of the unit. Further, based on empathy interviews with students, this part of the unit provided hands on learning including data collection, model development, and simulation.

Concept 3 focused on gravity. During this part of the Space unit, students used mathematical equations and gathered data to discover the relationship between weight and gravitational force. Students developed models to discover how gravity affects objects within a system. Students applied what they know about gravity to satellites and space missions by learning about gravity assist via simulation and media sources. This concept covered six sessions centered on the 5E model. It also included an optional session that will be used for enrichment for students.

The third concept used a guiding question of “What are the rules that govern whether something falls or orbits in the solar system?” Students used mathematics and computational thinking (CT) to determine the relationship between mass, distance, and gravitational force. For the purposes of this study, the researcher looked at the six sessions and implement culturally relevant teaching strategies, including centering students’ funds of knowledge in the curriculum planning, multimodal instruction, and inclusion of images of diverse cultural backgrounds across all six sessions (Appendices E-H). A summary of the cycle and the CRT strategies implemented is outlined below (see Table 2).
## Table 2. Summary of Culturally Relevant Teaching Strategies

<table>
<thead>
<tr>
<th>SESSION 1</th>
<th>ELICIT</th>
<th>The students completed a probe that asked them to consider where gravity is found, and how gravity on Earth would affect a hypothetical situation.</th>
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<tr>
<td></td>
<td>ENGAGE</td>
<td>The students watched a video of an astronaut on the moon and considered what caused the astronaut to move a certain way.</td>
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<tr>
<td>SESSION 2</td>
<td>EXPLORE</td>
<td>The students used a mathematical equation to discover weight as a measure of gravitational force and how mass affects gravitational force. Students created a model to investigate how gravity caused objects to interact in the solar system.</td>
</tr>
<tr>
<td>SESSION 3</td>
<td>EXPLORE</td>
<td>Students created a model to investigate how gravity causes objects to interact in the solar system.</td>
</tr>
<tr>
<td>SESSION 4</td>
<td>EXPLAIN</td>
<td>Students used internet simulations and readings to describe how gravity influences the movement of celestial bodies in our solar system.</td>
</tr>
<tr>
<td>SESSION 5</td>
<td>ELABORATE</td>
<td>Students used a kinesthetic model and internet simulation to illustrate gravity assist and satellite movement in our solar system.</td>
</tr>
<tr>
<td>SESSION 6</td>
<td>EVALUATE</td>
<td>Students applied their knowledge of gravitational force to predict critical speeds of planets in another solar system in the universe.</td>
</tr>
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2.0 Chapter 2: Literature Review

2.1 Culturally Relevant Teaching

Historically, schools have seen the home cultures of students of color as deficits to overcome for learning to occur in the classroom. Students’ use of their home and community linguistic practices is often frowned upon and can often be penalized in academic writing and social interactions. Culturally relevant teaching shows that the teacher honors and respects the students’ home culture and views culture as a resource for learning (Ladson-Billings, 2022; p. 151).

Culturally relevant teaching goes beyond simply being relevant. Muhammad (2020) defines cultural relevance as being an equity-centered practice that “charges educators to engage in practices that push for social justice (p. 45). Gay (2002) defines the phenomenon as a practice where educators use cultural characteristics, personal experiences, and unique perspectives as a resource to teach ethnically diverse groups of students. Culturally relevant teaching using students’ culture as a tool for better classroom instruction.

The importance of culturally relevant teaching is important as it builds bridges to form meaningful connections between school, home, and community. Learning becomes more meaningful and engaging when there are obvious parallels to students’ personal experiences. Students’ culture should be at the forefront as educators determine best teaching practices while also considering the important linguistic and learning differences that exist between students.

Dimick (2012) suggests that CRT allows students to feel both academically and socially empowered. CRT allows room to introduce issues of social justice and diversity into the classroom.
Teachers who are well-versed in culturally relevant teaching recognize and acknowledge the legitimacy of their students’ backgrounds. They recognize students’ cultural and linguistic backgrounds as a resource for instruction.

Gay (2002, 2010) defines culturally relevant teaching as including five essential components, (1) a knowledge-based related to cultural diversity, (2) a culturally relevant curriculum design, (3) learning communities, (4) cross-cultural communication; and (5) cultural congruity in classroom instruction. The study will focus on the first three components to guide the curriculum implementation, and the educator reflective journal.

A step beyond cultural relevance, Paris (2012) identifies culturally sustaining pedagogy (CSP) to sustain culture within the dominant framework of education. The goal of culturally sustaining pedagogy is to support cultural and linguistic norms as resources to help motivate students and engage them in the curriculum while honoring their culture (p. 94). The study will evaluate how the current science curriculum aligns with culturally relevant teaching components and address ways to engage students using culturally sustaining pedagogy.

2.1.1 Practical Implications of Culturally Relevant Teaching

In my classroom, all students start the day by writing a “scientist affirmation.” Before they write the learning target or the vocabulary for the lesson, they write, “Today, I am a ___________. “ In the blank, they write what type of scientist they will be for the lesson that day. Some days, they are biologists or chemists. On other days, students are food scientists, meteorologists, and coral reef ecologists. This practice centers students as the experts and the scientist in the room.

When faced with a challenge, students are consistently told, “You are a scientist...you can, and you will figure it out.” Students learn on the first day that if the teacher does not explain it in
a way they can understand, they should ask a peer that speaks their “language.” These common practices create a sense of accountability while centering students as the experts in the classroom.

The best practices for culturally relevant teaching are consistent across the literature (Gay, 2002; Muhammad, 2020; Greiner, 2020; Emdin, 2020; Hammond, 2015; Ladson-Billings, 1995). When broken into themes, these practices include the role of culture in the curriculum; multimodal instruction; relevant and meaningful learning; and representation in curricular materials. These practices aim to create inclusive, supportive, and engaging learning environments where all students feel valued, affirmed, and empowered to succeed academically and personally. The study will encompass these strategies through lesson planning, curriculum evaluation, and the educator reflective journal.

2.1.2 Culture and Curriculum

“I argue that the more teachers can consider the unique culture of their students, the more relevant and accessible their education will be.”

~ Christopher Emdin

In recent years, there has been a growing recognition of the importance of culturally relevant teaching strategies in education. One strategy is centering students’ culture in curriculum planning and using culture as a foundation for meaningful learning to occur. Centering students’ culture is an “instructional method that requires knowledge of all cultures present in the classroom” (Brown, 2017). CRT “uses the students’ culture to help them create meaning and understand the world” (Milner, 2011, p. 68). Centering students’ culture in the curriculum can be understood in a variety of ways. First, researchers look at the use of students’ community cultural wealth as a
benefit and resource for meaningful learning. Then, the use of popular culture (e.g., hip hop) can be utilized to bridge the existing gaps between students’ lived experiences and academic content. In doing this, educators can help to foster a sense of identity and belonging within the classroom.

2.1.2.1 Community Cultural Wealth

Community cultural wealth is “an array of knowledge, skills, abilities, and contacts possessed and utilized by Communities of Color to survive and resist macro and micro-forms of oppression” (Yosso, 2005, p. 77). This lens shifts educational research away from the longstanding deficit model that places students of color as being disadvantaged. The model of community cultural wealth includes various forms of capital, including cultural, aspirational, familial, social, navigational, resistant, and linguistic.

Cultural capital refers to the accumulation of cultural knowledge, skills, and abilities possessed by a group in society. Bourdieu proposes that some communities are wealthy in culture while others are poor. Members of the dominant culture have historically been viewed as culturally wealthy due to access to certain entities that are valued in the school setting. For example, access to a computer at home is valued in schools as these students have computer skills and vocabulary that others do not possess (Bourdieu, 1977).

Aspirational capital is a student’s ability to “maintain high aspirations despite challenging circumstances” (Menzies, 2016, p. 8). Challenging circumstances can include being from a low-income community and experiencing family and school challenges. Students may express high hopes for the future in terms of higher education and careers (p. 70). Aspirational capital may look like students voicing their desires for their future careers. Teachers can also connect aspirations to students’ everyday learning through affirmations and connecting the learning goal to potential careers.
Familial capital includes the acquisition of knowledge through family and kinship. Yosso (2005) defines familial capital as “cultural knowledge that carries a sense of community, history, memory, and cultural intuition” (p. 79). In this sense, the family may include immediate and extended family, close friends, or neighbors. In a study on community cultural wealth and achievement, Crystal Menzies (2016) found that familial support was important for academic success (p. 74).

Social capital refers to the networks of people who “support and guide minority students” (Menzies, 2016, p. 8; Bourdieu, 1977). Families with social networks, including professionals, create a valuable resource for their children. “One of the valued aspects of social capital is having connections to professionals” (Menzies, 2016, p. 13). The absence of this connection can isolate communities of color from positions of power needed to increase their cultural capital.

Navigational capital is the capacity of one to maneuver through social institutions. Given the country’s historical context, many institutions were not developed with students of color in mind. Most were designed to disadvantage minorities (Yosso, 2005). Navigational capital within the middle school context can be viewed as one’s ability to manage peer groups and academic perseverance. In her study, Menzies (2016) observed that students could use their navigational capital in situations around behavior, mindset, and academic success (p. 66).

Resistant capital “entails the ability of minorities to challenge negative stereotypes through the ownership of counter identities” (Menzies, 2016, p. 8). Yosso (2005) refers to resistant capital as “those knowledge and skills fostered through oppositional behavior that challenges inequality” (p. 80). This form of capital requires students to be aware of the structures of racism and be motivated to transform oppressive structures by challenging the status quo.
Linguistic capital includes the “intellectual and social skills attained through communication experiences in more than one language and style (Yosso, 2005, p. 78). This form of capital “encompasses the multilingual communication skills extant in communities of color” (Menzies, 2016, p. 8). Students communicate in various ways, including their home/community language, Native language, and academic language. Within the context of culturally sustaining pedagogy, teachers should be aware of the complexities of language and utilize linguistic differences as a resource rather than punishing styles of communication that are not representative of the dominant culture (p. 93).

2.1.2.2 Student Culture

In addition to community cultural wealth, teachers can leverage student culture in curriculum planning. In planning a curriculum, the teacher must consider the learner whose culture is “maintained and modified through education” (Offorma, 2016, p. 4). Therefore, the curriculum should reflect what people are, what they do, feel, and believe. Teachers who use student culture in their curriculum planning see students’ culture as an asset, not a deficit. By incorporating students’ culture in curriculum planning, students can see themselves in the curriculum. Within the classroom of the culturally responsive teacher, the student is “at the center of the cultural wheel and must be at the center of instructional design” (Allen, 1997, p. 14).

Teachers can leverage students’ culture through language. Language is an important part of culture and therefore who students are and relates to community cultural wealth and language capital. Adams (2022) highlights how language can become a “vehicle for the re/production of positive science identities” (p. 205). It can also be used to develop a sense of belonging within the school community.
Language can be used as a resource to engage and motivate students within the science classroom. Teachers can support students in using their home language during the initial learning phase and transitioning that language to academic vocabulary. For example, a student might initially describe repulsion as two things moving apart from one another. Over time, students will contextualize magnets not connecting as a singular academic word: repulsion.

During Hispanic Heritage Month (September 15 – October 15), students completed a project where they researched a Hispanic astronaut or scientist. In addition to writing a biography, students were given a list of words to translate to Spanish in honor of our two Hispanic students in the classroom. This helped to support and break a barrier that often exists with being a Hispanic student in a majority Black school.

2.1.2.3 Pop Culture

Hip hop, a cultural movement that emerged in the 1970s in the Bronx, has since evolved into a phenomenon encompassing music, visual art, fashion, dance, and spoken word. Deeply rooted in African American and African-diasporic traditions, hip-hop serves as a platform to express experiences, aspirations, and struggles. Its artistic elements, such as rap music, provide opportunities for people to voice their cultural identities (Rose, 1994; Eady & Smith, 2008; Alim, 2009).

Recently, hip-hop has been utilized as an engaging and creative approach to science education. Hip-hop-based science education uses rap music, lyrics, and other elements of hip-hop culture to enhance science education. The combination of scientific concepts and vocabulary into rhymes and rhythms allows educators to create a culturally relevant learning environment that is accessible to diverse students. Hip-hop in science education recognizes that students’ cultural
backgrounds and interests serve as resources to engage them in science learning (Barton & Tan, 2010, p. 195).

Research shows that hip-hop pedagogy can increase science identities. In 2012, Emdin and GZA piloted a project in New York City public schools to use hip-hop to teach science. The Science Genius program provided a space for students of color to exist in classrooms where “science content and hip-hop culture are equal” (Love, 2016, p. 422). In this, students’ cultures are affirmed and leveraged as a resource to propel motivation, engagement, and achievement (Emdin, 2013).

“Hip-hop pedagogy is an approach to teaching and learning that is rooted in hip-hop culture, which urban youth identify with” (Adjapong & Emdin, 2015; Adjapong, 2021, p. 847). This pedagogy provides an approach to teaching and learning that can be utilized across various content areas. Hip hop pedagogy can be utilized in the science classroom to increase engagement of learners. This section of the literature review highlights the five components of hip hop, including deejaying, emceeing, breaking, graffiti writing, and knowledge of self (Chang, 2007), and the ways they can be used in science education as identified in the literature.

2.1.2.3.1 Deejaying

Deejaying or disc jockey (DJ) primary duty is to play and control the music. When using hip-hop pedagogy, students in charge of being the DJ bring energy to the room by creating a playlist that is attractive to their peers (Adjapong, 2021, p. 852). In the science classroom, deejaying can be playing music, creating an agenda for students to follow for the lesson, or bringing positive energy to the learning environment. This can help to motivate students to learn while fostering a sense of belonging in the science classroom.
2.1.2.3.2 Emceeing

The master of ceremonies (MC) is known as the host of the event. Their role is to introduce speakers and maintain the flow of the event. Emceeing in and of itself is a culturally relevant approach as “the student is now deemed the professional is a part of the same population that is receiving the instruction” (p. 848). In the science classroom, a student may act as a co-teacher to lead an activity, teach part of the lesson, lead a station, or help with experiments by helping to set up or clean up.

2.1.2.3.3 Graffiti Writing

Graffiti writing or art draws a link between art and science (Alberts, 2008). Students can develop a better understanding of science content by creating visual representations of their learning. This pedagogical approach allows students to show their explanations in ways that are meaningful to them (Adjapong, 2021, p. 851). For example, when learning about particle motion, students can be tasked with illustrating a real-life example of objects made of solids, liquids, and gases and how when heat is applied, the motion of said objects changes.

2.1.2.3.4 Knowledge of Self

This component of hip-hop culture “encourages participants…to be aware of who they are, be authentic to themselves, and be confident in themselves to make a positive social-political change for their communities” (Adjapong, 2021, p. 853; Love, 2016, p. 415). Knowledge of self can include resisting, defining oneself through identity formation, and fighting for justice (Love, 2016, p. 418).
2.1.2.3.5 Conclusion

The integration of hip-hop into science education offers a culturally relevant approach engaging students in science content. There are several teacher tasks that can support the integration of hip hop pedagogy into the science classroom (Table 3).

<table>
<thead>
<tr>
<th>Component</th>
<th>Teacher Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deejaying</td>
<td>• Asking questions that guide discussion</td>
</tr>
<tr>
<td></td>
<td>• Appropriate use of technology</td>
</tr>
<tr>
<td></td>
<td>• Focused play</td>
</tr>
<tr>
<td>Emceeing</td>
<td>• Lead a lesson</td>
</tr>
<tr>
<td></td>
<td>• Lead an activity or experiment</td>
</tr>
<tr>
<td></td>
<td>• Act as a co-teacher</td>
</tr>
<tr>
<td>Breaking</td>
<td>• Include movement within the classroom</td>
</tr>
<tr>
<td>Graffiti Writing</td>
<td>• Use of art and illustration</td>
</tr>
<tr>
<td></td>
<td>• Skills and observations</td>
</tr>
<tr>
<td></td>
<td>• Mathematical skills</td>
</tr>
<tr>
<td>Knowledge of Self</td>
<td>• Use of social justice within the science curriculum</td>
</tr>
</tbody>
</table>

Research shows that combining hip-hop and science can increase student engagement, participation, and positive attitudes toward science (Emdin, 2010). Hip-hop-based science education aligns with the principles of culturally relevant teaching by connecting instruction to students’ cultural backgrounds. Hip-hop pedagogy helps to bridge the gap between students’ lived experiences and concepts in science curricula.
2.1.3 Multimodal Instruction

The combination of multimodal instruction and culturally relevant teaching provides a strong framework for inclusive and effective classroom instruction. The multimodal instructional design allows students to engage with a material using “both textual and visual meaning-making processes” (Si et al., 2022, p. 277). Multimodal learning can include reading text, listening to audio, watching videos, writing notes, talking with a partner or small group, or building or drawing a model (p. 286).

Each mode has the potential to be used within instruction. For example, a teacher may use photographs to teach through visualization. Other teachers may use books, comics, and posters to support students’ learning (Avermann & Wilson, 2011). Multimodal text and multimedia convey meaning. “Students need to integrate several modes to understand, learn, and communicate science. Seeing as the creation of multimodal texts has the potential to assist students in their meaning-making of scientific concepts” (Wanselin, Danielsson, & Wikman, 2022, p. 892; Cheng et al., 2020).

Multimodal instruction aligns with Zaretta Hammond’s work of helping to support diverse students to lead their own learning. In her book Culturally Responsive Teaching & the Brain (2015), Hammond outlines how the cultural learning traditions of story, song, movement, repetitious chants, rituals, and dialogic talk are beneficial to helping students actively process information under the right conditions (p. 127).

Hammond outlines how multiple ways of learning can inform how students process information to build intellective capacity. Teachers can use talking (p. 133) to engage students in academic conversation. Teachers may also use graphics, including graphic organizers, infographics, posters, and drawing pictures for students to represent their understanding of
concepts (p. 135). Finally, teachers may use review games to help students “review and rehearse new knowledge” (p. 137).

In science, multimodal instruction can be used to help students learn vocabulary. “Knowledge built through multimodal experience can allow for a deeper ownership of science vocabulary” (p. 331). The use of repetition can be utilized in science instruction to support student learning (Hammond, 2015; Townsend, Brock, & Morrison, 2018, p. 336). Teachers may also use games to teach vocabulary (Hammond, 2015; Bakhsh, 2016, p. 122). Games may include bingo, jeopardy, matching games, and computer-based games through programs such as IXL or Nearpod. Both IXL and Nearpod are district approved resources that provide engaging opportunities for students to interact with scientific content independently or with a teacher.

2.1.4 Relevant and Meaningful Learning

The intersection of relevant and meaningful learning and culturally relevant teaching is important as we look at the impact of the merger on student engagement and academic achievement. The connection of learning to real-world contexts involves making explicit connections between content and its application to the real world. The literature relates to relevant and meaningful learning through teacher pedagogy and teacher-student relationships. Through both methods, students learn to see the value and relevance of what they are learning and how they can use it to make a difference.

Keane & Malcolm qualify relevance—relevant to whom and for what purpose? Relevance is for students in and outside of the classroom. Stuckey et al. (2013) outline three dimensions for making science education relevant, including preparing students for careers, understanding scientific phenomena, and preparing students to become citizens in society (p. 8).
In preparing students for careers, teachers must be sure to provide rigorous coursework that will prepare students for higher education. Additionally, any necessary skills should be taught to prepare students for vocational training (Stuckey et al., p. 18). Teachers can do this by teaching skills labs and exposing students to careers in science. To make learning more meaningful to students, teachers can form connections between school activities and the life experiences of the student (p. 10).

Making learning meaningful can include teaching and studying topics that interest the student. This can increase the motivation and engagement of the student in the science classroom. Interest in science is one of the many primary drivers of science identity (Vincent-Ruz & Schunn, 2018, p. 2). By capturing what students are interested in, the teacher centers the student within the teaching and learning process.

Students see science as “a way of solving immediate problems and giving them skills” (Keane & Malcolm, 2003, p. 5). Stuckey et al. (2013) conceptualize relevance as it connects to students’ lives and their futures (p. 3). Additionally, science education should be relevant to our current socio-political environment (Yosso, 2005; Ladson-Billings, 1994, p. 18). Relevance to the world outside of the classroom connects to community cultural wealth and knowledge of self. Culturally relevant pedagogy challenges teachers and students to think about our society and critique it.

Social justice is one way to make science education more relevant for students. “An important tenet of social justice education is that students become “empowered” when provided with opportunities to engage in learning that aims to rectify social injustices” (Dimick, 2012, p. 221). Topics of social justice in science education can focus on topics such as food deserts, environmental racism, lead in drinking water, or science in hip-hop music (Mackenzie, 2020).
Social justice in science education situates students as change-makers in bringing about positive social change (Rodriguez & Morrison, 2019).

Finally, building relationships and rapport with students is critical to providing a meaningful and relevant science classroom. Through close and caring relationships, teachers are better able to situate students as the “experts” in the classroom, using students’ prior knowledge and experience as a foundation for learning. This practice of affirmation is important as teachers work to acknowledge the personhood of each student (Hammond, 2015, p. 77). When students engage in learning in environments that support them, they are more engaged and motivated to learn (Williams et al., 2018, p. 4).

It is evident that a shift towards a more relevant and meaningful science education is essential to students’ experiences in the science classroom. By making science relevant and meaningful to students, teachers can equip learners not only with scientific knowledge but also the necessary skills to shape society. Meaningful and relevant science education is important as educators work to ensure that students have equal access to high-quality learning experiences.

2.1.5 Representation

One culturally relevant teaching practice that is often overlooked is the integration of materials that are reflective of students’ cultural and linguistic backgrounds. The representation of minority students in science has historically been low. The images that are present are “not reflective of the cultures and people that make up many communities across the United States and around the world” (Barakat, 2022, p. 25). Further, the contributions of Black scientists in America are not included in science content and are absent from most science textbooks.
In education, over 80% of K-12 teachers are white, and only 7% are Black (NCES, 2019). This is important as White teachers have the power over the implementation of the science curriculum that Black children receive. Current research shows that instructional materials and content-related texts “provide poor, inaccurate, and absent representation of diverse and cultural and linguistic groups” (Gay, 2010; Aceves & Orosco, 2014, p. 20). The academic text should include “mirrors, windows, and sliding glass doors,” --which allows students to see images that reflect their own identities.

Selecting culturally responsive and relevant materials is one way to increase the representation that students see within the science classroom. Teachers must be aware of the diverse literature that exists to foster student learning. When learning about the water cycle, one could use *We Are Water Protectors*, a story about the experiences and perspectives of an Ojibwe girl. This opens the door to a larger conversation with students about practices related to water conservation. When learning about ecosystems, a teacher could use *The Boy Who Grew a Forest*, a story about a boy who saw the negative effects of deforestation and erosion in his home in India (Joshi, 2023).

Beyond academic text, teachers must work to actively counter stereotypes in science by sharing images and stories of scientists of color. Teachers may also invite scientists of diverse cultural backgrounds to talk with the students. Skype with a Scientist is a tool that allows students to meet with real-life scientists through Skype.

An important part of identity formation is where students develop a sense of self. Through this process, they learn about their place in society, which fosters a sense of belonging. The visual images that students are exposed to in school can play a critical role in identity formation. Diverse
images of scientists go beyond the Black Panther film, where Shuri is a “scientist and developer of the latest technology in Wakanda” (Sere, 2020, p. 11).

Being able to see a scientist who looks like you are important for young students. Scientists who are not well-known can be invited as guest speakers in science education classrooms (e.g., Patricia Bath, Alexa Canady, and Wangari Maathai). The use of diverse images of scientists should be embedded within the curriculum, including student research projects, posters on classroom walls, and instructional pedagogy.

2.1.6 Role of Race and Gender

Critical race theory declares that racism is permanent in our everyday lives and is sewn into the fabric of our nation (Ladson-Billings, 2022; White, 2019). Black girls often do not feel welcomed and experience racism in the science classroom (King & Pringle, 2017). Combined with societal images of Black girls, they are not often viewed as scientists but as troublemakers who are loud (Morris, 2007) and incapable of learning science (King, 2022; Pringle, 2012).

In science, Black girls face racialized and gendered stereotypes that contradict their academic abilities (King, 2022, p. 56). Bettina Love (2019) describes racism as an entity whose intent is to “reduce, humiliate, and ultimately destroy” Black girls (p. #). Coupled with microaggressions (Parsons et al., 2018) and over-disciplining (Love, 2019), Black girls face racial and gendered challenges within the science learning setting.

As a biology major, I never had a professor at the collegiate level that shared the same racial and ethnic identity. During the lecture, I did not learn about the contributions of Black scientists and inventors. It was not until I became a graduate student and then a science teacher that I learned about the countless Black women scientists. This “dearth of credentialed African
American scientists” (Fields, 1998, p. 12) is common across science classes despite the grade level. Black scientists are left out of science textbooks, and they are not often mentioned in science lessons. This absence only adds to the stereotypes that Black girls face every day. Additionally, the lack of positive representation in curriculum, pedagogy, and the media send a message to Black girls that they do not exist or belong.

2.1.7 Science Identity and Self Efficacy

Middle school students experience identity development during their adolescence. Their identity work helps them solidify how they see themselves as students and future professionals (Puente et al., 2021). Their science identity can be defined as “the extent to which individuals see themselves and feel comfortable in STEM” (MSCompass.org). Further, identity can be defined as how students view themselves based on participation in science-based activities and a sense of belonging in science communities (Vincent-Ruz & Schunn, 2018). Puente et al. (2021) name science identity as an important determining factor of what students will pursue as a career.

Researchers view at least three factors that contribute to and drive science identity. Carlone & Johnson (2007) identifies a sense of community and affiliation as one driving factor. Students need to feel a sense of belonging within the community. This can be marked by feeling welcome and competent in science content. Science identity can also be built by consistent extrinsic and intrinsic motivational factors. Intrinsic factors can include interest in science content which leads to participation in activities and science pathways. Extrinsic value is marked by how students view science and their self-beliefs about their ability to participate on meaningful levels (Vincent-Ruz & Schunn, 2018).
Self-efficacy can be defined as one’s belief in their capabilities to be successful at a given task (Yeakey, Thompson, & Wells, 2013). Bandura’s theory of self-efficacy identifies four components, including mastery experiences, vicarious learning, verbal persuasion, and physiological states or emotional arousal (Kiran & Sungur, 2012). Mastery experiences involve the acquisition of skills. In science, these skills include “facts based on evidence, developing questions; graphics, charts; data analysis, hypotheses, observations, and investigations” (Muhammad, 2020, p. 96). Vicarious experiences involve learning from other students and identifying their abilities as either successful or failures. Verbal persuasion includes positive or negative feedback from teachers, families, or peers. With positive feedback, students exert more effort. With negative feedback, students’ self-efficacy beliefs decrease. Finally, the physiological state involves how students feel about their engagement despite their intellectual capability.

Studies suggest that students with high levels of self-efficacy are likely to be highly motivated, highly engaged in academic tasks, and experience higher achievement and academic aspirations (Yeakey, Thompson, & Wells, 2013, p. 329). Even when accounting for class, Black STEM achievement is lower than that of their white peers (p. 355). Throughout history, Black students have been viewed as inferior due to social constructs. This deficit mindset has contributed to negative images of Black people in the media and educational bias that views Black students as incapable of high science achievement (p. 357).

The research suggests that middle school years are vital to ensuring that students develop a positive science identity that will support them in their high school and post-graduation years. Meaningful professional development experiences for teachers that provide tangible lessons and tools are vital as educators work to ensure that students have engaging lessons that help enhance their mastery while also empowering students to be confident in their academic performance.
2.2 Purpose of Review

The problem of practice is my middle school Black female students do not see themselves as scientists within the middle school science classroom. It is important for students to see themselves as scientists so they can continue to build the confidence and content-level skills and knowledge they need to take high-level science courses in high school and then pursue science-related study in college. For this review, I am examining the various factors that contribute to students developing a science identity during their middle school years.

Through this review, I seek to better understand the problem of practice through teachers’ practices of culturally sustaining teaching, the role of race and gender in developing science identity, and best practices for developing science identity. The review will look at issues of student access, interest in science, and science achievement in middle school Black girls.

Black students already have the scientific experience and basic knowledge of how “to do” science-based on their everyday living experiences. Whether students are aware or unaware that their everyday activities, such as cooking, walking, and talking, are scientific, they participate in science daily. Educators must create and support a learning environment where students feel safe to ask questions, be hands-on, and exhibit joy in a way that is not seen as misbehavior (Adams, 2022).

For this review, I am examining the various factors that contribute to students developing a science identity during their middle school years. Through this review, I seek to better understand the problem of practice through teachers’ practices of culturally sustaining teaching, the role of race and gender in developing science identity, and best practices for developing science identity. The review will look at issues of student access, interest in science, and science achievement in middle school Black girls.
My dissertation in practice will begin with a statement of Black students as geniuses with a natural joy for learning science content. Science is all around students, and their innate curiosity about the world around them needs to be fostered. In this, teachers should be aware of their own positionality and awareness of self that may impede how they interact with their students and how their Black students specifically interact with the science curriculum. The dissertation will highlight the structural barriers and historical perspectives that often impede students’ participation in science content.

Black students experience systematic racism and structural barriers through the implementation of policy, including school choice, science class placement, discipline, etc.). These barriers can lead to Black students with lower levels of participation, persistence, and completion rates compared to their White counterparts (Bannister et al., 2017). Black students are placed in schools where “content, instruction, school culture, and assessment are often racially hostile, exclusive, and serve as impediments for school success” (Howard & Navarro, 2016, p. 255).

Further, Black students’ experiences in the science classroom exhibit and align with the dominant culture. The images of students of color are nonexistent in science content, while dominant perspectives are used to enhance the experience of White students (George, 2003). These dominant perspectives, paired with colorblindness, reinforce deficit thinking with a negative, falsified perception of Black youth (Nelson, 2016; Howard & Navarro, 2016; Solorzano, 1997).

The school-to-prison pipeline also plays a role in students’ participation or lack of science education. Morris (2018) states that students often have their behavior criminalized, and thus participation is diminished. Curiosity and asking questions can be seen as misbehavior or disrespect (Miles & Roby, 2021). Over-criminalization can lead to students focusing on the rules and following them and not on actual STEM content. Further, students are often prohibited from
using scientific instruments because teachers do not deem them “ready.” However, tests often question students on instruments that they have limited to no interaction with (Miles & Roby, 2021). Beyond participation, students often experience lower expectations which can lead to lower performance and culturally insensitive or absent curricula (Ortiz et al., 2019).

Black students deserve to see themselves in the world around them and in their science education experiences. More so, they deserve teachers with a wide depth of knowledge on how to interact with students and the curriculum in ways that honor their innate joy. Culturally sustaining pedagogy serves to make students the foundation of their science learning opportunities as teachers empower students to use their funds of knowledge and lived experiences while embedding them into teaching and learning.

Teachers’ self-efficacy and effectiveness are at the center of how students learn. If done correctly, students become the center of the learning experience. Further, students can experience freedom in their classrooms when historical and present policies and structures are dismantled and replaced with practices that center on Black genius and joy. When Black students see themselves as scientists, the lives of those around them (in the present and the future) will be better because of it (Adams, 2022).

2.2.1 Empathy Interviews

Based on empathy interviews, students would like to engage in more hands-on learning experiences such as experiments. They would also like to have artifacts such as clipboards, lab coats, and lab goggles during experiment days. Students feel that taking notes in a science notebook helps them feel like scientists because they have a lot of information and can use their notes to remember things.
2.2.2 Statement of the Problem of Practice

My problem of the practice statement is my Black female middle school students do not see themselves as scientists.

2.2.3 Review of Supporting Knowledge

To approach the literature about the problem of practice, I identified three guiding questions to consider with a focus on best practices for teachers and the impact of race and gender.

1. How can educators in a public-school setting teach science in a culturally responsive way?
2. What role do race and gender play in developing students’ science identity and self-efficacy?
3. What are the best practices to develop science self-efficacy in Black girls?

The first question investigates the needs of public school teachers to learn how to implement culturally relevant teaching strategies. It also looks at the district's need to provide appropriate professional development experiences for teachers.

Culturally relevant teaching (CRT) is new to the district with the recent adoption of anti-bias and anti-racism standards. To better understand CRT, I looked at literature that explained the importance of CRT in the classroom and various CRT strategies. From there, I will identify where I implement said CRT strategies into the individual science lessons.

The second question looks at the role of race and gender in science identity development. Identities of race and gender are important to focus on because of the historical implications of
race in our country and the existing structural barriers of both race and gender in America. The third question evaluates best practices to develop science self-efficacy in Black girls.

2.2.3.1 Guiding Question 1: How can educators in a public-school setting teach science in a culturally responsive way?

2.2.3.1.1 Cultural Pedagogy

Culturally sustaining pedagogy centers on honoring and valuing communities of color while promoting equality and ensuring access and opportunity to all racial and ethnic communities. Culturally responsive/relevant teaching calls for a change in how educators view students and educational systems.

Many teachers uphold a deficit perspective of students and their ability to learn within the classroom (Paris & Alim, 2014). Deficit thinking places minoritized students and their families at fault for low academic achievement, with the assumption that students navigate school without “normative cultural knowledge and skills” and that families do not “value nor support their child’s education” (Yosso, 2016). Williams et al. (2018) say teachers must reject this approach. Instead, they should adopt the theory of community cultural wealth (Crystal Menzies, 2016) where teachers view the “multicultural, lived experiences of students as strengths, capitalizing on “the rich and varied cultural wealth, knowledge, and skills that diverse students bring to schools (Williams et al., 2018).

The cultures of students of color can help to nurture and empower them to utilize their funds of knowledge in the classroom (Yosso, 2016). In valuing students’ assets, teachers are in a better position to connect learning to students' lives outside of school. This in turn, helps to foster positive relationships between students and teachers.
2.2.3.1.1 Role of Teachers

Culturally relevant teaching practices are vital to teachers to provide the best education possible for students (Mensah, 2011; Taylor, 2010). Educators must give students the opportunity to learn in ways that validate who they are. Educators must capitalize on the strengths, values, and cultural wealth that students bring to the classroom (Williams et al., 2018). By providing teaching opportunities that affirm, validate, and connect to their interests and backgrounds, teachers are better able to meet the needs of diverse students (Ladson-Billings, 1994). Culturally relevant teaching realizes opportunities for teachers and students to maximize their learning experiences and place science education at the forefront (Mensah, 2011).

Beyond the classroom, there needs to be a shift within the larger institution (Taylor, 2010). Further, educators and education leaders must go beyond being responsive and relevant to sustaining students (as they are) while “offering access to dominant cultural competence” (Paris, 2012).

2.2.3.1.1.2 Professional Development

Teachers require training and professional development in culturally responsive and sustaining teaching. Mensah (2011) states that teacher education itself must be culturally responsive. Teacher education programs must learn to “embrace and instill in preservice teachers the concept of culturally responsive pedagogy (Taylor, 2010). Further, education systems need to move towards culturally sustaining pedagogy (CSP) which supports multiculturalism for students and teachers. Paris & Alim (2014) highlight how CSP shifts from “cultural pluralism through education to
challenges of social justice” in ways that culturally responsive teaching did not. The professional
development for teachers should focus on culturally relevant strategies in the science classroom.
Teachers would have time to implement these strategies within an upcoming lesson.

2.2.3.1.3 Implications

Teachers must work to integrate new approaches to science education. Emdin (2010) notes the
curriculum that teachers use as a valuable tool that can shift students’ levels of achievement and
interest in science. Curriculum should bring students’ life experiences and interests into the science
lessons. Further, lessons should center on who students are and what they bring to the classroom
as the foundation for the learning that will take place.

2.2.3.2 Guiding Question 2: What role do race and gender play in developing students’
science identity and self-efficacy?

2.2.3.2.1 Intersectionality

Using an intersectional lens, practitioners should be aware of the implications of both race and
gender in exploring the formation of science identity in Black girls (Bianchini, 2017). The
intersectional lens encourages practitioners to view the interconnectedness of race and gender
together instead of separate entities of identity. Race and gender identity attitudes intersect to
influence the academic outcomes of Black girls. Research reveals negative stereotypes in the social
construction of both race and gender about Black girls in STEM and the related consequences that
have emerged from stereotypes and discrimination. Negative stereotypes of Black girls in the
classroom can lead to disparities in out-of-school suspensions and lack of support in identity development (Butler-Barnes et al., 2018).

2.2.3.2.2 Science Identity

Science identity is vital for students to feel a sense of belonging in the classroom. Jarvis (2020) says that identity is “this feeling that you either belong or do not belong to a certain group of people”. The sense of belonging in science matters more than achievement and background when choosing a college major and future career (Jarvis, 2020). Students’ experiences in schools have an impact on their perceptions of science and themselves as scientists. Factors such as science identity, discrimination in school, and the need for changes at the institutional level are vital to students developing a sense of belonging and their feelings towards science (Kang, 2018; Jarvis, 2020). Kang (2018) says that often “students may not see themselves as a part of that community, they may not feel fully welcomed, or they may not be recognized for the assets that they bring to STEM.”

2.2.3.2.3 Transitions

Middle school is a crucial time for students to develop a science identity and determine later career aspirations (Kang, 2018). The relationship between students’ career interests and self-perception suggest the importance of developing and preserving students’ feelings of self-efficacy and identity during this unique time of their life. It is vital for students to develop their science identity during their middle school years and sustain this as they transition to high school as it can decline from middle school to high school (Puente, 2021).
2.2.3.2.4 **Structural Barriers**

There are many factors in determining if students will pursue a career in a STEM field—science identity is just a part of it. Research names discrimination, marginalization (Jarvis, 2020; Bianchini, 2017), lack of diversity, and institutional structures (Kang, 2018) all play a role in students pursuing a career in STEM post-graduation. Discrimination is inherent in assessment (Boykin, 2014) and many students face discrimination at the college level, which alters their feeling of belonging in school. Further, discrimination works against students’ sense of science identity (Jarvis, 2020).

It is vital to consider the ways institutions and social structures create barriers to success. Change at the institutional level is vital as educators work to help students in marginalized groups see themselves as scientists (Jarvis, 2020). Diversity within science would allow students to be engaged in science. Further, educators who are aware of the lack of diversity and intentionally include more active learning strategies help develop engaged students (Puente, 2021).

2.2.3.3 **Guiding Question 3: What are the best practices to develop science self-efficacy in Black girls?**

According to research, self-efficacy is not stagnant—it changes as a student transitions from elementary school to middle school and from middle school to high school (Lofgran et al., 2015) along with self-efficacy, motivation, interest in school academic achievement and attitude change as a student transitions from one grade group to another. These changes are particularly noticeable in science. Britner & Pajares (2006) note the greater emphasis on grades and competition and a larger, less personal environment as potential influences on students’ academic self-beliefs as they progress academically across grade levels.
Factors such as science self-efficacy, scientific involvement outside of the classroom, self-perception, science achievement, and science anxiety are critical in understanding how Black girls see themselves as science scholars. Academic transitions can act as a problem in students’ self-efficacy as they move from one grade band to another. A study by Lofgran et al. (2015) showed a decline in science self-efficacy scores for ninth graders at the transition to high school showing the need to consider how transitions have an impact on students’ identity development from elementary to middle school and from middle school to high school.

Along with a culturally responsive curriculum and pedagogy, teachers must also ensure that students have scientific experiences within the classroom. Bandura explains that an individual’s self-efficacy beliefs come from a variety of sources, such as mastery experiences, vicarious experiences, verbal persuasions, and physical and emotional states (Britner & Pajares, 2006). Students’ experiences in the classroom can be separated into both mastery experiences and vicarious experiences (Brown et al., 2016). Studies have found that mastery experiences are the solitary source to predict a students’ self-efficacy (Britner & Pajares, 2006). Britner & Pajares (2006) state that how students interpret these experiences are related to their confidence. While successful experiences raise confidence, unsuccessful ones lower it. These phenomena can be found in how teachers instruct these experiences in ways that are meaningful and developmentally appropriate for the group of students. According to Bandura (1997), experiences are typically the strongest and most consistent predictor of a student’s self-efficacy.

Finally, the racial and gender differences in students’ self-efficacy is worth discussing. Girls tend to report more anxiety about their performance in science classes (Britner & Pajares, 2006). This is supported by a study by Lofgran (2012) where females scored almost a full point lower ($b = -.89$) than males on the modified Self-Efficacy Questionnaire for Children (SEQ-C). In
the same study, Lofgren (2012) found that Hispanic students' science self-efficacy was scored almost three points (b=-2.95) lower compared to White students. Another study by Britner (2002) used the Lab Skills Self-Efficacy Scale to show that science self-efficacy successfully predicted science achievement by science grade point average (GPA). For Black students, both mastery experiences and social persuasions predict their academic self-efficacy (Usher & Pajares, 2006).

The racial, gender, and class disparities of science self-efficacy and achievement within middle school students create an equity barrier in middle school science students. There are gaps in the literature on best practices to increase science self-efficacy in middle school Black girls. The existing literature does find differences in self-efficacy between groups based on race, class, and gender. Females and Hispanic students scored lower than males and White students, respectively on a modified Self-Efficacy Questionnaire for Children (SEQ-C).

2.2.4 Gaps in the Literature

This study aims to address the lack of existing research on science identity development and science identity in Black middle school girls. Much of the existing literature focuses on STEM identity, math identity, attitudes, interests, and perceptions. Further, while there is much literature on Black boys in schools, there is limited research on how Black girls experience school and learning.

Research by Barton (2007) and Mensah (2013) identify that students of color in urban schools often experience the subject of science as “boring, confusing, and frustrating.” Other research reports disparities in science achievement by race, class, and gender. Black girls have scored below basic on science assessments compared to their White classmates (Hanson, 2009; Aud, Fox, & Kewal Ramani, 2010).
Research supports the importance of Black girls’ interest in science during their middle school years. Those who lose interest in science during middle school are less likely to take advanced science courses in high school and in college (Hanson, 2009). It is not enough for Black girls to be good at science—they must see themselves as scientists. There is a high need for Black girls in science related fields to increase diverse perspectives and to contribute to the field. Diversification of individuals in the field creates opportunities to provide new points of view that can advance the field and provide better care and products to constituents (Meador, 2018).

The existing literature is beneficial as we work to gain a more comprehensive understanding of how students identify as scientists, the lack of supporting literature and tools to measure science identity creates a gap of understanding. There is a need to reevaluate and reimagine the culture of science and the process by which it is learned in the classroom. Additionally, Black girls need counter spaces that support their scientific identity (Wade-Jaimes et al., 2021). Black girls are often overlooked making them invisible in science education.

This study aims to close the gaps that exist while placing Black girls at the forefront to inform future research. Further, the study will center the voices and experiences of Black girls in ways that make them visible.

2.2.5 Conclusion

Culturally relevant teaching practices are vital to teachers to provide the best education possible for students (Mensah, 2011; Taylor, 2010). While affirming the racial and ethnic identity of students, teachers can work to center Black joy in the science classroom. “Centering Black Joy offers the space for Black science learners to have and pursue their innovative ideas while being
engaged in scientific endeavor, discovery and using their lens and experiences to transform their world” (Adams, 2022, p. 2013).

Educators must give students the opportunity to learn in ways that validate who they are. Educators must capitalize on the strengths, values, and cultural wealth that students bring to the classroom (Williams et al., 2018). By providing teaching opportunities that affirm, validate, and connect to their interests and backgrounds, teachers are better able to meet the needs of diverse students (Ladson-Billings, 1994). Culturally relevant teaching realizes opportunities for teachers and students to maximize their learning experiences and place science education at the forefront (Mensah, 2011). Beyond the classroom, there needs to be a shift within the larger institution (Taylor, 2010). Further, educators and education leaders must go beyond being responsive and relevant to sustaining students (as they are) while “offering access to dominant cultural competence” (Paris, 2012).

Using an intersectional lens, practitioners should be aware of the implications of both race and gender in exploring the formation of science identity in Black girls. Race and gender identity attitude intersect to influence the academic outcomes of Black girls. Social construction of both race and gender unveils negative stereotypes about Black girls in STEM and the related consequences that stem from stereotypes and discrimination. Negative stereotypes of Black girls in the classroom can lead to disparities in out-of-school suspensions and lack of support in identity development (Butler-Barnes et al., 2018). Factors such as science identity, discrimination, and the need for changes at the institutional level (Kang, 2018; Jarvis, 2020).

The racial, gender, and class disparities of science self-efficacy and achievement within middle school students create an equity barrier in middle school science students. There is a gap that exists between self-perception and achievement within the science classroom. There are
differences between groups based on race, class, and gender. Factors such as science self-efficacy, scientific involvement outside of the classroom, self-perception, science achievement, and science anxiety are critical in understanding these gaps. Transitioning also acts as a problem in students’ self-efficacy as they move from one grade band to another.

**Chapter 3: Theory of Improvement & Implementation**

The purpose of my study was too address the problem of Black girls not viewing themselves as scientists. The aim of the study was to use culturally sustaining pedagogy (CSP) to teach science to increase Black girls’ science identity. My theory of improvement was guided by the review of literature, which examined the historical contexts of Black students’ achievement, self-efficacy, and identity in urban public schools. I incorporated culturally responsive teaching (CRT) to explore with Black girls their science identity. The study used critical race theory (CRT), ethnic identity development, and ecological systems theory to help situate the study within the existing literature.

**2.3 Critical Race Theory**

Critical race theory (CRT) was used to guide this study to view how race and gender had an impact on Black girls as they navigate school-based science learning spaces. CRT acknowledges the reality that race is a social construct that defines American society. Further, it challenges researchers to conduct studies with racial implications in mind (Mensah, 2019). Critical race theory aims to “expose and unveil White privilege” to better understand how it works to shape systems, ways of knowing and thinking, and its intertwined nature within relationships (Lopez, 2003, p. 84).
The intersectionality of race and gender is equally of importance as we consider how race and gender constructs impact how certain narratives have become dominant and superior to marginalized racial and ethnic groups (Solorzono & Yosso, 2000, p. 24). The research argues that Black girls are stereotyped and subjected to biased perspectives in both literature and media (Morris, 2007; Gay, 2000). These instances create a narrative that is placed on Black girls leaving them little to no space to tell their own. Critical race theory and critical race methodology both center on narratives, counter-narratives, and stories told by people of color. By generating knowledge through storytelling, race and racism are placed at the center allowing the stories of Black girls to become the dominant narrative within the given time and context (Duncan, 2005). How Black girls perceive their experiences in education are important. Therefore, their stories are crucial to educational practice. Through the themes of critical race methodology, Black girls are encouraged to share their stories reclaiming what stories get told about them (King & Pringle, 2018, p. 549).

The data sources for this study included interviews, student reflection journals, samples of student work, and researcher observation notes. These data sources were used to create counter stories from the Black girls’ perspective. The hope was that this study would provide a safe space for Black girls to reflect on their science learning experiences and produce new understandings that give a more in-depth view of the impact of race and gender on their experiences.

2.4 Identity Development

Given the gaps in the literature around science identity and science identity development, I used racial identity development to draw parallels between racial identity and science identity.
Gee (2000) describes identity as “multilayered and shaped by the social and cultural environment.” Examples of identities include racial, ethnic, gender, religion, sexual orientation, age, language, culture, and others. Each of these has its own culture and norms that produce a sense of belonging for those within the group.

2.5 Racial Identity Development

Race can be used by Black and African American adolescents to help them understand their social identity (Congress & Gonzalez, 2012; p. 80). Phinney’s theory of ethnic identity is crucial as we consider how one comes to terms of being a part of a group. During the ethnic identity journey, one makes connections to and within an ethnic group with whom they share common values, customs, and cultural activities (Phinney, 1996; Phinney, 2007; Zastrow & Kirst-Ashman, 2010).

2.6 Ecological Systems Perspective

Identity in adolescence can be informed by the media and their peers. Bronfenbrenner’s ecological systems perspective argues that your environment affects every part of your life (Zastrow & Kirst-Ashman, 2010; Congress & Gonzalez, 2012). With school being an integral part of students’ lives, we can conclude that school and the messages that are sent within classrooms are vital to students’ identity development. Often, schools focus on students perceived racial, ethnic, gender, and socioeconomic identities with little regard to their self-identifying academic
identities. Students deserve the opportunities to “try on” various academic identities and to see themselves in the curriculum.

2.7 Implementation Plan

My problem of practice is that middle school Black female students do not see themselves as scientists. This can have a negative impact on their engagement, interest, and achievement in science. By the end of the 2023-2024 school year, the science identity of Black female middle school students at Ferguson Middle School in Ferguson Florissant School District will increase by 25% with a culturally relevant science curriculum as measured by a modified pre and post version of a single item measure for assessing STEM Identity (see Appendix B). The modified measure was used to assess Science Identity. This aim statement served as a foundation for commitment to increasing students’ science identity through culturally relevant pedagogy and scientific experiences in the classroom. The rates of Black women in STEM fields are far lower than their gender and racial counterparts.

My change ideas were guided by my review of supporting literature and will help to increase engagement and science identity for Black girls. This project was designed to include culturally responsive pedagogy in a space unit that emphasizes science identity. My empathy interviews with my Black female middle school students revealed a need for more hands-on learning, engaging lessons, field trips, scientific materials (i.e. Lab coats, goggles), and Black scientist exposure. These themes outlined the needs of Black girls and their experiences in the science classroom.
2.8 Driver Diagram

This driver diagram serves as a tool to illustrate why intervention and research study is important. My primary and secondary drivers guided my change ideas and served as a central piece to informing my intervention plan. I aimed to increase the science identity of Black female students at Ferguson Middle School through the employment of culturally relevant teaching strategies in the science classroom.

**Figure 1. Driver Diagram**

2.9 Driver Descriptions

Quality science instruction and meaningful science experiences play an important role in supporting students to develop a positive science identity. To ensure the effectiveness of science
education, it was important to implement and evaluate change ideas that will increase students’ science identity. I implemented a cycle of the culturally responsive teaching strategies and a culturally sustaining curriculum during the school year, analyzed the data from the surveys, and reflected on whether the curriculum impacted the students’ self-efficacy, achievement, interest in science, and their identity (Perry et al., 2020). A diagram was necessary to illustrate potential improvement areas related to a specific aim.

The primary driver of the system in my problem of practice was middle school Black girls’ lacked opportunities to be situated as scientists within the science classroom. Within Ferguson Florissant School District, little work has been done to help students of any race with their science identity formation. The literature marks science identity of importance when discussing Black girls’ involvement in science at the high school level and in choosing a career (Kang, 2018; Puente, 2021; Jarvis, 2020).

2.10 Driver Measures

Improvement science is largely based on systems thinking. We should look to improve the problem and the system that has created the problem. Data is collected throughout the intervention to determine if the change ideas are moving the primary and secondary drivers forward. Data is crucial to determine if the change idea is working the way it was intended (Hinnant-Crawford, 2019).
2.11 Process Measures

The process measure tells the researcher if the change idea is yielding the results they predict. The use of the pre and post survey helped to determine if students’ science identity increased after the intervention is put into place. In theory, if the impact was high, I would not adjust the curriculum. If the impact was low, more work would be done to improve the curriculum to yield the desired results.

2.12 Balancing Measures

The balance measures helped to determine if the change idea has helped/disrupted the system or if it has cost the system. Balance measure asks if changes designed to improve in one area of the system cause new problems in another part of the system (Perry et al., 2020; Hinnant-Crawford, 2020; Bryk, Gomez, Grunow & LeMahieu, 2015). These measures are especially important if the change idea works as, it provides evidence to inform science instruction and professional development efforts within the school district. In students, when increasing science identity, ensure that identity in other subject areas is not decreasing. The science sessions had a mathematical component for this purpose. No mathematical related questions were developed or asked of participants for this study.
2.13 AIM Statement

The aim of my research study was to increase Black female middle school students’ science identities through a culturally responsive curriculum. My research inquiry was driven by the historical racialized and gendered stereotypes that impact the science identity development of Black middle school girls. By centering Black girls’ voices and setting their needs and wants as the foundation for changes in the science classroom, I focused on both equity and inclusion by amplifying voices of the marginalized. The change was an improvement according to the data. At the start and end of the intervention, students were given a modified pre- and post-version of a single-item measure for assessing STEM Identity. An improvement was evident as students’ scores increased from the pre survey to the post-survey by more than 25%.

Some of the primary drivers were the curriculum, teacher self-efficacy, vicarious experiences, personal and family backgrounds, and student academic achievement (Kang et al., 2019). I knew this change was an improvement when I observed a shift in the systems that negatively affected students’ identity in the science classroom. The primary drivers were good ways to impact change because they are feasible given the amount of energy, power, and support that were provided to support the goal. As a result of the primary drivers, I saw that students were met from a holistic approach to support their science identity. For example, students identified teacher participation and assistance as a driver for their science identity. Students also identified the teacher using affirmations to lift their self-esteem and science self-efficacy. My primary drivers were students, teachers, administrators, and the system. The main secondary systems driver was increased access to science-related activities. At the completion of the study, participants asked about joining STEM club and participation in the Black Girls Do STEM program.
From the lens of a middle school science teacher, I saw that students needed more than what the current school day provides. There were several identified programs within the St. Louis/Ferguson area, including but not limited to Black Girls Do STEM (BGDS), Girls Inc., and a summer science program for Black students at the local Historically Black College Harris Stowe State University. The changes I wanted to make were an evaluation of the implementation of the school district’s current science curriculum and a teacher reflective journal to better understand teaching practices.

2.14 Change Ideas

2.14.1 Science Curriculum Intervention

The science intervention was the primary change idea. The district utilizes the MySci science curriculum for grades K-8. Middle school students engage in 60-70 minutes of science class every day. Students are in school for 180 days (about 6 months) from the months of August to June. The researcher implemented the curriculum and used culturally relevant teaching strategies within each lesson. The culturally relevant teaching strategies included using students’ background knowledge, multimodal instructional strategies, and hands-on learning. Six lessons were implemented throughout the research study.

The first unit of study was Space. Students encountered a driving question of “How can we as space scientists analyze data to plan a space mission?” The curriculum covered four concepts and a performance task for students.
Concept 1. The focus was on day, night, and the seasons. Students learned how the position and movement of the Earth affects day and night on Earth. They also learned about the relationship between Earth’s axis produce the seasons.

Concept 2. The focus was on the moon. Students learned about the causes and appearance of the moon in Earth’s sky and the causes of lunar and solar eclipses.

Concept 3. The focus was on gravity. Students learned about the rules that determine whether something falls or orbits in the solar system.

Concept 4. The focus was on scale properties of the solar system. Students learned about how different representations of the solar system illustrate different characteristics of celestial objects within the solar system.

Performance Task. The performance task was a culminating project where students placed themselves as space scientists and delved into the guiding questions of how they can plan a space mission. This included a field trip to the local Challenger Center.

Eighth grade science classes included field trips, hands-on activities such as making a rocket, and using knowledge about space. The teacher implemented ideas from students and research-based strategies to help Black girls develop their science identity. For the study, the teacher focused on Concept 3, which included six sessions. Each session was aligned with CRT strategies. A description of each session is outlined below.

Session 1: During session one, students were asked about their existing knowledge about the role of gravity in space. Students acknowledged what they already knew with their small groups in science class. Participants recognized how gravity keeps us on the ground. They also were able to differentiate between gravity on Earth and in outer space.
During the cultural exploration part of the lesson, students engaged in conversation on how various cultures celebrate celestial events including the winter solstice. Participants made connections between cultures as they recognize the pot stickers from Chinese culture to what they have personally experienced before. Students asked if they can make pot stickers in class.

While engaging in the lesson, participants were fully immersed in using math to learn more about science. Each participant was given an object of varying weight and tasked with calculating the weight of that object on various planets. Once their calculations were complete, they observe patterns between the weights on the planets. Finally, students completed a graph with the weight. They noticed how the weight of the object varies depending on the inner and outer planets.

**Session 2:** Students were asked to discuss the importance of data collection in science. They were also asked to discuss who collects data. Participants were able to relate data collection to experimentation and a foundation for providing evidence to a claim. They also knew that doctors collected data on their patients. Participants saw data collection as something necessary and important to science.

I displayed photos of African American mathematicians. Participants were easily able to recognize Katherine Johnson and did not recognize anyone else. Participants were split amongst 7-8 groups to engage in the jump activity. They all had different jobs including quality control, mathematician, measurer, and recorder. After the activity, students calculated the length of the average of the five jumps and plot their data. Finally, students plotted their data and observed patterns between planets. Participants took note of how the impact of gravity was different for jump than weight.
**Session 3:** Students discussed the importance of creating models in science. Participants understood that models help us to visualize something in science. Additionally, they saw models to make science more relatable as many said they connected to what they are learning.

Participants engaged in a hands-on activity where they create a gravity simulation. They followed a procedure to test different weight marbles and the impact gravity has on the motion. Participants were seen working collaboratively with their respective groups and making observations. Some participants suggested fixing their model to get more “accurate results.” Other participants questioned if “this is how [scientists] figured out gravity for each planet.”

**Session 4:** Students discussed the importance of reading literature in science. Participants named reading to learn more and to discover new information. They also recognized reading in science as a new skill that differed from reading for pleasure or for personal interest.

During the cultural exploration part of the lesson, students learned about Black scientists. As they were reading, students learned new vocabulary including inertia. When the researcher explained inertia using a basketball rolling on the ground or a pencil rolling on the table, students went “oooh.” Later in the lesson and unit, a participant used the researcher’s example to explain inertia to a peer who walked in late.

Participants completed a data table based on the simulations. They compared data and create drawings of the simulation model. Finally, participants answered analysis questions to show their comprehension of the lesson.

**Session 5:** Students discussed the relationship between energy transfer and gravity. Participants had little background knowledge of the topic, and many responded they did not know or did not know yet. Students are encouraged to use a growth mindset so “yet” signifies that they believe their knowledge of the topic will grow by the end of the lesson/unit. One participant made
the connection between the term “energy transfer” to thermal energy transfer which they learned in 6th and 7th grade.

Students watched a video of a seismic accelerator and many participants said “wow” when they witnessed how stacking the balls during the drop caused the top ball to shoot high into the sky. During independent work, students engaged in a four-part simulation. They learned about collisions, trajectory, and the relationship between speed and gravitational pull. Participants recognized the simulation as a type of model that can be used to learn more in science. Finally, participants answered questions as they follow along with the simulations.

Session 6: Students learned about the relationships between mass and gravity and distance and gravity. Students had already had some discussions around the relationship between mass and gravity. When asked, a participant broke into the quick rap that the researcher made up to help students remember. Participants used the terms mass and weight interchangeably but know that this relationship is positive.

Participants completed a five-question evaluation to test their knowledge of the past sessions. They were also given the opportunity to complete any of the graphs they had not finished yet. One participant made the connection between data and the graphs and dictates how the graph can also be seen as a model. “It is a way to visualize the data table.”

2.14.2 Teacher Reflection Journal

The teacher reflection journal’s purpose was to develop a better understanding of my own teaching practices related to culturally relevant pedagogy. It allowed me to look at student engagement and their natural responses to the curriculum and teacher pedagogy. Reflective
journals can be used to establish identities as teachers and their belief systems and enhance critical thinking abilities in teaching and lesson planning (Mavric & Medic, 2022, p. 3804).

A teacher reflection journal allowed me to look at my teaching practices, observe and reflect on student reactions and engagement with the content, and promote questions about my practice. I used these questions to consider the choices I made in the classroom. I used prompts from the Colorado Department of Education and research by Dr. Django Paris, Professor at the University of Washington see (Appendix A, Educator Reflective Journal Prompts). The following prompts were answered one time over the course of the research study:

**Welcoming and Affirming Environment (1)**
1. What are you doing to learn more about your students’ culture?
2. How are you building and sustaining student relationships?
3. How do the instructional materials you use affirm your students’ identities?

**High Expectations and Rigorous Instruction (2)**
1. How are you encouraging student-led civic engagement in your classroom?
2. How are you engaging your students in a critical examination of power structures?

**Inclusive Curriculum and Assessment (3)**
1. Are your students co-designers of the curriculum?
2. How are you adapting your instructional strategies to the diverse learning styles of your students?
3. Are you incorporating resources that are written and developed from racially, culturally, and linguistically diverse perspectives? How so?

The observations, insights, and curriculum implementation challenges were documented weekly. The journal entries were reviewed and analyzed to identify common themes and areas for improvement.

**2.14.3 Conclusion**

My theory of improvement included change ideas such as a science intervention, observations, and a teacher reflection journal. I hoped to accomplish increased science identity for
my students from my dissertation in practice. I also hoped to shift the culture of science education in a way that fosters science identity for Black middle school girls.
3.0 Methods & Measures

3.1.1 Research Methods

My research was guided by critical race methodology. This form of methodology centers narratives, counter-narratives, and stories told by people of color. By generating knowledge through storytelling, race, and racism are placed at the center allowing the stories of Black girls to become the dominant narrative within the given time and context (Duncan, 2005). How Black girls perceive their experiences in education is important. Therefore, their stories are crucial to educational practice.

Critical race methodology centers Black girls’ stories that have been historically silenced. This methodology captures five themes to better understand Black girls’ experiences and their response to the educational system:

- The interconnectivity between race and oppression
- The challenge of the dominant view of Whiteness
- The importance of funds of knowledge, community cultural wealth, and the lived experiences of Black girls
- The approach to understanding how race and gender impact Black girls.
- The importance of social justice and empowerment
3.2 Research Questions

1. How does the districts’ use of the MySci curriculum affect the science identity of the Black girls in my classroom?
2. How does the implementation of a culturally sustaining middle school science unit improve Black girls’ science identity?
3. What factors impact Black girls’ science identity in a middle school science course?

3.3 Participants

I recruited the participants through convenience sampling as the study participants were selected because of their self-identified gender and middle school enrollment status in the Ferguson Florissant School District. Recruitment of the girls began upon IRB approval and after obtaining parental consent and student assent. All self-identifying girls were invited to participate. Participants were all rising 8th graders

3.4 Data Sources, Collection, and Analysis

The data sources collected and analyzed aligned to the research questions guiding the study. The analysis plan was consistent with the existing literature on qualitative and quantitative measures. Table 4 outlines how each data sources aligned with the research questions. It also outlines the collection and analysis plan for each data source.
Table 4. Research Study Questions, Data Sources, and Analysis Alignment

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<thead>
<tr>
<th>Research Question</th>
<th>Data Source</th>
<th>Data Analysis</th>
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<tbody>
<tr>
<td>Research Question #1: How does the districts’ use of the MySci curriculum affect the science identity of the Black girls in my classroom?</td>
<td>Empathy interviews, Semi-structured interviews</td>
<td>Open coding, Thematic coding</td>
</tr>
<tr>
<td></td>
<td>Educator Reflection Journal</td>
<td>Thematic coding, Descriptive coding</td>
</tr>
<tr>
<td>Research Question #2: How does the implementation of a culturally sustaining middle school science unit improve Black girls’ science identity?</td>
<td>Empathy interviews, Semi-structured interviews</td>
<td>Open coding, Thematic coding</td>
</tr>
<tr>
<td></td>
<td>Pre and post measure (single item measure for assessing STEM identity)</td>
<td>Statistical analysis</td>
</tr>
<tr>
<td>Research Question #3: What factors impact Black girls’ science identity in a middle school science course?</td>
<td>Pre and post measure (single item measure for assessing STEM identity)</td>
<td>Statistical analysis</td>
</tr>
</tbody>
</table>

3.4.1 Qualitative Interviews

The research utilized empathy interviews (see Appendix C) and semi-structured interviews (see Appendix D) to explore Black middle school girls’ science identity. The qualitative interviews were used to address research questions 1 and 2 regarding Black girls’ science identity. The semi-structured interviews provided more in-depth information about what parts of the lesson, school, and their everyday lives had an impact on their science identity. The empathy interviews were a concise way to gather information about how Black girls felt about science and what they felt will make them feel like a scientist. Both qualitative interview types helped to determine the impact of the implemented culturally sustaining lessons.

Using critical race theory and critical race methodology as a framework to guide this study, the need for multiple forms of qualitative data collection was to ensure that Black girls’ voices were centered in this research study. While the quantitative data tells a story, the qualitative
measures deepened the understanding of culturally relevant teaching, culturally sustaining pedagogy, and science identity development from Black girls' perspectives and lived experiences.

The qualitative methodology was important to comprehend how the girls saw themselves as scientists as a function of their school-based and home/community experiences. Before data collection, permission was received from the Institutional Review Board (IRB) to conduct this research with minor human subjects. Interview questions were designed to frame questions broadly to allow for individual open-ended answers from participants. The interview questions included topics of interest, subject likes, science classroom experiences, perceptions of teacher impact on identity, and recommendations for teachers. All interviews were conducted in person using the online video conference software Zoom for transcription purposes. Each interview lasted between 20 – 40 minutes.

After conducting and transcribing all interviews and survey responses, I analyzed the qualitative data using open coding. Open coding relies on a close examination of the data (Babbie & Rubin, 2010). The practice of open coding allowed me to break down the qualitative data into parts and compare them for similarities and differences (Saldaña, 2021, p. 100). The coding process included initial and focused coding. In initial coding, individual words, lines, and segments were coded. During focused coding, the initial codes were aligned against the data to determine their validity in the bigger picture (Mertens, 2019, p. 426). A codebook was utilized, including a brief description of each code used. An analytic memo was written to reflect on the coding process for each interview.

Saldaña (2021) explains that the In Vivo method is an appropriate coding technique when researching youth because “adolescent voices are often marginalized, and coding with their actual words enhances and deepens an adult’s understanding of their discourse, cultures, and
worldviews” (p.138). The In Vivo method allowed the researcher to capture students’ voices while also centering them.

Confidentiality and anonymity were protected during this study as the researcher used pseudonyms for participants. The researcher did not use participants’ real names when writing the results of the study. Identifying details from the qualitative data were replaced with generic descriptors to prevent the participant’s identity disclosure.

3.4.2 Quantitative Pre and Post Survey

The researcher used a modified version of the quantitative single item measure for assessing STEM identity (Appendix B). The quantitative survey was administered as a pre- and post-survey to answer research questions 2 and 3. For the purposes of the research study, the gray/shaded circles were modified to read “scientist.” Participants will be instructed to select the picture that best describes the current overlap of the image they have of themselves and their image of what a scientist is.

![Figure 2. Modified Version of Single Item Measure](image-url)
Students took the pre- and post-measure using a printed version of the measure on paper. Students label the top of the paper “pre-survey” at the beginning of the intervention and “post-survey” at the end of the intervention. The measure was coded using a numeric system to calculate students’ science identity based on their selected overlap image. For example, a student who selected overlap image number 1 was given a score of 1.

Students were given the following instructions:

“[Scientists] are individuals whose professional activities relate to the [science field]. Select the picture that best describes the current overlap of your image of yourself and your image of what a [scientist] is.” Participants will select from a set of seven overlapping circles varying in the degree of overlap: 1 = no overlap and 7 = near complete overlap (see Figure 2). (McDonald et al., 2019, p. 6; Aron, et al., 1992, p. 6.)

Students were given the measure similarly for both the pre and the post. Student growth was measured by how they select the overlap image. A student who shows growth in science identity selected an overlap image of a higher rating for the post than the one they selected for the pre. For example, a student who selected number 1 for the pre and number 4 for the post showed growth in their science identity. A student who selected number 3 for the pre and number 1 for the post was considered to have shown a decline in their science identity.

Ethical issues most involved with this distribution included consent, risk, privacy, anonymity, confidentiality, and autonomy. During this study, ethical issues were addressed and reduced by using a consent form. The consent form informed participants of the risk, privacy, anonymity, confidentiality, and their right to autonomy by permitting them to leave the study at any time without any risk to them.
3.4.3 Educator Reflection Journal

The researcher kept a reflection journal to track the process of the intervention and to answer research question 1: How does the districts’ use of the MySci curriculum affect science education for Black girls? The researcher’s reflections focused on the impact the curriculum had on Black female students based on classroom observations and field notes. The reflection journal included three daily prompts: (1) things that went well, (2) things to improve, (3) things to do next time. I also utilized journal prompts from the Colorado Department of Education (see Appendix A). These prompts were analyzed through coding to determine common themes. Thematic coding allowed the researcher to quantify the qualitative data. For example, thematic coding quantified student language such as how many times students mentioned lab coats or experiments during science lessons through teacher observations. The journal was also used to inform my instructional practice and to capture student quotes and moments that occurred within the intervention. Students’ names or other identifying information was not included in the journal.

To analyze the journal data, I will read through the journal entries and code using Saldaña’s (2021) method of Descriptive Coding (p. 134). This method of Descriptive Coding will be useful to construct a narrative of observational notes and researchers’ thoughts on their professional teaching practice. Through multiple rounds of coding using the Descriptive Coding method, the researcher can determine if their lesson plans and observations will fall into specific categories. From there, the researcher will employ Saldaña’s method of theming the data (2021). Theming of the data will allow the researcher to identify what the data is about and/or what it means (Saldaña, 2021, p. 258). Explanations of the themes will be found in the results section.
3.4.3.1 Use of Pseudonyms

For this research study, the researcher used pseudonyms to refer to participants. Pseudonyms are often used to de-identify participants for research purposes. For the study, participants were asked to choose their own pseudonym. The purpose of the pseudonym was to connect the interviews, student work samples, and pre and post measure to convey a narrative that centered the students’ voice while also protecting their identity.

3.4.4 Conclusion

In conclusion, the data sources, collection, and analysis section of this dissertation overview have been carefully designed to ensure a comprehensive and rigorous process that centers Black girls’ voices. The proposed data collection methods, such as surveys, student work samples, interviews, and the educator reflection journal were chosen to capture a diverse range of perspectives and provide a rich foundation for analysis. They also aligned closely with the research questions.

To maintain integrity in the research study, measures were taken to ensure the confidentiality and anonymity of participants. This involved implementing appropriate sampling techniques and maintaining ethical considerations throughout the research process.

The analysis of the collected data involved a combination of qualitative and quantitative methods grounded in critical race methodology. The qualitative data was analyzed using thematic analysis to identify patterns, themes, and insights from the participants’ responses during the interviews and focus groups. Quantitative data underwent statistical analysis to examine relationships, trends, and patterns. The data set was placed in a spreadsheet to produce tables and
charts to represent the data. The combination of both approaches provided a comprehensive understanding of the research phenomenon.

In summary, the data sources, collection, and analysis section of this dissertation overview outlined a comprehensive approach to gathering and analyzing data. This research aimed to generate meaningful finding that will contribute to the advancement of knowledge in the field while centering Black girls’ voices and situating them as experts on their own lived school-based experiences.

3.5 Ethical Considerations

The proposal for this dissertation was reviewed and approved by the Institutional Review Board at the University of Pittsburgh. In addition, the researcher also completed the required modules on research ethics by the University of Pittsburgh.
4.0 Results

4.1 Overview

This results section presents findings from an investigation into the science identity development of Black girls. Through a rigorous quantitative analysis of survey results and qualitative analysis of interviews and observational data, I unveiled unique insights that shed light on the interplay of societal, educational, and individual factors shaping the science identity of Black girls. In doing so, valuable knowledge will be added to the ongoing discourse on fostering equity in STEM, while prioritizing the voices of the Black girls who desire to take part in a more diverse and innovative scientific school community.

This research study sought to illuminate the impact of culturally relevant teaching and culturally sustaining pedagogy on Black girls’ science identity. Data shows that CRT and CSP provide a useful lens for examining the science identity development of 15 Black middle school girls in an urban school district in Missouri.

To answer research questions one and two, participants underwent empathy and semi-structured interviews. Responses to the empathy interview questions were recorded and transcribed by the researcher. Once data were organized, the researcher analyzed it through open and thematic coding. From there, several themes arose from the data. The empathy interviews were conducted before the intervention and the semi-structured interviews were conducted at the end of the intervention. The interviews helped to show students’ perceptions of science lessons and activities and the impact of teachers, community programs, and external factors on students’ science identity. The interview data for each question is presented in a data table. Actual quotations
from the participants are inserted into the text. To maintain confidentiality, participant pseudonyms are used in the text.

Chapter four of the dissertation will utilize the results of the pre and post measure, empathy interviews, and semi-structured interviews with the research participants. Additionally, the results of classroom observations and the educator reflection journal will be analyzed to explore the problem statement and answer the research questions.

**4.1.1 Growing Science Identity - Participant Profiles**

The fifteen middle school students in this study are of African American descent and live in the neighboring communities in Ferguson. Each student is in 8th grade and a student of Ms. Jordan’s science class. Brief profiles of their career goals, attitudes of science, and science identity influences are discussed below. All participants chose a pseudonym which is used to protect their identity.

**4.1.1.1 Kay**

This is Kay’s first time as a student in Ms. Jordan’s science class. She wants to be a pediatrician when she gets older. She has learned about Black girls in science from literature (papers, newspapers, articles, etc.) and social media (i.e. Instagram). She loves doing hands-on projects like experiments and appreciates how the teacher explains scientific phenomena and reassures her.
4.1.1.2 Jeniyah

This is Jeniyah’s second year with Ms. Jordan. She wants to be a brain surgeon when she gets older. She is in the afterschool STEM club that Ms. Jordan sponsors. She was also selected as a student to travel to Missouri S&T for a STEM day. Both of her parents are in graduate degree programs and she notes them being an influence to do well in school. Jeniyah enjoys hands on learning projects and says that she “already feels like a scientist.” She will be attending the local STEAM high school next fall.

4.1.1.3 Jenae

Jenae has known Ms. Jordan since 4th grade but this is her first year as a student. She wants to be an Emergency Medical Technician (EMT) when she gets older. Jenae says this is the second year she has done hands-on activities in science class. When asked about a scientist that she knows, she names her 7th and 8th grade teachers. She has seen Black girls on Tik Tok doing science.

4.1.1.4 Marie

Marie has had Ms. Jordan as a teacher for all three years of middle school. She wants to be an entrepreneur when she gets older. Marie notes how the teacher easily explains science so she can comprehend. She can remember science lessons (lecture and hands-on) from 6th grade. Marie has been involved in Black Girls Do STEM(BGDS) for the past two years. BGDS is a community-based program that helps to “empower Black girls to achieve equitable STEM representation.” She has also been in STEM club for the past two years.
4.1.1.5 Kahleia

Kahleia has known Ms. Jordan since 4th grade. This is her 1st year having Ms. Jordan as a middle school science teacher. Her previous interaction was as a 4th grade student. Kahleia wants to be a real estate agent. She recognizes her stepmom as a scientist because she builds and creates. Kahleia notes how she has not seen a lot of Black girls in science. However, at the end of the intervention, she recognized her friends (Jenae and Jeniyah) as two Black girl scientists.

4.1.1.6 Bella

Bella has a lot of career aspirations. She wants to be a nail artist, hair stylist, and a nurse. She recognizes her friend Danae as a Black girl scientist that she knows of. She also sees Ms. Jordan as a scientist. Bella enjoys the hands-on learning experiments and how her teacher explains science in a fun and easy way.

4.1.1.7 Angel

This is Angel’s fourth year with Ms. Jordan as a teacher. Angel would like to be a lawyer when she gets older. She enjoys field trips, activities, and experiments. Angel is the only student who felt she strongly identified as a scientist at the beginning of the intervention.

4.1.1.8 Saniyah

Saniyah has been in Ms. Jordan’s science class and STEM club for the past two years. She wants to be a real estate agent. She enjoys the hands-on experiments and creating in class. Saniyah notes how Ms. Jordan can put things into her own words to help her understand as a student. While Saniyah does not see many Black girls or people in general in the field of science, she does see Black girls doing science on social media including TikTok, YouTube, Pinterest, and Instagram.
4.1.1.9 Danae

Danae has known Ms. Jordan since 4th grade. This is her 1st year having Ms. Jordan as a middle school science teacher. Her previous interaction was as a 4th grade student. Danae wants to be an ultrasound tech, hair stylist, and entrepreneur. She recognizes Ms. Jordan as a scientist because of the experiments she does in class and the way she explains stuff. Danae notes how she has not seen a lot of Black girls in science. However, she does identify Ms. Jordan and her 6th grade female science teacher as scientists that she knows.

4.1.1.10 Staci

Staci would like to be a fashion designer. She really enjoys the hands-on learning activities and appreciates all the new learning that she has encountered this year. This is her first year as a student with Ms. Jordan.

4.1.1.11 Dior

This is Dior’s first year with Ms. Jordan. Dior would like to be a real estate agent in the future. She first got interested in science when she learned about the sun, Earth, and moon. She also really enjoyed the science field trip to the local Challenger Center. Dior enjoyed the simulations and the rocket challenge.

4.1.1.12 Princess

Precious had Ms. Jordan as a teacher in 6th grade and now again in 8th grade. She would like to be a lawyer or a real estate agent because she knows that she can help people. Princess enjoys field trips, experiments, and social media.
4.1.1.13 Taylor

Taylor’s favorite scientist is George Washington Carver. She knows she wants to be a scientist but is unsure of what her field of study will be. Taylor enjoys science because she likes taking notes and learning new information. She also enjoys making models, experiments, and the way Ms. Jordan is as a teacher.

4.1.1.14 Felicia

Felicia’s favorite scientist is Mae Jemison. This is Felicia’s 3\textsuperscript{rd} year with Ms. Jordan in middle school science. This is Felicia’s 2\textsuperscript{nd} year with STEM club and tells everyone about how she put together the 3D printer. She notes how her family is supportive in her education and how her dad would buy her learning and science toys as a child. Felicia still remembers how Ms. Jordan used jolly ranchers to learn about the rock cycle in the sixth grade.

4.1.1.15 Marley

Marley has had Ms. Jordan as a teacher for all three years of middle school. Marley says that Bill Nye and Ms. Jordan are her favorite two scientists. Marley has been involved in Black Girls Do STEM(BGDS), coding camp at a local Missouri University, and Little Medical which “inspires young minds by sharing [their] passion for learning, health and careers in medicine.” She wants to be a computer scientist when she gets older.
4.2 Answering the Research Questions

The following section will examine how each data collection method seeks to answer the research questions:

1. How does the districts’ use of the MySci curriculum affect the science identity of the Black girls in my classroom?
2. How does the implementation of a culturally sustaining middle school science unit improve Black girls’ science identity?
3. What factors impact Black girls’ science identity in a middle school science course?

The researcher tied in the various theoretical frameworks of community cultural wealth, hip hop pedagogy, and critical race theory. Additionally, quantitative and qualitative data was weaved throughout to help support answers to the research questions.

4.2.1 Research Question One

*How does the districts’ use of the MySci curriculum affect the science identity of the Black girls in my classroom?*

This study investigated the impact of the curriculum on Black girls’ science identity during an intervention. The girls interviewed were Black girls enrolled in Ms. Jordan’s 8th grade science class at Ferguson Middle School. Their experiences were assessed to learn how they felt about the science lessons. Several themes emerged from the qualitative interviews that help to answer research question one. The themes include hands-on learning activities and the use of field trips. Hands-on learning including creating models, conducting experiments, and demonstrations. The
field trip was to the local Challenger Center. Participants discussed how they felt like a scientist and had fun in the engaging activities on the trip.

4.2.1.1 Hands-On Learning Activities

A common theme from the data included the impact of the intentional use of hands-on learning activities in the science classroom. Elements such as affirmations and connecting the learning goals to skills that scientists also engage in were beneficial for students to feel like scientists. For example, all the girls named experiments, hands-on learning activities as something that made them interested in science, made them feel like a scientist, and an element of the classroom experience they enjoyed.

During the intervention, students engaged in five different hands-on/interactive learning activities (Table 2). The activities included using math skills to calculate the weight on the planets, jumping a distance, calculating an average and the jump distance on planets, and multiple simulations.

<table>
<thead>
<tr>
<th>Table 5. Interactive Activities by Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1</td>
</tr>
<tr>
<td>Session 2</td>
</tr>
<tr>
<td>Session 3</td>
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<tr>
<td>Session 4</td>
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<tr>
<td>Session 5</td>
</tr>
<tr>
<td>Session 6</td>
</tr>
</tbody>
</table>
The course content itself can be seen as a positive element for all participants. Each of the participants were able to discuss a positive experience from the curriculum of the course. Many noted the hands-on learning activities that were a part of the MySci curriculum. For example, Saniyah noted an activity where students modeled the Sun, Earth, and Moon alignment. “[I felt like a scientist] when we do hands-on projects in the classroom…like when we did the light with the sun and the wood and stuff.” In this example, Saniyah is referring to a curricular activity that had students use a model to show how seasons change over time. Princess agrees when stating: “The field trip. When we did the light bulb experiment [to show shadows on the moon]” Princess is referring to the field trip to the Challenger Center and a classroom activity where students used science tools to create a model to show how night and day occur.

Participants discussed how hands-on learning was a changing point in their interest in science as well as their science identity. Many could name specific hands-on learning opportunities that they engaged in during 8th grade and previous middle school years.

Marie, who has had me as a teacher for 3 years says:

“Hands on stuff makes me interested in science I’m interested in science. My favorite experiment was making ice cream in 6th grade and when we made s’mores. I like food science…you tried to have us melt the marshmallow under the heated lamp or a candle or in the microwave. And when we made elephant toothpaste”

Princess states how experiments help her feel like a scientist:

“The labs. I think I just like how it feels to be a scientist. They work on a lot of things. I like the experiments. And when we did the labs and go to the different stations.”
Taylor says:

“I first got interested because we started doing more active hands on stuff and learning more things. My favorite science project would be we had this cup with water and oil and we had a light on it and it changed colors.”

These experiences stress the importance of inclusive learning practices within the science classroom. The girls who mentioned hands on learning all increased their science identity through the course of the intervention. The influence of hands-on learning illustrates how “doing” science can impact Black girls’ science identity in a middle school science course.

4.2.1.2 Field Trip

The field trip to the local Challenger Center was a part of the performance task outlined in the MySci curriculum. While on the field trip, students engaged in two different main activities: a rocket launch and a space mission simulation.

4.2.1.2.1 Rocket Launch

For the rocket launch, students used engineering and design to build and launch a rocket. Students were given various roles including project director, budget director, safety supervisor, materials engineer, and structural engineer. Students engaged in these roles to create a rocket that would launch the farthest compared to their peers.

Students were provided with a budget for necessary materials to build the rocket. They used their budget to “purchase” various materials to help build and launch their respective rockets. Students were allowed to launch one time and then used the engineering and design cycle to make any necessary changes to improve their design before their second launch. All students
were able to improve their launch distance after they made the necessary changes to their original design.

### 4.2.1.2.2 Space Mission

For the space mission simulation, students took on various roles of scientists and astronauts in space (Table 6). The roles included communications, navigation, rover, space weather, medical, astrobiology, robotics, life support, and geology. Each role included various activities while on the space mission simulation.

**Table 6 Space Mission Crew Descriptions**

<table>
<thead>
<tr>
<th>TEAM</th>
<th>DESCRIPTION</th>
<th>JOB TITLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM</td>
<td>Provide communications support between astronauts and Mission Control.</td>
<td>Audio Engineer</td>
</tr>
<tr>
<td></td>
<td>Manage the distribution of assignments during an event and during some</td>
<td>Communications Engineer</td>
</tr>
<tr>
<td></td>
<td>emergencies. Provide critical ROVER launch information. Key skills:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Comfortable reading out loud; multi-tasking</td>
<td></td>
</tr>
<tr>
<td>NAV</td>
<td>Calculate and plot the course for the Space Craft to reach and navigate on</td>
<td>Navigation Engineer</td>
</tr>
<tr>
<td></td>
<td>the moon. Key skills: Efficient worker; comfortable with math</td>
<td>Navigator</td>
</tr>
<tr>
<td>ROV</td>
<td>Build and test a remotely operated robot to study the Moon, installing</td>
<td>Aerospace Engineer</td>
</tr>
<tr>
<td></td>
<td>critical equipment and components and retrieving data. Key skills:</td>
<td>Mechanical Engineer</td>
</tr>
<tr>
<td></td>
<td>Oral communication; problem-solving</td>
<td>Electrical Engineer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structural Engineer</td>
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</tbody>
</table>
This part of the intervention showed a positive relationship with Black girls’ science identity. For example, Princess related the field trip as a positive experience where she felt like a scientist because she was able to play a role. The field trip to Challenger Center positioned students as scientists and helped them grow in their learning. Princess says, “I liked the spaceship part because we got to choose different space roles and experience how it would be as an astronaut or engineer.” In their roles, students were able to control the “vibe” of the mission.
by introducing their own personality into the roles. Jeniyah liked how she was able to “pretend that we were working on a space station.”

The field trip also included the deejaying element of hip hop pedagogy. The act of centering students in roles was important and evident during the interview process. Students discussed how they felt like scientists when they went on the field trip to The Challenger Center. Students stated how they “had to pretend that we were working in a space station.” Princess stated:

“[I liked the] simulations and we went to the different parts and switched. I liked the spaceship part because we got to choose different space roles and experience how it would be as an astronaut or engineer...I felt like a true scientist.”

4.2.1.3 Conclusion:

In conclusion, participants felt like scientists when they were engaged in hands-on learning experiences and field trips. The theme of role playing was interconnected through both types of experiences. Additionally, role playing connects to elements of hip hop pedagogy including deejaying and emceeing.
4.2.2 Research Question Two

*How does the implementation of a culturally sustaining middle school science unit improve Black girls’ science identity?*

In addition to the impact of the curriculum, this research study also evaluated how a culturally sustaining science unit could improve Black girls’ science identity. A culturally sustaining science unit situates students at the center of learning while creating a space where students have voice and choice in the curriculum. It also places students as the experts of the content where students are able to incorporate joy and freedom of expression to take place in the science classroom. In this way, we see a shift from rote memorization of facts to a more inclusive learning space where students experience science in a variety of ways that are meaningful to them.

### 4.2.2.1 Increase in Science Identity

The quantitative data showed an increase in science identity from the pre- to post-measure. For research question two, the common themes include affirmations, multimodal instruction, and relevant and meaningful learning. Additionally, the researcher used qualitative interviews, observations, and the educator reflection journal to answer research question two.

The modified version of the pre and post measure (single item measure for assessing STEM identity) was administered at the beginning and end of the intervention to answer inquiry questions two and three. The survey helped to show students’ change in their science identity throughout the intervention. An overall summary of the data from the survey can be found in Appendix K.

The results show approximately 81% of participants grew in their area of science identity. The average pretest score was 3.40 while the average post test score was 5.33. The average growth of the students was 1.93. According to the results, the highest growth was 4 while the smallest
growth was -2. One participant did not complete the study due to a move from the school district. Only one participant (Staci) showed negative growth, which could be due to her absences from school due to illness. One participant (Angel) showed no growth as she identified as a scientist (score of 7) at the beginning of the intervention.

Overall, 86% of students showed growth in the science identity as measured by the single item measure. No student made more than 4 points of growth (Figure 3). The study aim was to increase participants’ science identity by 25%.

![Science Identity Growth](image)

**Figure 3. Science Identity Growth**

In addition to the pre and post survey, the interviews were also used to show how curriculum can impact science identity. The increase in girls’ science identity was not surprising, as I had hypothesized that the girls’ science identity would increase. The qualitative data uncovered various themes including the use of hip hop pedagogy in the classroom as a factor that increases Black girls’ science identity. When asked about when they have felt like a scientist, participants named experiences where they were engaged in one of the elements of hip hop pedagogy including affirmations. Another theme is the use of multimodal instruction. During the intervention,
participants engaged with a wide range of activities including videos, simulations, demonstrations, and reading. The final theme that depicts how culturally sustaining pedagogy increases Black girls’ science identity is relevant and meaningful learning where students were able to leverage their background knowledge.

4.2.2.2 Hip Hop Pedagogy

The innovative approach to hip-hop pedagogy in science education helps to shape the educational landscape of student-centered learning. Elements of hip-hop pedagogy including emceeing, breakdancing, deejaying, graffiti, and knowledge were highlighted in students’ responses as they highlighted how these elements added to their scientific learning experiences. This results section highlights the impact of implementing hip-hop pedagogy into the science classroom and how the impact on science identity based on participants’ responses helped to increase their science identity.

4.2.2.2.1 Breakdancing

Instances of using breakdancing were done before the intervention took place but were still highlighted during interviews. Danae stated that “We do fun experiments instead of just watching people do stuff (videos). I liked it when we made the flip grid video, and we did like this (shows motions with her arms). Another participant stated, “when we made the planets and when we had to use our body it was me and [Angel] over there and I had to move around her.” Students identified these experiences as a teacher pedagogical method that helped them to feel like a scientist.

4.2.2.2.2 Knowledge

The component of knowledge in hip-hop pedagogy includes defining oneself through identity formation. This can be modeled as students identifying themselves as scientists.
Participants identified notebook affirmations as a determining factor that helped them feel like a scientist in the classroom. Other participants felt that “dressing up” or putting on “science clothes” helped them feel like a scientist. In four separate mentions, students identified the impact a lab coat had or could have on their science identity. Three students said they felt wearing a lab coat during science class would help them feel more like a scientist. Saniyah stated she felt like a scientist when:

“Putting together the microscope…because I feel like a real scientist would do. And we put the slides on it. And we got to design lab coats.”

4.2.2.2.3 Graffiti

Graffiti allows students to use visual representations to show their learning or to support their learning. Students expressed how using visuals in science helped them be interested in science. Dior stated, “when we did the moons and the earth and the sun project where we had to draw, and we made it in our notebook.” Taylor said, “I like science because we learn a lot and I enjoy it…I like taking notes about what we learn and doing models.” For this study's purposes, models are considered art as students create 3D visual representations.

A final example of graffiti writing is where students created drawing of what they experienced during a classroom simulation. Students participated in four different simulations and had to draw trajectories of planets at various speeds. They also created drawings of the same simulation where the Earth was closer to and farther from the sun.
4.2.2.3 Role Playing

Role playing and aspirational capital was highlighted through elements of hip hop pedagogy as students engaged with experiential learning. Students were assigned jobs throughout the sessions and the field trip. This aspect of connecting roles to learning helped to engage participants further in the content and helped them feel like scientists. Within hip hop pedagogy, the elements of breakdancing, emceeing, and deejaying were highlighted.

4.2.2.4 Emceeing

Another hip hop pedagogy element that was embedded within the curriculum was emceeing. In this instance, emceeing allows students to step into the teacher role by helping to co-teach a class. Lynn said, “she let me teach the class.” During one activity, Lynn acted as a co-teacher by helping students complete the jump activity in session 2 (Appendix F). Throughout the activity, Lynn was guided to tell her peers what to do next and how to measure the length of the jump. Lynn wants to be a science teacher when she gets older, and you could see the excitement on her face as she helped her peers and stood at the front of the class.

Emceeing also places students in the role as a professional in the classroom. At the beginning of class, students are asked to write affirmations in their science notebooks. During session 1 (Appendix E) and session 5 (Appendix I), students were intentionally centered as scientists. In session 1 students engaged in the gravity activity where they calculated how much an object would weigh on various planets. Students were given various roles including recorder and mathematician. In session 5, students were given the role of experts where they interacted with an online simulator and answered analysis questions at the end. At the beginning of the lesson, students write “Today, I am an astronaut. I can work on an aircraft and learn about the relationships between gravity, distance, and speed.”
During sessions 2 (Appendix F), 3 (Appendix G), and 4 (Appendix H) students were centered as scientists, mathematicians, and engineers. In session 2, students completed the jump activity where they calculated the length of their jump on various planets according to the planets’ gravity. Students were given various roles including recorder, measurer, quality control, jumper, and mathematician. Felicia marked the jump activity as a moment where she felt like a scientist in the classroom. She said:

“I like the science things…I like how we did the jumping thingy. I was the quality control and I feel like that’s something a real scientist would do is be in charge that people are doing things right.”

In session 3, students create a simulation model to discover the relationship between mass and gravity. Students were centered as scientists, data collectors, and engineers as they created and engaged with the simulation. In session 4, students read about gravity and engage in a simulation. Students also engage in a class discussion concluding the reading and simulation.

In session 3 only, students were given specific jobs as they completed their tasks. The jobs included recorder, measurer, mathematician, jumper, and quality control. The recorder had to record the data from each jump; the measurer used the yard stick to measure the length of the jump; the mathematician calculated the average of five jumps; the jumper made the five jumps; and the quality control ensured that the jumper started the jump at the exact same spot each time.
4.2.2.5 Writing affirmations

“If you say it long enough, it starts to be a part of you”

Rita Pierson

Writing affirmations helped to center students as scientists at the start of the lesson. When asked what the teacher does to help you feel like a scientist, at least two participants noted the affirmations as a key part of their science identity. The question of who is (or not) a scientist is answered for students before any official part of the lesson takes place. Affirmations can be important for persistence in science. Microaffirmations can happen in a variety of ways. A study by Estrada et al., shows that microaffirmations can happen by showing students that people of their culture, ethnicity, sexual orientation, and gender can help them persist. Further, microaffirmations can also include showing students that they belong (Estrada et al., 2019). The affirmations included as part of the study include connecting participants to those of the same ethnicity and gender. Finally, affirming students as scientists creates a positive and welcoming classroom environment.

Participants identified affirmations as a tool that helped them feel like a scientist. Marie stated that she feels like a scientist “when we collect data and when we do notebook affirmations: “Today I am a scientist.” Saniyah agrees and says that writing in notebooks: “Today I'm going to be a scientist.” helps her feel like a scientist in the classroom. When Marley was asked to expand on how the teacher encouraged her, she referred to writing “Today I am...and then you have us write down what type of person we will be today. That encourages me because I feel like I can actually do those things and be those people.”

Throughout the intervention, students were asked to write affirmations where they were scientists, mathematicians, and data analysts. The affirmations helped to place students at the
center during the lesson. Further, the affirmations connected student learning to their identity and role in the activities.

4.2.2.6 Multimodal Instruction

Participants of the study were exposed to multimodal instruction. Multimodal instruction “relies on a variety of pedagogical techniques, deliveries, and media” (Picciano, 2009, p. 11). This mode of learning includes various learning styles based on our senses which enables students to understand and remember more. Participants of the study engaged in classroom discussions, notetaking, hands-on activities, reading for information, and engaging in simulations or videos.

Participants were able to name all these entities—except discussions—as a marker in their science identity development. Not one participant named discussions during either of their interviews. However, notetaking, reading, and videos/simulations were named as a part of the intervention that helped them to feel like a scientist. When asked what the teacher does to make you feel like a scientist Jasmine said: “[you] make us do notes and we usually have to since we do models and we test stuff…because I know scientists take a lot of notes before they do something, to test something too.” At least one participant felt that making a video helped her feel like a scientist. Danae said: “I felt like a scientist when we made the flip grid video.”

4.2.2.7 Relevant and meaningful learning

The study included elements to make learning relevant and meaningful to students. During the intervention, participants placed themselves in the curriculum by discussing how they celebrate the winter solstice. They were also able to make connections between themselves and other cultures. They also learned about Black and Hispanic astronauts to make connections between themselves and the role of other scientists that shared their same ethnicity and gender. Finally,
participants calculated the weight of common objects on various planets. These connections between their personal experiences and knowledge helped to make the lesson more relatable.

Another example is where participants were positioned at the center of the lesson as they took on specific roles to complete the task of calculating jump distance on various planets. During the field trip to the Challenger Center, students were placed in roles including communications, navigation, medical, astrobiology, robotics, life support, and geology. Participants named being given a job as something that made them feel like a scientist. Princess stated:

“When we went on the field trip. The simulations and we went to the different parts and switched. I liked the spaceship part because we got to choose different space roles and experience how it would be as an astronaut or engineer.”

Finally, the use of conversation and activation of background knowledge was embedded throughout all of the sessions. As students participated in the various activities, they were fully engaged in the learning process. Students engaged in classroom conversations around the importance of learning goals and showed that they understood the importance of using models and simulations in science. During the opening part of the lesson, students engaged in conversation around the guiding questions. Participants were spread out through the classroom. The researcher circulated the classroom to capture conversation. If a participant had already shared, the researcher asked the participant the question again and wrote down what they had said (see Appendix K). In this sense, students became the experts on the content.

During sessions, participants are given the opportunity to discuss with their peers and activate their background knowledge. Dialogue is important in the implementation of culturally
sustaining pedagogy as it creates a shared power dynamic within the classroom. Additionally, it acknowledges young people as those with substantial knowledge that helps to support their academic scholarship and ability to respond to curriculum in a rigorous manner.

At the beginning of each session, students were asked to engage in dialogue with their peers (Appendix K). When asked about the role of gravity in space, Kahleia stated “gravity keeps us grounded to the floor” and “people float in space.” She was able to differentiate how gravity works on Earth and in the solar system. During session 2 when participants were asked about the importance of data collection, Marley stated: “it helps us see the results and allows you see what it means.” Danae said

“[data collection] helps us keep track of information and mistakes. [It] give us evidence for science and helps us made predictions.”

Finally, Marie talked about how data collection is used in the medical field:

“Doctors collect data...they have their little clipboard.... The nurse tracks my weight when I go to the doctor.”

During session 3 students engaged in conversations on the use of models in the science classroom. Danae stated that “[models] helps us to have a visualization of what we are learning.” Felicia chimed in stating that “[models] help us to see details up close.” Finally, Kay said [models are] diagrams of what we are learning about and get a better visual.”

In session 4, participants explained how reading in science is important. Jenae said:

“Reading in science is important. The book or article or something like that teaches us stuff we didn’t know before.”
In session 5, participants leveraged a growth mindset while activating prior knowledge about the relationship between energy transfer and gravity. Dior asked “so when the thing goes faster...the pull is greater?” Other participants stated they did not know or did not know...yet. Bella stated “Like hot and cold and one has more gravity than the other.” In this instance, Bella is leveraging her prior knowledge of the term “energy transfer” from 6th and 7th grade science units on thermal energy transfer to apply to her current learning.

Finally, in session 6 students are asked about the relationships between mass and gravity and distance and gravity. In this instance, Staci begins to bang on the table repeating the rap that the teacher made up in a previous lesson. As she bangs on the table she says “more mass more gravity...more mass more gravity.” Staci was able to remember a meaningful moment in science class and this helped her remember the relationship. This meaningful connection between content, concept, and culture is important as it gave students an anchor to remember important information.

Overall, the observations helped the researcher focused on the dynamics of the conversation, the quality of participants’ engagement, and the application of scientific language. By analyzing the observed interactions, valuable insights can be gained into students’ conceptual knowledge. Further, participants’ ability to apply scientific principles in a collaborative learning environment were also observed. The observation data was helpful in informing teaching strategies, curriculum development, and enhancing the overall quality of science education.

4.2.3 Research Question Three

*What factors impact Black girls’ science identity in a middle school science course?*

The third research question investigates what factors impact Black girls’ science identity. From the participant interviews, there were main themes that aligned with research on culture and
curriculum outlined in the literature review. Both concepts of community cultural wealth and hip-hop pedagogy were revealed in the qualitative data. From the models of community cultural wealth and hip-hop pedagogy emerged themes that allowed the researcher to identify similarities and differences between the Black girls’ experiences and identity development. Throughout the interviews, the girls’ responses illustrated how their experiences in the classroom and in their social lives, their interest, teacher pedagogy, and science activities shaped their science identity throughout the intervention. Based on the quantitative results of the survey and qualitative results of the interviews, there are multiple factors that the Black girl participants identified within their responses including:

1. Teacher Support
2. Community Cultural Wealth
3. Experiential Learning

4.2.3.1 Teacher Support

Participants identified their teacher as someone who was supportive in their learning endeavors. Participants stated how the teacher explained science in ways that made it easy to comprehend. The teacher also helped students with classwork in ways that were meaningful to them. The teacher was encouraging to students and helped them to feel good about their academic endeavors.

During the empathy interviews, participants were asked “what does your teacher do that helps you feel like a scientist?” Participants identified factors such as the teacher helping them, experiential learning (i.e. field trips and hands-on learning activities), use of scientific tools such as microscopes, science goggles, and lab coats, and classroom activities such as collecting data, using notebooks, and drawing models as factors that helped them feel like a scientist (Table 7).
Marley stated how Ms. Jordan helps her to feel good about herself:

“You been with me since 6th grade and because of how you good you teach, for a moment I wanted to be a teacher… [you tell] me I’m doing good and [encourage] me and [help] me to stay focused and make me feel good about myself.”

Overall, participants felt that experiential learning (50%) had an impact on them feeling like a scientist. Notebook activities were also a contributing factor at 27%.

Table 8. Participant Responses to Teacher Impact on Science Identity

<table>
<thead>
<tr>
<th>Question 7: What does your teacher do that helps you feel like a scientist?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity</strong></td>
</tr>
</tbody>
</table>
| Teacher help | "When you ask for help you give help…you reassure me"  
"She tells me I'm doing good and encouraging me and helps me to stay focused and make me feel good about myself." | 2 (9.1) |
| Experiential Learning | | |
| Field Trips | "When we went to the Challenger Center and when we went to Missouri S&T." | 2 (9.1) |
| Hands-on Learning | "When we do hands-on projects in the classroom…like when we did the light with the sun and the wood and stuff. " | 9 (40.9) |
| Use of Scientific Tools | | |
| Microscope | "Putting together the microscope…because I feel like a real scientist would do." | 1 (4.5) |
| Science Goggles | "She makes us do experiments where we put on goggles and gloves and bring stuff from home that’s really important. Tells us stuff that scientists should do and not do." | 1 (4.5) |
| Lab Coat | "Oh...we got a lab coat in STEM club." | 1 (4.5) |
| Notebook Activities | | |
| Collect Data | "I feel like a scientist when we collect data..." | 1 (4.5) |
| Affirmations | "When we do notebook affirmations like 'today, I am a scientist.'" | 2 (9.1) |
| Academic Vocabulary | “Making me understand stuff by using scientific words and language and when I do hands on stuff I feel more useful and like I'm actually doing it." | 1 (4.5) |
| Notebooks | "When we take notes and draw our models in our notebooks."  
"I like writing in journals but I get to write stuff down and make sure | 2 (9.1) |
4.2.3.2 Experiential Learning

Participants explained on more than one occasion the impact of hands-on learning such as activities and experiments, and field trips had on their science identity. Participants connected hands on learning with feeling like a scientist. The engaging activities such as creating a gravity simulator to learn about the impact of gravity on the planets’ orbit. Students also enjoyed taking on various “jobs” while completing the jump activity in session 2 and the field trip to the Challenger Center.

4.2.3.3 Community Cultural Wealth

Participants named their families, teachers, and social influences (i.e. social media) as important factors in their science identity. Some participants had role models who encouraged their interest in science from a young age through purchasing science toys and books. Other participants have had influences from their teachers who have incorporated meaningful hands-on learning experiences that students have remembered through the years. Some participants remember experiments they did in 6th grade—two years ago. Participants also felt that community programs such as Black Girls Do STEM exposed students to seeing Black girls in science. These outside factors connect to the various types of capital within community cultural wealth.

4.2.3.3.1 Cultural Capital

Cultural capital is the acquisition of knowledge, skills, and abilities held by a group in society. As it relates to the study, the group in question are scientists. Participants named specific activities and skills as what made them scientists. Several participants named experiments, note
taking, building models, and testing stuff as the key skills of a scientist. One participant said “[we] do notes and we do models and test stuff...because I know scientists take a lot of notes before they do something, to test something too.” Another participant said, “I like taking notes about what we learn and doing models.” A final participant said that she feels like a scientist “when we collect data and when we do notebook affirmations like today, I am a scientist.”

In addition to notetaking and completing labs, students also identified using tools and wearing lab coats as something that helped them feel like a scientist. Saniyah was asked what the teacher does to help her feel like a scientist. Her response is as follows:

“Oh we got a lab coat in stem club, [we do] hands on experiments. We write in our notebooks ‘Today I'm going to be a scientist’...Writing in journals...I like writing in journals but I get to write stuff down and make sure I remember it. It makes me feel like a scientist because I'm writing down information and observations. Putting together the microscope...because I feel like a real scientist would do. And we put the slides on it. And we got to design lab coats.”

When Dior was asked the same question, she reported the following:

“[The teacher] makes us do experiments where we put on goggles and gloves and bring stuff from home...that’s really important. [She] tells us stuff that scientists should do and not do. Scientists stay safe so when I wear the things, I am a scientist.”

4.2.3.3.2 Aspirational Capital

One of the interview questions asked participants “What do you want to be when you get older?” Participants identified 11 STEM related jobs as potential future careers. Participants identified 8 non-STEM related professions. For this question's purposes, entrepreneurship and
beauty-related careers (i.e. fashion, nails, and hair) were counted towards a STEM profession. Several participants chose multiple careers, most of which fell into STEM professions.

In the traditional science related careers, participants identified their future careers as scientist, neuroscientist, brain surgeon, pediatrician, ultrasound technician, nurse, and computer science. In non-traditional science related careers, participants identified hair stylist, fashion designer, and nail artist. They also identified entrepreneurship as a career goal. Participants’ career goals can be found in Table 8.

<table>
<thead>
<tr>
<th>Table 9. Participants’ Career Aspirations</th>
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<tbody>
<tr>
<td>Science Related Profession (7)</td>
</tr>
<tr>
<td>Scientist</td>
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<tr>
<td>Scientist</td>
</tr>
<tr>
<td>Neuroscientist</td>
</tr>
<tr>
<td>Computer Scientist</td>
</tr>
<tr>
<td>Doctor</td>
</tr>
<tr>
<td>Pediatrician</td>
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<tr>
<td>Brain Surgeon</td>
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<tr>
<td>Other Medical</td>
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<tr>
<td>Nurse</td>
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<tr>
<td>Ultrasound Technician</td>
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<td>Law</td>
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<tr>
<td>Law</td>
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<tr>
<td>Lawyer</td>
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<tr>
<td>Beauty</td>
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<tr>
<td>Beauty</td>
</tr>
<tr>
<td>Nail Artist</td>
</tr>
<tr>
<td>Hair Stylist</td>
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<tr>
<td>Fashion Designer</td>
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<tr>
<td>Entrepreneur</td>
</tr>
</tbody>
</table>

Out of 15 participants, a science or STEM related profession was mentioned 14 out of 8 times (77%). Of the students who showed growth, 5 of 15 identified a profession that was not
science or STEM related (33%). Of the twelve participants who made growth, nine identified their future career as being science or STEM related (75%). The one participant who showed growth of zero, did not identify a profession in the science or STEM field. Finally, the participant who showed negative growth identified a future career in a STEM related field (fashion design).

While several students admitted they had no interest in science or STEM professions before their interaction with science class, many did state that writing the affirmations, having “jobs” while completing experiments, and being situated as a scientist made them think that science could be a possibility as a future career. Participants with a strong science identity were more likely to declare a science or STEM related profession. Conversely, having interest in a science or STEM related profession influenced student engagement, sense of belonging, and interest in the science field.

4.2.3.3.3 Familial Capital

At least three participants identified members of their family as someone they know in science or someone, they look up to learn about science. Kay said:

“My grandma because she’s a teacher and she teaches all the subjects and she know mostly about science and math, and she gives good information about that.”

Jeniyah stated how her mom being in school helps her know more about science. She said:

“My mama...tells me stuff and last year she was learning about [science] too. My mom is in school at Harris Stowe and UMSL.”

Kahleia said that her stepmom is a scientist that she knows by saying “My dad’s wife because she builds hands on stuff and she’s good at creating stuff”. Dior stated how her family helps her in school as they tell her to “pay attention in class and to never give up.”
4.2.3.3.4 Social Capital

Participants named a community-based program Black Girls Do STEM as a source of social capital that allows them to see Black girls in science. One participant says, “There’s a lot of us (Black girls) and Ms. Cynthia (Founder of program) because she gave us the opportunity to learn about science.” Marie is one of two participants involved in the program.

4.2.3.3.5 Navigational Capital

Participants explained how they use their navigational capital in their experiences around behavior, mindset, and academic success. They named the teacher being able to explain scientific concepts in user friendly language as a source of their confidence in science class. “The teacher makes it easy to comprehend [science] in class.” Another participant said, “I feel my environment is easy to learn in and the teacher gives examples using notes.”

4.2.3.3.6 Resistant Capital

Resistant capital means that students can challenge negative stereotypes. Several students identified how Black girls do not do science because you must be “very smart” and have “more knowledge”. However, many of the girls that stated how being a scientist is “other” for Black girls. Though Bella wants to be a nurse, she acknowledges “I don’t think I could be a scientist. I probably don’t have enough patience for that.”

Dior discussed how she believes science is not for Black kids because of how they think. She stated:

“No... It’s really a lot of uncolored kids because Black kids don’t think science is for them because they think it’s too hard or because they think they have to go into space or something...and Black kids are easy to give up and don’t like to try and if they just look at the paper and they get nervous but if they were to actually read it
they would know that they can be a scientist. Like, I am a scientist and Ms. Jordan is a scientist-- I look up to Ms. Jordan.”

**4.2.3.3.7 Linguistic Capital**

Linguistic capital pertains to students being able to communicate in various ways including using home language and academic language. Participants identified how the teacher would help students understand academic language by putting science vocabulary in words that were easier for students to understand. One participant said, “Sometimes the information don’t make sense to me but [the teacher] put it into her own words and that helps me.” Another participant stated, “The science teacher like if you ask for help [she] puts it into her own words or [she says] it in an easier way so I can understand it better.” Marie stated:

“I like [science] because it’s easy to comprehend stuff in class. The teacher makes it easy to comprehend stuff. For example, when we learned about the northern and southern hemisphere activity simulation.”

**4.2.3.4 Experiential Learning**

**4.2.3.4.1 Field Trips**

Students want to engage in more field trips. Out of the 15 participants, there were 7 mentions of the field trips. One participant stated that they want to “do more science field trips like the Challenger Center and when we learned about space.” When asked what made them interested in science two students named the field trips as a pivotal moment. Participants said “on the field trip...the simulations and we went to the different parts and switched. I liked the spaceship part because we got to choose different space roles and experience how it would be as an astronaut or
engineer.” The act of being placed in the role of a scientist is strong for the girls as one stated “we had to pretend that we were working in a space station”.

At least three students discussed the field trip they took to a local Missouri science and technology school. “Something I remember when I went on that field trip...it was a thing about girl power and a lot of diversity.” One participant said she felt like a scientist “when we went...and we learned about science stuff.” Another stated that when “we went to Missouri S&T and we did the robots...it made me feel like a scientist.” Finally, Angel said that “the field trips are the best part of class.”

4.2.3.5 Critical Race Theory

4.2.3.5.1 Race and Racism

Critical race theory utilizes 5 tenets understanding how race and gender impacts Black girls. During semi-structured interviews, participants were asked about their experiences with race and potential impact on their self-esteem and interest in pursuing scientific interests. All participants said they had not encountered instances of stereotypes or biases. They also said they have never felt like their race or gender has affected how they feel about science.

4.2.3.5.2 Use of Black Images

“You cannot be, what you cannot see”

Sheretta Butler-Barnes, PhD

Another tenet of critical race theory includes challenging the dominant view of Whiteness. McGee (2023) establishes that STEAM is for Whiteness. Buck et al. (2019) highlights how teachers rarely use images of Black scientists which further perpetuates the idea that White mean is
the ideal image of a scientist. From the educator reflection journal, I observed students as they were shown images of Black and Brown scientists.

“When shown the images of Black and Hispanic scientists, students engage in a conversation around why they haven’t learned or seen more images of diverse scientists before today. Some students who have had me as a teacher before, disagree by explaining that in 6th or 7th grade they did projects on Black inventors. Another student who had a Black male science teacher in 6th grade remembers the posters of Black male and female scientists that he had hanging in the classroom. Another student interjects and says that schools only teach what they want us to learn, and they want “us to think we can’t be anything.”

During empathy interviews, students were asked about the Black girls they look up to in science. Out of 15 participants, 12 participants were able to identify a Black girl that they know or an image they have seen of a scientist (80%). At least one participant identified the community program Black Girls Do STEM and the founder as someone they look up to. The founder, Cynthia Chapple, has a background in chemistry. Another participant identified their friend (who is a participant) as someone they look up to. Nine out of fifteen participants (60%) identified the researcher as a Black scientist that they look up to. At least five participants (20%) said they did not have a Black female scientist that they could look up to.

During the semi-structured interviews, participants were asked to describe an image of a Black female scientist. Participants identified posters they have in their current or previous classrooms. “I seen a poster in 6th grade in my science class.” Other participants identified social media outlets such as Tik Tok, Instagram, and Pinterest as a platform where they see Black girls
in science. Dior stated that she sees scientists in the ads on Tik Tok. “They be having black girls making stuff and they have on lab coats and glasses.”

“I remember when I was like 7 and I was at church we did a Black history thing and I was Mae Jemison and it was a black girl in space she had on a suit—it made me feel happy. Because when I was younger I wanted to be an astronaut.”

Participants stated that they felt happy and proud to see these images. Princess says “when I see the images, I feel happy because like earlier on in life, Black people didn’t get opportunities. Like back in the day, they couldn’t read or go to school. So, when it’s for Black people it shows that we can learn and [do] science.” Taylor stated that “Yes, I seen Mae Jemison [and it] made me feel happy because she got somewhere and did a lot.” Kahleia said seeing a Black scientist image “made me feel good because I got to see us as smart.”

4.3 Summary of Results

To summarize, there are several factors that affect how Black girls see themselves as scientists and what teachers can do from a pedagogical perspective to empower them to increase their science identity. The qualitative portion of the study provided emerging themes that showcase the importance of intentional culturally responsive teaching strategies and the use of a culturally sustaining science curriculum. Additionally, the use of hip hop pedagogy and the implementation of various types of capital from the community cultural wealth framework helped support the teachers’ pedagogy as they worked to increase Black girls’ science identity.
5.0 Discussion

The purpose of this study was to evaluate the impact of culturally responsive teaching and culturally sustaining pedagogy on middle school Black girls’ science identity. Specifically, this study examined how pedagogy and curriculum were relevant to their science identity development, and if so, to what extent. Fifteen participants engaged in a pre and post survey and two types of interviews (empathy and semi-structured).

This chapter contains discussion and future research possibilities to help answer the research questions:

1. How does the districts’ use of the MySci curriculum affect the science identity of the Black girls in my classroom?
2. How does the implementation of a culturally sustaining middle school science unit improve Black girls’ science identity?
3. What factors impact Black girls’ science identity in a middle school science course?

5.1 Summarization of Findings

The findings can be separated by the three research questions. Findings for the first research question showed that the district’s science curriculum includes some culturally relevant factors including experiential learning. Findings also revealed that the curriculum encompassed some elements of hip hop pedagogy including breakdancing and deejaying. Finally, the curriculum also supports the inclusion of community cultural wealth and capital throughout lessons.
Findings for the second research question highlighted how the teacher’s pedagogical use of hip hop pedagogy and culturally relevant teaching strategies had an impact on Black girls’ science identity. The focus on role playing when completing a task was highlighted as a strength to pedagogy that empowered Black girls’ to increase their science identity. The use of affirmations was also highlighted as a factor that supported positive science identity growth. Further, leveraging community cultural wealth into the lessons was a factor in Black girls’ science identity as stated by participants.

Findings for the third research question uncovered elements around teacher pedagogy. Participants identified experiential learning, use of science tools, and use of notebooks in the classroom. They also said that teacher support, outside factors such as role models, and elements of community cultural wealth made them feel like a scientist.

5.2 Interpretation of Results

In this study, I sought to explore the factors that impact science identity in Black girls in an urban science classroom. The data collected provided valuable insights in the factors impacting science identity and its implications for educational practices.

5.2.1 Emerging Themes

The theory for what impacts Black girls’ science identity is multidimensional and comprises themes for science education moving forward (a) teacher pedagogy, (b) curriculum, and (c) leveraging critical race theory to challenge the dominance of Whiteness in the science
classroom. The implementation and use of these themes within the science classroom helped to contribute to a learning environment where Black girls are centered as scientists and see themselves as such.

These themes were evident in participants’ interview responses with some overlap between them. After reviewing the findings and themes, I developed Figure 4 to visualize findings and implications this study provides that impact Black girls’ science identity.

![Figure 4. Building Science Identity in Black Girls](image)

I believe figure 7 creates a framework for educators to utilize to form pathways toward science identities for Black girls. The themes of teacher pedagogy, curriculum, and critical race
theory were evident throughout the findings as key components of science identity. Each theme is described in detail in the following sections.

5.2.2 Teacher Pedagogy

Career connections were weaved throughout the findings of the research study. For the purposes of this discussion section, career connections tie into elements of the frameworks outlined in the literature review of this study. Hip hop pedagogy and deejaying, aspirational capital, and the use of role playing and affirmations will be highlighted in the section of career connections.

5.2.2.1 Hip Hop Pedagogy

Hip hop based science education uses rap music, lyrics, and other elements of hip hop culture to enhance science education. The research study found elements of hip hop pedagogy in both the curriculum and teacher pedagogy. Participants named activities that correlated with hip hop as factors that made them feel like scientists.

5.2.2.1.1 Deejaying

Role playing and deejaying intertwined as a key factor that influenced science identity. Deejaying was prevalent in experiential learning experiences such as the field trip to the Challenger Center as a part of the curriculum. It was also evident in teacher pedagogy when the teacher used role playing for students to complete the session of calculating jump distance in space. This same session also used the element of breakdancing where students used their bodies to complete the learning task. The elements were specifically named by participants as experiences that made them feel like scientists.
The researcher used the component of deejaying in the daily discussions around the lesson’s learning target.

5.2.2.1.2 Emceeing

Emceeing acted as a support for Black girl's science identity when a student acted as a co-teacher to lead their fellow peers through developing a model. This overlaps with the element of deejaying in the sense that the student now becomes the professional. This practice situates the “emcee” as a scientist given that students see the teacher as a scientist. It places them as scientists further as they are imparting knowledge on their peers.

5.2.2.2 Breaking

Breaking was also present in both curriculum and teacher pedagogy. In the curriculum, breaking students manipulated their bodies to complete five jumps as a part of session 2. Movement was present in the lesson as students jumped, measured distances, and ensured that jumpers repeated the activity consistently. As a part of teacher pedagogy, the teacher included breaking when students created a flip grid video to show their understanding of the sun, earth, and moon alignment. Further, the researcher had students use movement when they created their model on how gravity and mass interacted with each other.

Breaking was used as an element to increase engagement in the science lesson. During the session, students were fully engaged in their activities. Breaking was leveraged as a tool to excite students and have them fully participate in learning. Kinesthetic learning honors students’ various learning styles which helps to foster an inclusive learning environment.
5.2.2.3 Graffiti

Participants also named graffiti as an element of hip hop pedagogy that had an effect on their science identity. Black girls’ noted that using notebooks, collecting data, and drawing models were activities that their teacher had them complete that helped them feel like scientists. Within the notebooks, participants named affirmations as a factor that influenced their science identity. The use of affirmations is supported in the literature where micro affirmations help to support students to feel confident in their identities. Micro affirmations can be defined as “actions, verbal remarks or environmental cues that lead the recipient to feel that their thoughts, feelings, sensations, and behaviors…are accepted, corroborated, legitimized or given value” (Rolón-Dow & Davison, 2018, p. 4). Participants named affirmations as a contributor to feeling like a scientist.

Graffiti writing also included the use of mathematical skills in session one and two. Students were positioned as both scientists and mathematicians who could use two subjects to complete a given task. Ladson-Billings (1995) identifies rigor and the ability to develop students academically. This includes helping students to compute and solve higher order problems.

5.2.3 Community Cultural Wealth

The results of this study showed that participants’ science identity development was impacted by several influences including those of community cultural wealth (CCW). The presence of community cultural wealth in teacher pedagogy was a determining factor in students feeling like scientists in the science classroom. Analysis of the data showed that cultural, aspirational, familial, and linguistic capital were explanatory factors in participants’ science identity development. Similar to hip hop pedagogy, leveraging CCW in the science classroom has an impact on Black girls’ science identity.
Cultural capital is the accumulation of knowledge and skills held by a group in society. For the study, this group in question are scientists. Students acquired knowledge, learned skills, and engaged in tasks that mimicked those of a scientist. Participants identified experiments, note-taking, and developing models as elements of the lessons that made them feel like a scientist.

Data from this study shows that Black girls have cultural capital that empowers them to identify as scientists. From the community cultural wealth framework, aspirational, social, resistant, and linguistic capitals were each applicable to participants’ science identity. There is limited research on the relationship between community cultural wealth and science identity. However, findings from the study support a need for growth in this area.

5.2.3.1 Aspirational Capital

Aspirational capital refers to the maintenance of hopes and dreams despite challenges (Yosso, 2005). This type of capital is applicable in explaining science identity in the participants in this study. Aspirational capital overlaps with deejaying in hip hop pedagogy as it relates to participants being given a role to play. It also connects to graffiti since participants were situated as professionals (i.e. scientists and mathematicians) when they wrote affirmations in their notebooks.

During the study, aspirational capital was evident in both curriculum and pedagogy. In the curriculum, participants went on a field trip to the Challenger Center where they were given roles during their rocket design and launch, and during the space mission. Student narratives showed that aspirational capital is applicable in the study. Each participant showed career aspirations within and outside of the science related field.

Despite the statistics on Black women in STEM fields, participants maintained hopes to attain a career in the field. This is representative of possessing aspirational capital. Study
participants used their aspirations as avenues to want to help others and express themselves creatively. Pursuance of a career in science and science identity are interconnected. Science identity positively impacts the likelihood of entering a science occupation (Stets et al., 2017, p. 4). How a student believes others see them is an indicator of their own science identity and in turn likelihood to pursue a science-related job (p. 15). This highlights the importance of teacher affirmations and situating students as professionals within the science classroom.

5.3 Curriculum

Within curriculum and instruction, the data showed the importance of experiential learning including the use of field trips, hands-on learning through the development of models, and experiments as factors that can increase Black girls’ science identity. Participants identified hands-on learning, experimentation, and field trips as key parts that supported their science identity within the science classroom and learning tasks. The MySci curriculum embedded hands-on learning, experiments, and a field trip into this particular unit (Space). Further, the MySci curriculum includes a guiding question where students are frequently asked how their learning helps them to get closer to answering the question. The curriculum provides space for students to engage in vocabulary acquisition, inquiry, and discussions. Students engage in the curriculum in meaningful ways as they are able to determine how they can utilize their prior knowledge to get closer to their understanding of the scientific content. Paired with culturally sustaining pedagogy, students are able to engage in the curriculum in meaningful ways.
5.4 Critical Race Theory

Critical race theory examines the presence and persistence of racism within all social institutions (Mensah, 2019). The tenets of critical race theory include challenging the dominant view of Whiteness, intersectionality of race and gender, and counter storytelling. Within these tenets, there is also evidence of how hip hop pedagogy element of knowledge of self emerges as a foundation to challenge the status quo of science pedagogy and instruction. Further, inclusivity is also foundational as educators evaluate their classroom environments from an equity and justice lens.

5.4.1 Whiteness as Dominance

The concept of race can be used to ‘maintain and reinforce power relations in which the normality of White dominant group is endlessly restated as the means by which other groups of color can be identified as subordinate because they are distinct from the White norm” (Bhopal, 2023, p 114). White privilege has persisted through history and is evident in residential segregation (Johnson, 2010); school segregation (Warren, 1954); and lack of representation of Black scientist images (Chambers, 1983).

During sessions, students were exposed to various images of Black scientists. Students saw images of astronauts, mathematicians, and others who contributed to the fields of earth and space sciences. These shared images were connected to students’ learning targets for the day’s lessons. Based on participants’ responses, seeing images of Black females' scientists made them feel happy and helped them to feel connected. When developing curriculum and planning the implementation of lessons, teachers should be aware of their students racial and ethnic backgrounds. From this,
teachers can intentionally include images, information, and opportunities to learn about the contributions of Black scientists that have had contributions to the field related to the day’s lesson. Further, Ladson-Billings (1995) highlights the importance of exposing Black girls who have succeeded in the fields of mathematics and science.

5.4.2 Intersectionality of Race and Gender

Effective teaching of females of color is necessary in the growing fields of science and STEM. Examples of what a classroom environment could look like include recommendations from Halpern et al. (2007). Teachers can use affirmations as a tool to show Black female students that they are capable of learning science. This can be done through journaling, cycling through the classroom during lessons, and by providing feedback on assignments. Finally, the classroom should be a place that sparks curiosity and engages students in fun and meaningful lessons. This should be coupled with “frequent access and exposure to science equipment and scientific experimentation.” This allows these two elements of race and gender to combine with the need for experiential learning in the science classroom.

5.4.3 Counter Storytelling

Counter storytelling is a powerful tool used to challenge dominant narratives that perpetuate stereotypes and marginalization. A key tenet of critical race theory, it can be used to disrupt narratives that negate, neglect, and misrepresent Black girls’ lived experiences and contributions in the field of science. Counter storytelling involves sharing alternative narratives
that challenge the mainstream narratives of Whiteness as the dominant culture—specifically in science. It provides a platform for Black girls in science to share their own stories.

This study and dissertation in practice serve as a method of counter storytelling that helps to challenge the narrative Black girls do not belong in science and cannot be a scientist. Counter storytelling helps to broaden the understanding of the diversity of what a scientist looks like and helps to foster a sense of belonging for Black girls in science. By exposing students to diverse narratives, teachers contribute to an equitable and empowering learning environment. Further, this can inspire a future generation of scientists.

5.4.4 Knowledge of Self

The only component of hip hop pedagogy that was not evident in the findings was knowledge or the students’ position to create change. While participants were aware of the need to advance their own learning to help people—especially in the medical field and the world of science, the intervention lacked sessions that left room to incorporate topics of social justice or enact meaningful change. Students understood how their learning could make a great difference for the lives of the people they want to impact. This aligns with Ladson-Billings (1995) and the need to develop students who strive to impact change. Future research should uncover how to incorporate elements of social impact into a Space unit. This would better support research in the use of hip hop pedagogy in science education.
5.4.5 Inclusive Learning Spaces

Students are given the opportunity to connect with their fellow peers with a “relate break”. Students are presented with a fun question and given one minute to discuss and share with the class. They also engage in conversations around culture including how various cultures celebrate winter solstice, diverse scientists and mathematicians, and the types of careers that fit into their lesson’s learning goals. Finally, students are given the opportunity to activate background knowledge on scientific topics and other experiences including seeing films that highlight Black scientists and mathematicians (i.e. Hidden Figures film) (Appendix L).

5.5 Limitations

The first limitation of this study was the constraints placed on the sample size. Given the nature of the intervention, only students taught by the teacher could participate. Approximately 48% of the school’s student population are females. The limitation reduced the sample pool to about 16% of the whole female population. Given the wide variety of students’ lived experiences, a more robust sample size may have uncovered more themes and therefore could have had a greater impact on contributing knowledge to the existing field.

Another limitation of the study was the timing of the pre-survey administration. The survey was given in October and not in August at the beginning of the year. Given when IRB approval was obtained, students had already experienced various science lessons. This could have had an impact on how students answered the pre-survey. Ideally, it would have been given at the start of the school year so students could answer the question based on their current time placement.
This study did not collect any grades or test scores from the participants. While the research connects the use of culturally relevant teaching practices and achievement, that was not the goal of this study. The lack of achievement data from the study leaves an important element unexplored. A future study should look at achievement data of participants as a potential outcome of the teaching practices. Finally, the researcher could not track students’ science identity during all three middle school years. While some girls have had the same science teacher over the course of their middle school years, many girls have had different teachers all three years. Approximately 8 out 17 girls have had Ms. Jordan as a science teacher at least 2 years. Only four of the girls have had Ms. Jordan for all 3 years of middle school.

5.6 Implications for Science Educator Practice

The exploration of Black girls’ science identity has profound implications for science educators who aim to create inclusive and equitable learning environments. Through recognition of the unique challenges faced by Black girls in science, educators are best able to address the need for a diverse scientific community. Here, I outline key implications for science educators based on the findings of this research.

5.6.1 Cultivate Inclusive Learning Spaces

Science educators should actively work towards creating inclusive classrooms where Black girls are affirmed in their science learning. Black girls should also feel supported by their teacher in developing an understanding of science content. This includes acknowledging and celebrating
diverse perspectives, experiences, and contributions. Through fostering an environment that values diversity, educators can help dismantle barriers such as academic challenges that may impede the development of Black girls’ science identities.

5.6.2 Embed Culturally Relevant Content

Integrating culturally relevant content into science curricula helps to make the subject matter more relatable and engaging for Black girls. Through multimodal instruction, use of examples, academic discourse, and embedding aspirations into lessons, Black girls can foster a stronger connection to the world of science. Inclusion of the scientific contributions from Black scientists into the curriculum can help to bridge the gap between the curriculum and the lived experiences of Black girls.

5.6.3 Promote Hands-On and Experiential Learning

Due to this study, our school should find more opportunities for students to engage in hands-on learning opportunities. Participants in the study held experiments and other hands-on activities in high regard as it pertains to their science identity. Teachers should plan their lessons, so students are equally learning across lectures, activities, and experiments.

Additionally, schools should also identify field trips that align to the content. Traditionally, there are 4-5 science units that middle school students are taught throughout the school year. Therefore, schools should plan at least one field trip per unit during the school year. Field trips allow students to apply their learning from the classroom to a meaningful, real-life experience.
Engaging Black girls in hands-on and experiential learning opportunities, allows them to explore and apply scientific concepts in real-world contexts. Providing opportunities for active participation sparks joy and enhances their confidence, curiosity, and ownership of their science learning. The application of scientific concepts in real-world contexts empowers Black girls to develop a sense of agency in the scientific learning process. Project Based Learning (PBL) would be a meaningful addition to the district wide curriculum resource and serve as a foundation for learning across content areas. PBLs would allow Black girls to engage in experiences outside classroom walls as they use learning as a tool to solve meaningful and relevant problems.

5.6.4 Continuous Professional Development

Science educators should prioritize professional development to stay informed on the latest research in equitable teaching practices within science education. This may include attending workshops, conferences, and training programs focused on culturally responsive teaching practices and strategies for fostering an inclusive learning environment. Professional development can promote meaningful networking of educators as they share resources that will amplify and enrich learning in the classroom.

5.6.5 Teacher Education Programs

Teacher education programs should focus on embedding an equity, justice, and critical race theory lens into science curriculum writing and teacher pedagogy. Teachers should have foundational knowledge of how to implement culturally relevant teaching strategies and a culturally sustaining curriculum into their science classrooms before they graduate from their
teacher education programs. There is value in housing schools of education within the same colleges as schools of social work, so teachers within preparation programs can “marry” concepts of equity, social justice, and cultural competence within their pedagogy as educators.

5.7 Implications for All Educators

Embedding culturally sustaining practices in the classroom requires intentional strategies that honor and leverage the diverse cultural backgrounds of students. The following implications provide a roadmap for all educators in their quest to create inclusive and empowering learning environments:

1. Culturally relevant curriculum: Integrate students’ cultural backgrounds, histories, and experiences into the curriculum to make learning more relevant and engaging. This may include but is not limited to using books that highlight Black characters and learning about Black history.

2. Inclusive pedagogy: Employ teaching methods that recognize and value the diverse learning styles and cultural strengths of all students such as collaborative learning and project-based learning. An example could be conducting a project where students work together to solve a real problem in their community.

3. Reflective Teaching Practice: Continuously reflect on and adapt teaching practices to better meet the needs of culturally diverse students. This may include keeping an educator reflection journal and recording observations to capture the impact of curriculum and pedagogy.
4. Student Voice and Leadership: Empower students to take an active role in their education and school community. An example of this could be allowing students to assist with lesson set up/break down. Another example would be to encourage student-led initiatives and projects that reflect their cultural interests.

5.8 Conclusion

In conclusion, this dissertation has delved into the often-overlooked topic of Black girls’ science identity. Through an in-depth exploration of the experiences, challenges, and triumphs faced by Black girls in the field of science, this research has shed light on the critical importance of recognizing and nurturing their unique identities. By acknowledging the intersectionality of race and gender, we work to uncover the nature of science identity formation for Black girls. Through a deep examination of curriculum and pedagogy, education professionals are urged to implement inclusive practices that empower Black girls in their pursuit of scientific knowledge and the embodiment of themselves as scientists.

The findings of this study lay a foundation for educational institutions, policymakers, and the scientific community to support educators in their pursuit of an equitable science education where Black girls are at the center. The decolonization of current science curriculum as essential as educators work to dismantle systemic barriers and create an environment where Black girls can thrive and contribute to the scientific world in meaningful ways.

There is much work to be done to ensure equity and representation in the science field. The narratives and shared experiences of Black girls must be amplified to contextualize the importance of the conversation. Further, these experiences need to be integrated in existing research in science
education. Our science community only benefits from the unique perspectives and contributions of Black girls. This dissertation serves as a call to action, urging concerned parties to prioritize inclusivity and diversity to pave the way for a future where every Black girl can see themselves as a scientist.
Appendix A Educator Reflection Journal Prompts

From Colorado Department of Education and research by Dr. Django Paris, Professor at University of Washington
Journal prompts – These will be answered at least 3 times over the course of the study by the practitioner.

Welcoming and Affirming Environment (1)
• What are you doing to learn more about your students’ culture?
• How are you building and sustaining student relationships?
• How do the instructional materials you use affirm your students’ identities?

High Expectations and Rigorous Instruction (2)
• How are you encouraging student-led civic engagement in your classroom?
• How are you engaging your students in a critical examination of power structures?

Inclusive Curriculum and Assessment (3)
• Are your students’ co-designers of the curriculum?
• How are you adapting your instructional strategies to the diverse learning styles of your students?
• Are you incorporating resources that are written and developed by racially, culturally, and linguistically diverse perspectives? How so?

Other journal prompts to be completed at least 2-3 times a week after lesson implementation.

• What went well today? Why did it go well?
• What needs work? Why do you think this?
• What comments did students make that affirm the work?
• What percentage of students were engaged in the learning process?
  o What parts of the lesson did engagement increase? Decrease?
  o Name specific examples of student engagement.
• What are the student objectives for the lesson today/this week?
• What were the students’ reactions to the lesson?
• What were students saying to each other during the lesson/experiment?
• What challenges did I observe and how will I address them?
Appendix B: A Single Item Measure for Assessing STEM Identity


Modified Version reads “scientist” in place of “STEM professional”
Appendix C: Empathy Interview Questions

1. Tell me about your favorite scientist and why.
2. What do you want to be when you get older?
3. Tell me how you feel about your science classroom and the lessons. These experiences can be both positive and negative.
4. Do you see many Black girls in science? Are there people you look up to for learning about science?
5. What made you interested in science? Can you tell me about your favorite science experiments or discoveries?
6. What do you think about Black girls in science? What images/media/examples have you seen of Black girls in science?
7. What does your teacher do that helps you feel like a scientist?
8. What do you wish your teacher did to help you feel like a scientist? (How about, “What do you think would help you feel like a scientist)…this way they can draw on other experiences.
9. Is there anything else you would like to share about your experiences in the science classroom?
Appendix D: Semi-structured Interview Questions

1. If you had a free day to do whatever you wanted, what would you do?
2. What are some topics that you are interested in?
3. What is your favorite in school and why?
4. What are your hobbies?
5. If you could pick any career, which would you pick and why?
6. How interested in science are you? Can you tell me about your favorite science experiments or discoveries?
7. Do you know of any Black girls in science?
8. Describe an image (poster, flyer, etc.) that you have seen of a Black girl as a scientist. How did it make you feel and why?
9. Are there people you look up to or resources you find helpful for learning about science?
10. Tell me about any challenges or difficult moments while doing science. Why do you think you faced these difficulties? Can you share an example and how you handled it?
11. Have you ever felt like your race or gender affected how you feel about science? How did that make you feel, and what did you do to stay confident and motivated?
12. Have you ever encountered stereotypes or biases? Can you give an example?
13. Can you tell me about a time when something really exciting or positive happened to you in science? How did it make you feel, and did it change the way you think about science?
14. What do you think can be done to make science more fun and inclusive for Black girls like yourself? Do you have any ideas for projects or activities that could help?
15. Who supports you in school? How do you think your teachers, parents, or other grown-ups can support you in exploring science and feeling confident in your abilities? Is there anything specific they can do to help?
16. What are some things you dream of doing in science? Are there any steps you want to take to make those dreams come true? How can others support you along the way?
17. Is there anything else you would like to share or talk about when it comes to science and being a Black girl? Any other thoughts or stories you'd like to tell?
# Appendix E: Concept 3 Session 1 Culturally Relevant Teaching Strategy Alignment

## Introduction (10 minutes)
- Begin the lesson by asking students about their understanding of gravity and its effects on Earth.
- Discuss briefly how gravity keeps objects on Earth and influences their movement.
- Introduce the idea of gravity in space and explain that in this lesson, they will explore its role beyond Earth, incorporating culturally relevant examples and perspectives.

| • Centering students’ culture and funds of knowledge in curriculum planning. |

## Cultural Exploration (15 minutes)
- Display pictures or posters representing diverse cultural backgrounds and traditions.
- Engage students in a discussion about cultural diversity and the importance of incorporating diverse perspectives in science.
- Show videos or multimedia resources that highlight cultural perspectives on space, such as indigenous knowledge, ancient myths, or cultural celebrations related to celestial events.
- Facilitate a class discussion, encouraging students to share their thoughts, connections, or questions about the cultural perspectives on space.

| • Centering students’ culture and funds of knowledge in curriculum planning. |
| • Use of culturally diverse images |
| • Multimodal instruction |

## Gravity in Space (25 minutes):
- Explain that gravity is not limited to Earth and that it also exists in space, influencing the motion of celestial bodies.
- Discuss key concepts related to gravity in space, such as the force of gravity, weightlessness, and how gravity affects the orbits of planets, moons, and satellites.
- Use visuals, diagrams, or animations to illustrate the effects of gravity on celestial bodies.
- Provide examples of culturally relevant space-related phenomena or concepts, such as cultural beliefs about stars, moon phases, or celestial navigation practices.
- Engage students in hands-on activities, such as calculating weights on different planets or creating models to demonstrate gravitational forces.
- Students create a scatter plot graph

| • Centering students’ culture and funds of knowledge in curriculum planning |
| • Multimodal instruction |
| • Relevant and meaningful learning |
| • High expectations with rigor |

## Conclusion (10 minutes)

| • Multimodal instruction |
a. Students engage in a turn and talk about how weight changes across the solar system and share their patterns with a partner.

b. Restate the guiding question: **What are the rules that govern whether something falls or orbits in the solar system?** Ask students: *How did what we did today help us get closer to answering this question? What did we figure out?*

- Relevant and meaningful learning
Appendix F: Concept 3 Session 2 Culturally Relevant Teaching Strategy Alignment

<table>
<thead>
<tr>
<th>Introduction (10 minutes)</th>
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<tbody>
<tr>
<td>a. Begin the lesson by asking students what they know about the rules that govern whether something falls or orbits in the solar system.</td>
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<td>b. Briefly discuss the importance of data collection in science.</td>
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<tr>
<td>Explore (35 minutes):</td>
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<td>c. Introduce the idea of relationship between mass and gravitational force.</td>
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<td>d. Display pictures or posters that highlight mathematicians of diverse backgrounds.</td>
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<td>e. Students turn and talk to a partner about the relationship between mass and gravity.</td>
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<td>f. Students engage in a lab where they measure how far they can jump in centimeters.</td>
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<td>g. Students calculate their average in jumps.</td>
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<td>h. Students divide their average the gravity factor on each planet.</td>
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<td>i. Engage students in a discussion about cultural diversity and the importance of incorporating diverse perspectives in science.</td>
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<tr>
<td>j. Students graph their scatter plot to depict mass of the planet vs. Student weight on planet for inner planets (Mercury, Venus, Earth, &amp; Mars)</td>
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<td>Extension: Students plot data for inner and outer plants.</td>
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<tr>
<td>Conclusion (10 minutes)</td>
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<tr>
<td>k. Students engage in a discussion of the patterns and relationships they see between the mass of an object and their weight, the mass of an object and their jump length, and the mass of an object and gravitational force.</td>
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<td>l. Restate the guiding question: <strong>What are the rules that govern whether something falls or orbits in the solar system?</strong> Ask students: <strong>How did what we did today help us get closer to answering this question? What did we figure out?</strong></td>
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- Centering students’ culture and funds of knowledge in curriculum planning.
- Use of culturally diverse images
- Multimodal instruction
- Multimodal instruction
- Relevant and meaningful learning
### Introduction (10 minutes)

- Begin the lesson by asking students what they know about the rules that govern whether something falls or orbits in the solar system.
- Briefly discuss the importance of creating models in science.

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<td>a.</td>
<td>Begin the lesson by asking students what they know about the rules that govern whether something falls or orbits in the solar system.</td>
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<td>b.</td>
<td>Briefly discuss the importance of creating models in science.</td>
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### Explore (35 minutes):

- Introduce the idea of inertia and the impact of gravity.
- Introduce the idea of simulations and how they mimic scientific phenomena to deepen understanding.
- Students form a hypothesis concerning the relationship between gravitational force, inertia, and the orbit of celestial bodies.
- Students watch video of gravity simulator.
- Students engage in a gravity simulator.
  - Students answer questions during the simulation process:
    - i. What might happen if the orbiting body has greater mass than the body in the center?  
    - ii. Do you think the amount of mass in the center influences the orbit? How can we modify our model to answer the question?  
    - iii. How did your marble behave differently with a larger mass in the center?  
    - iv. How did the marble behave relative to the ball bearing? How did the ball bearing behave relative to the mass in the center of the simulator? What system does this model? What did you notice happening to the orbiting bodies as their speed slowed down?

### Extension:

Students create video of themselves completing the simulation.

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### Conclusion (10 minutes)

- Restate the guiding question: **What are the rules that govern whether something falls or orbits in the solar system?** Ask students: *How did what we did today help us...*  

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<td>h.</td>
<td>Restate the guiding question: <em>What are the rules that govern whether something falls or orbits in the solar system?</em> Ask students: <em>How did what we did today help us...</em></td>
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- Centering students’ culture and funds of knowledge in curriculum planning.
- Use of culturally diverse images.
- Multimodal instruction.
- Multimodal instruction.
- Relevant and meaningful learning.
get closer to answering this question? What did we figure out?
Appendix H: Concept 3 Session 4 Culturally Relevant Teaching Strategy Alignment

<table>
<thead>
<tr>
<th>Introduction (10 minutes)</th>
<th>Explain (35 minutes):</th>
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<tbody>
<tr>
<td>a. Begin the lesson by asking students what they know</td>
<td>c. Students read article about gravity (How Does Gravity &amp; Inertia Keep the Planets in Orbit Around the Sun?)</td>
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<td>about the rules that govern whether something falls or</td>
<td>d. Students learn about Black scientists with their work in</td>
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<td>orbits in the solar system.</td>
<td>gravity and inertia.</td>
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<td>b. Briefly discuss the importance of reading literature in</td>
<td>e. Students engage in 2 simulations about gravity.</td>
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<td>science.</td>
<td>a. Simulation 1: Gravity Force Lab</td>
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<td>b. Simulation 2: Gravity and Orbits</td>
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<td></td>
<td>f. Students share their responses to the simulation with the class</td>
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<td>• Centering students’ culture and funds of knowledge in curriculum planning.</td>
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<td>• Multimodal instruction</td>
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<td>• Relevant and meaningful learning</td>
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<table>
<thead>
<tr>
<th>Conclusion (10 minutes)</th>
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<tbody>
<tr>
<td>g. Restate the guiding question: What are the rules that</td>
<td></td>
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<tr>
<td>govern whether something falls or orbits in the solar</td>
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<tr>
<td>system? Ask students: How did what we did today help us</td>
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<tr>
<td>get closer to answering this question? What did we figure</td>
<td></td>
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<tr>
<td>out?</td>
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<tr>
<td></td>
<td>• Multimodal instruction</td>
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<tr>
<td></td>
<td>• Relevant and meaningful learning</td>
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</table>
## Introduction (10 minutes)

- a. Begin the lesson by asking students what they know about the rules that govern whether something falls or orbits in the solar system.
- b. Briefly discuss the relationship between energy transfer and planetary gravity assist drives the motion of a satellite/spacecraft

## Elaborate (35 minutes):

- c. Students participate in a demonstration of a seismic accelerator.
- d. Students engage in a discussion of their observations of the demonstration.
- e. Students watch a video of a stacked ball drop.

### Part A: Class Demonstration

- f. Students create an Earth-Sun-Spacecraft/Satellite model.
- g. Students engage in 2 simulations about gravity.
- h. Students share their responses to the simulation with the class.

### Part B: Gravity Assist Simulation

- i. Students observe a Gravity Assist Simulator
  - a. Part 1: Elastic Collisions
  - c. Part 3: Use of gravity assist to increase speed.
  - d. Part 4: Messenger spacecraft and gravity assist
- j. Students engage in a discussion to explain the importance of gravity assist while considering the following criteria/constraints.
  - a. Time
  - b. Cost and weight of fuel

## Extension: students create their own video of a stacked ball drop

## Conclusion (10 minutes)

- h. Restate the guiding question: *What are the rules that govern whether something falls or orbits in the solar system?* Ask students: *How did what we did today help us get closer to answering this question? What did we figure out?*

- **Alignment:**
  - Centering students’ culture and funds of knowledge in curriculum planning.
  - Multimodal instruction

- **Relevant and meaningful learning**
<table>
<thead>
<tr>
<th>Introduction (10 minutes)</th>
<th>Evaluate (35 minutes):</th>
</tr>
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<tbody>
<tr>
<td>a. Begin the lesson by asking students what they know about the rules that govern whether something falls or orbits in the solar system.</td>
<td>d. Students apply their understanding of gravity to another solar system in our galaxy (Gliese 581)</td>
</tr>
<tr>
<td>b. Briefly discuss how gravity affects the motions within galaxies and the solar systems.</td>
<td>e. Students demonstrate their knowledge of inertia and gravity through different scenarios.</td>
</tr>
<tr>
<td>c. Briefly discuss the relationship between mass and distance and the effect on gravitational force</td>
<td>f. Students discuss the importance of gravity to human life</td>
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</tbody>
</table>

- Centering students’ culture and funds of knowledge in curriculum planning.
- Multimodal instruction

<table>
<thead>
<tr>
<th>Conclusion (10 minutes)</th>
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<tbody>
<tr>
<td>i. Restate the guiding question: <strong>What are the rules that govern whether something falls or orbits in the solar system?</strong> Ask students: <strong>How did what we did today help us get closer to answering this question? What did we figure out?</strong></td>
</tr>
</tbody>
</table>

- Multimodal instruction
- Relevant and meaningful learning
## Appendix K: Observation Quotes from Participants

<table>
<thead>
<tr>
<th>Session</th>
<th>Topic</th>
<th>Quotes</th>
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</thead>
</table>
| Session 1 | Role of gravity in Space          | “Gravity brings things back down to the Earth”  
“People in space float.”  
“All things have gravity.”  
“[Gravity] keeps us grounded to the floor.” |
| Session 2 | Importance of Data Collection     | “It helps us see the results and allows you to see what it means.”  
“Gives evidence for science”  
“Helps us make predictions”  
“Keep track of information and mistakes”  
“Doctors collect data...they have their little clipboard.”  
“The nurse tracks my weight when I go to the doctor.” |
| Session 3 | Models                            | “…helps us to have a visualization of what we are learning.”  
“Shows a new way of what we are learning.”  
“Helps us to see details up close.”  
“[Models are] diagram of what we are learning about and get a better visual” |
| Session 4 | Importance of Reading Literature in Science | “We learn more information.”  
“We get to get better at reading about science.”  
“The book or article or something like that teaches us stuff we didn’t know before.” |
| Session 5 | Relationship between Energy Transfer and Gravity | “I don’t know yet.”  
“Maybe it’s...like...idk”  
“I’m not sure yet...but I think we’ll learn about that today.”  
“Like hot and cold and one has more gravity than the other.”  
“This is a model...”  
“So when the thing goes faster...the pull is greater?” |
| Session 6 | Relationship between Mass and Gravity and the relationship between distance and gravity. | “More mass more gravity...more mass more gravity.” (beats on the table)  
“More gravity then more mass.”  
“More weight more gravity.”  
“I’m not sure.”  
“I don’t know yet.”  
“It is a way to visualize the data table.” |
Appendix L: Educator Reflection Journal Part 1

<table>
<thead>
<tr>
<th>Welcoming and Affirming Environment (1)</th>
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</table>
| **What are you doing to learn more about your students’ culture?** | Students are asked “What do you do to celebrate the winter solstice?”
| **Students are asked fun questions the day before the start of the lesson. The questions were shared by a teacher from a neighboring school district and were chosen at random.** | The questions were as follows:
| 1. On a Stich Scale, how are you feeling today? |
| 2. Which type of potato do you prefer? Standard, Curly, Waffle, Crinkle, Sweet Potato, or Tots |
| 3. Would you rather have unlimited tacos or unlimited ice-cream? |
| 4. Would you rather have Cheez its or goldfish? |
| 5. Would you rather have a pink house or a pink car |

| **How are you building and sustaining student relationships?** | Students can answer a fun question of the day. Today’s question is “Would you rather have unlimited tacos or unlimited ice cream?” One student asks if ice cream tacos count. Students can share with their table groups. I prompt students to give more details…what type of tacos…what toppings…what type of ice cream. |
| **Students also can discuss what they already know about gravity. Students recollect a joke that the teacher gave about how gravity is what makes her fall when she trips over her clumsy feet.** |
| **Students are centered as the expert professional by writing in their notebooks “Today, I am a scientist, mathematician, and data analyst.”** |
| **Students see the images and read descriptions of how other cultures celebrate the winter solstice. They make connections between the Chinese celebration as they recognize the pot stickers in the photo. They deviate and talk about how they like pot stickers. They asked me if we could order some and I let the students know that when I lived in Chicago, a friend I met taught me how to make those and California roll (sushi). Another student asks if they have Asian month like they do Hispanic and Black history month. They then ask if they can make food then. When I hesitate to say yes, a participant of the study says that we can relate it to food science and learn about thermal energy and we can be food scientists.** |

| **How do the instructional materials you use affirm your students?** | Students see the image of Mae Jemison and know that she is an astronaut and that people talk about her a lot as being the first Black woman in space. Students also see Katherine Johnson and know that she is in the movie Hidden Figures. They know that she is really smart and identify with her going through struggles |
students’ identities? on the job. They have seen the movie several times. I also included pictures of some of the Hispanic astronauts that students learned about during Hispanic Heritage Month. Students remember the Spanish words they completed for a portion of that assignment. I have two Latinx students (Mexican and Puerto Rican) who are in class. They connect with the images. The student who is Puerto Rican and Black says that she likes the pictures because she sees all of her in them.
## High Expectations and Rigorous Instruction (2)

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
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<tbody>
<tr>
<td>How are you encouraging student-led civic engagement in your classroom?</td>
<td>n/a</td>
</tr>
<tr>
<td>How are you engaging your students in a critical examination of power structures?</td>
<td>When shown the images of Black and Hispanic scientists, students engage in a conversation around why they haven’t learned or seen more images of diverse scientists before today. Some students who have had me as a teacher before, disagree by explaining that in 6th or 7th grade they did projects on Black inventors. Another student who had a Black male science teacher in 6th grade remembers the posters of Black male and female scientists that he had hanging in the classroom. Another student interjects and says that schools only teach what they want us to learn and they want “us to think we can’t be anything.”</td>
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**Appendix N: Educator Reflection Journal Part 3**

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<thead>
<tr>
<th>Inclusive Curriculum and Assessment</th>
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<tr>
<td>Are your students’ co-designers of the curriculum?</td>
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<tr>
<td>How are you adapting your instructional strategies to the diverse learning styles of your students?</td>
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<tr>
<td>Are you incorporating resources that are written and developed by racially, culturally, and linguistically diverse perspectives? How so?</td>
</tr>
</tbody>
</table>
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