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Examining the Influence of Argument Driven Inquiry Instructional Approach on Female Students of Color in Sixth Grade Science: Its Impact on Classroom Experience, Interest, And Self-Efficacy in Science, Written Argumentation Skills, and Scientific Voice

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Dedication

This dissertation is dedicated to my loving, supportive husband Patrick Duggan who continues to provide the support, understanding and patience needed in my pursuit of advanced degrees and other personal endeavors important to me. Thank you for encouraging me to move forward and never give up when I did not see an end in sight. You are my universe.

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Abstract

Four of the eight Engineering Standards in the Next Generation Science Standards (NGSS, 2013) focus on authentic science communication: "asking questions (science) and defining problems (engineering), analyzing and interpreting data, constructing explanations (for science) and designing solutions (for engineering), engaging in argument from evidence, obtaining, evaluating and communicating information" (Sampson et al., 2010, p. 218). Authentic science communication is supported in NGSS through cross-cutting concepts (Driver et al., 2000) that integrate the structure and function of science concepts together with communication strategies that include reading, writing, and peer critique. These cross-cutting concepts include reading strategies that focus on reading informational text such as cause and effect relationships, reading captions and challenge text. These skills are used in all science and engineering fields. Mastery in both science concepts and authentic scientific communication is critical to success in the STEM fields which require collaboration among scientists and independent contribution. Argument Driven Inquiry (ADI) is an instructional practice that integrates reading, writing, and peer critique that is grounded in authentic scientific practices (Driver et al., 2000). As such, ADI is an instructional approach that supports students in learning these NGSS standards. Further, ADI is a culturally-relevant pedagogical (CRP)

instructional approach that is grounded in raising students' critical consciousness (learning 21st century critical thinking skills, such as evaluation, and questioning subject matter text). It is well-known that in the literature that students' interest in STEM declines in middle school grades, especially around sixth grade, even for students who demonstrate high academic achievement in science. Thus, ADI has been hypothesized as an instructional approach that can impact student engagement which has the potential to increase and sustain their interest in STEM at a critical point at which has been found to decline. While the correlation between high science performance and decreasing interest is well-documented for students, in general, and a few studies have examined this relationship in females, studies have not yet examined this correlation for the intersectionality of two of the highest under-represented populations in STEM based on race/ethnicity and gender: African American and Latina females.

This study utilized qualitative methods to address two research questions:

Research Question 1: In what ways did implementing and scaffolding the ADI instructional approach influence the classroom experiences, interest, and self-confidence for female students of color (i.e., non-White) in middle school (sixth grade) science?

Research Question 2: In what ways did using the ADI instructional approach impact female students of color (i.e., non-White) written argumentation skills (including peer review) and scientific voice in middle school (sixth grade) science?

Participants were four female students in sixth grade science classes representing African American and Latina females with low socio-economic status ranging in ages from 11-12 years of age. These students received ADI science instruction within the same school. The study took place during the first quarter of the fall semester of sixth grade. I was the researcher and also the classroom science teacher. I taught using the ADI instructional approach, and I collected the data from the students that was used for this study. Specifically, I took field notes while observing the students during their interactive labs, and I conducted semi-structured individual interviews three times during this study with each student and two focus groups that included all four participants at the end of this study. Several data sources were used to form the basis of the interviews: participants' ratings on science interest and self-efficacy questionnaires completed at the beginning of the school year as a regular part of classroom procedures, as well as their academic performance as measured by their repeated-measure teacher team-completed ADI Rubric for each individual student for each lab and their written lab reports. Two independent coders and I coded the transcribed data, and an inductive analysis approach was used to analyze the data. Because I was the researcher and also the students' classroom teacher, precautions were taken to protect against bias. Namely, the ADI rubric was scored by a collective group of teachers in the science department rather than me as the primary teacher alone (note that this practice of multiple teachers scoring the ADI rubrics is standard procedure at this school and was not implemented differently for this study), independent coders were used in addition to my coding transcripts, and other triangulation of various data sources (e.g., written work through peer-reviewed and teacher team-scored lab reports, focus group interview, individual interviews and questionnaires) were used to assist me in making valid inferences. Findings from this study have the potential to impact decisions made about selecting instructional approaches in science for underrepresented middle school students, specifically females who are African American or Latina.

Keywords: Argument Driven Inquiry, science interest, self-efficacy, African American/Black females, Latina middle school females, STEM, science talk, discourse, argumentation

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ADI	Argument Driven Inquiry
CES	Classroom Environment Scale
CRP	Culturally Relevant Pedagogy
IRE	Initiate-response-evaluate
IRF	Initiation-response-feedback
LEI	Learning Environment Inventory
NAEP	National Association of Educational Procurement
NGSS	Next Generation Science Standards
NOS	Nature of Science
NRC	National Research Council
NSF	National Science Foundation
SEP	Science and Engineering Practice
SES	Socioeconomic Status
STEM-CIS	Science, Technology, Engineering, and Math Career Interest Survey

Chapter 1: Introduction

1.1 Science Engineering Practices and Cross Cutting Concepts

This introduction begins with a brief explanation of the Science Engineering Practices (SEPs) and the cross-cutting concepts and how they contribute to literacy in the science content area. Next, I will present a comparison between traditional and non-traditional discourse practices in classroom instruction. I will then review research on discourse in science classrooms and how it impacts learning. Then, I will focus on the relationship between Argument Driven Inquiry and the nature of science. The research will then center on the benefits of non-traditional classroom instruction for underrepresented population in science. Following this will be a concentration on culturally relevant pedagogy and its connection to the seven steps of Argument Driven Inquiry (ADI). Then, I will review specific underrepresented groups including the intersectionality of gender and race among African American and Latino/a females in science. This chapter will conclude with a critical focus on research for two populations underrepresented in science: African American and Latino/a females.

The *Goals 2000: Educate America Act and the School-to-Work Opportunities Act (1993)* established scientific literacy for all U.S. students as a national priority due to the increasing demand for graduates in the areas of science, technology, engineering, and mathematics (STEM) (Quinn & Cooc, 2015). A core pedagogical practice in science is developing scientific literacy. The term literacy is defined as “comprehending, interpreting, analyzing, and critiquing text, the study of argument and its construction, then the evaluation of the data and warrants and the consideration of opposing hypothesis” (Norris & Phillips, 2003, p. 225). Nearly two decades later, in a Framework for K-12 Science Education: Science Practices, Engineering Standards, Cross Cutting Concepts, and Core Ideas (National Research Council [NRC], 2012), on which The Next Generation Science Standards (NGSS) is based is a way to change the way science is being taught in classrooms and develop scientific literacy.

> …Understanding science and engineering, now more than ever, is essential for every American citizen. Science, engineering, and technologies influence every aspect of modern life. Indeed, some knowledge of science and engineering is required to engage with major public policy issues of today as well as to make informed everyday decisions such as selecting among alternative medical treatments or determining how to invest public funds for water supply options. In addition, understating science, and the extraordinary insights it has produced can be measured and relevant on a personal level, opening new worlds to explore and offering lifelong opportunities enriching people’s lives. In these contexts, learning science is for everyone, even those who eventually choose careers in fields other than science and engineering (National Research Council, 2012, p. 7).

A main objective of the Cross Cutting Concepts and the Science and Engineering Practices (SEPs) is for all students to expand their understanding of scientific literacy and develop skills needed to engage in this practice by the time they graduate from high school (American Association for the Advancement of Science, 1993; National Research

Council (NRC; 1996, 2005, 2008). The SEPs move students away from rote performance of scientific actions and instead engage them in meaningful knowledge construction. These Science and Engineering Practices represent authentic scientific practices used by scientist and engineers in their everyday occupations. Shifting classroom instruction to models that prioritize knowledge construction and validate this through inquiry is a focus of instructional models such as Science Writing Heuristic (Wallace et al., 2005) and Modeling Instruction (Hestenes et al., 1992).

These models build community in the classroom as well as support SEPs by teaching students to discover how science knowledge and concepts evolve through frequent questions, conducting investigations, obtaining and analyzing data, constructing explanations, arguing claims supported by evidence, and communicating and evaluating information (National Research Council of the National Academies Committee on a Conceptual Framework for New K-12 Science Education Standards, 2012). Community is defined as the school, classroom, and attendance area. Bridging students learning to their community, language, and culture motivates students to communicate their learning, revise work, and provide evidence to support their views (Sadler & Zeidler, 2005). Community collaboration supports scientific literacy by having students become familiar with science ways of knowledge through real world connections and drawing from their own experiences.

Four of the nine SEPs require students to be active participants in argumentation during the inquiry process. Argumentation is an essential skill in which students are expected to “listen to, compare, and evaluate competing ideas and methods based on their merits” in the process of scientific inquiry (NAEP, 2009, p. 13). The term argumentation refers to a form of logical discourse with a primary goal to discover the relationship between ideas and evidence (Duschl et al., 2007). The skill of arguing from evidence is often neglected inside classrooms (Sampson et al., 2010).

Current science classrooms tend to focus on learning and memorizing subject matter rather than developing an understanding of how scientific knowledge is developed and understood. Emphasis is placed on content rather than the process of evaluating and justifying evidence especially in elementary classrooms (Sampson et al., 2010). Students are often not given the opportunity to learn how to engage in productive science conversations. Researchers and policy makers tend to focus on gaps in mathematics and literacy rather than science (Quinn & Cooc, 2015). Teachers who focus on high stakes testing and basic recall skills neglect the creative and innovative needs of the student (Renzulli et al., 2004).

Another problem confronting classroom discourse is restrictive pacing guides that prioritize instruction on content that is covered by state testing and high stakes standardized tests. Current science classrooms primarily focus on learning (memorizing) subject matter rather than developing in-depth understandings of scientific knowledge and how it's developed. Teachers, especially those in elementary and middle schools, stress science content over the process of evaluating and justifying evidence (Sampson et al., 2011). Due to testing requirements, some teachers feel devoting time to the Nature of Science (NOS) will detract and interfere with the learning of subject matter. For NOS to be successfully implanted within K-12 instruction, teachers must understand and develop the pedagogical tools to teach the "fundamental" aspects of NOS. Students often are not given opportunities to learn how to engage in productive science conversations (Driver et al., 2000).

1.2 Traditional verses Non-Traditional Science Discourse in Classroom Instruction

Educational research has shown students often lack a clear understating of science content leaving them confused, unfocused, and unproductive in their use of language (Edwards & Mercer, 1987). The potential of conversational interactions among students to develop knowledge is often squandered in a classroom (Galton & Williamson, 1992). Science teachers tend to stress the importance of memorizing science content rather than the process of clarification, evaluation, and justification toward a phenomenon, especially at the elementary level (Sampson et al., 2010). Much of the emphasis in elementary classrooms is focused on math and English language arts due to the high emphasis in these content areas in state testing which reduces the amount of instructional emphasis placed on and time devoted to science. Placing the emphasis on testing often neglects the needs of the gifted, creative, and innovative students (Renzulli, 2005). This focus may contribute to a “lack of scientist, engineers, inventors, entrepreneurs and creative contributors to all areas of arts and sciences” (Renzulli, 2005, p. 40). A recent emphasis on science, technology, engineering, arts, and mathematics (STEAM) and ADI add to student’s creativity in the science domains. This emphasis shows creativity is not limited to the arts but enriched through multiple subjects.

The emphasis on testing pushes teachers to cover science content using textbook-based “cookie cutter” laboratories or teacher-focused lectures. Non-traditional, inquiry-focused classrooms have students actively engaged in dialogue exchanging ideas, discussing observations, and possible explanations regarding phenomena observed during the class. In classrooms that include an inquiry-focused instructional approach, learning occurs through students' social interactions, experiences, and ideas. This phenomenon can be conveyed and communicated through conceptual and physical models (Louca & Zacharia, 2012). Teachers still question students; however, students' responses and frequent teacher responses do not fit the traditional discourse structure in which teachers typically call on students, students provide responses from rote memory of facts taught, and teachers comment on whether these responses are "correct" or "incorrect." This type of instructional approach is typical in Western type schooling and is referred to as the initiation-response-feedback (IRF) discourse structure: teacher initiates a question, student responds, and teacher provides feedback (Cazden, 2001). In non-traditional, inquiry-based instruction, students observe phenomena and construct their own claims using methods and use their experiences to construct an explanation.

1.3 Discourse in Science

What kinds of student discourse develop meaningful learning and understandings of science and scientists' ways of thinking? Discourse in elementary, middle, and secondary classrooms can be classified as traditional lectured based classes, textbook dominated, or a non- traditional approach (Roth et al., 1987). This dialogue/recitation, which is typical of the IRE (initiate-response-evaluate) or IRF (initiation-response-feedback) follows this pattern:

"Teacher calls on a. child to share/ respond

Student tells the narrative

Teacher comments on narrative"

(Cazden, 1988, p.30).

An example of this IRE dialogue occurs when the talk is dominated by the teacher telling students science facts, with teacher-student dialogue limited to traditional questions such as (teacher ask) "How does a cloud form?" followed by student response of "condensation" followed by the teacher replying "correct" (Roth, 2002). Learning science in a traditional classroom has students listening and responding to factual questions. With a one- or two-word response. Students often are not given the opportunity to argue from evidence or justify their answer based on data or build on other students' reasoning due to lack of time devoted to science or a lack of student discourse. Teachers who ask IRE and/or IRF questions provide inauthentic science experiences and oversimplified questions with answers already known (Cazden, 2002, p. 46).

According to the National Association of Educational Procurement (NAEP), only eight percent of fourth graders, three percent of eighth graders, and six percent of twelfth graders can make informed, critical judgments about written text (NAEP, 2002). Only two percent of these fourth graders can support a position using evidence (NAEP, 1999). Students are unable to apply argumentative text structures. The importance of argumentation to students' lives makes it crucial to identify instructional practices that support the development of argumentation (Rezniskaya & Anderson, 2002).

1.4 Non-Traditional Classroom Instruction: Argument Driven Inquiry and the Nature of Science

Developing scientifically literate students is a main goal for science instruction. Science literacy is defined as "comprehending, interpreting, analyzing and critiquing text, the study of argument and its construction, then the evaluation of the data and warrants and the consideration of opposing hypothesis" (Norris & Phillips, 2003, p. 3). Argument

Driven Inquiry (ADI) is an instructional practice that integrates and supports reading, writing, math, and peer critiques in the science content areas. It is a scientific practice supporting science discourse in that scientists socially construct knowledge through claims, examining evidence, and assessing alternative explanations (Driver et al., 2000). Students who are scientifically literate understand how "scientific knowledge is developed and the nature of scientific knowledge" (Lederman, 1999, p. 918).

Both NOS and argumentation are essential for developing scientific literacy and supporting the development of scientific knowledge (American Association for the Advancement of Science [AAAS], 1989, 1993; National Research Council [NRC], 1996). The eight understandings of NOS that are identified in the *Next Generation Science Standards (NGSS)* (NGSS Lead States, 2013) are embedded in the seven steps of ADI (defined later) (Sampson et al., 2010):

- Step one is the *identification of the task*
- Step two is the *generating ideas/ data*
- Step three is the *production of an alternative argument*
- Step four is the *argumentation session*
- Step five is the *creation of the written investigation report*
- Step six is the *double-blind peer review*
- Step seven is the *revision of the report*

NOS identifies the following (Lederman & Lederman, 2004):

- Scientific knowledge a variety of methods
- Scientific knowledge is based on empirical evidence
- Scientific knowledge is open to revision considering new evidence

- Science models, laws, mechanisms, and theories explain natural phenomena
- Science is a way of knowing
- Scientific knowledge assumes order and consistency in natural systems
- Science is a human endeavor
- Science addresses questions about the natural and material world

Understating NOS allows students to construct informed debates and make informed decisions regarding multiple perspectives and interpretations on science issues (Sadler & Zeidler, 2005). Students understanding the NOS impacts their engagement while participating in argumentation (Nussbaum et al., 2008). In other words, students with limited scientific knowledge may have limited participation in an argument due to the lack of comprehension that claims are open to challenge and open mindedness to refute (Kuhn, 1992; Clark & Sampson, 2007).

Students who are scientifically literate in their understating of NOS use arguments to verify their claims using evidence against opposing viewpoints (Bell & Linn, 2000), which is referred to as "argumentation" (NGSS, 2013). More informed views of NOS support complex arguments (Khishfe, n.d.). Engaging students in argumentation helps support and improve their understating about NOS. Scientists come from a variety of culturally and linguistically diverse backgrounds and experiences as do students. These differences cause data to be interpreted and debated in different ways, such as debates surrounding global warning and impact theories of extinction (Lederman, 1992). For this reason, it is critical for students to understand and develop the scientific skill of argumentation which is the ability to use evidence to support or refute their claims from the data.

1.5 Benefits of Non-Traditional Classroom Instruction for Underrepresented Populations

The National Science Foundation (NSF) states, “inquiry should be viewed as a process of explanation and argument as well as a process of exploration and experiment” (NRC, 1996, p. 113). New state standards have concentrated efforts on science language development and literacy through student engagement in the practices used by scientists and integration of content specific texts (Bunch, 2013). Taking students from settings where instruction is teacher-led to a classroom that fosters students’ conversations, student-lead arguments, student lead explorations of phenomena, and peer critique are important for nurturing student creativity; this is accomplished by allowing students to promote, support and refine ideas (Jimenez- Aleixadnre et al., 2000; Kuhn & Reiser, 2006). High quality inquiry-oriented classrooms focus on more prominent student-to-student talk and creativity. Students at very young ages can reason in scientific ways and develop strong understandings of abstract concepts (Duschl et al., 2007).

Students receive multiple benefits from engaging in scientific argumentation such as learning concepts, participating in science discourse altering their views of science, and supporting them in decision making (Eduran & Jimenez-Aleixandre, 2008). Argumentation also focuses on reading and writing in the content area to develop science literacy. Students establish strong revision, communication, and interactive connections with their school and local community by participating in rigorous cognitive opportunities that integrate technology and engineering practices.

Instructional models that focus on the discourse of science, giving students a basic understating of “what counts” as evidence and explanation in a scientific argument, assist in the development of student knowledge and their abilities to participate in science argumentation (Sampson & Walker, 2012, p. 1484). Students learn how to collaborate through argumentation, reflecting the authentic practice and norms of the scientific community (Clark & Sampson, 2008). The development of instructional models, like ADI, that focus on science content, processes, and social norms support students' cognitive and conceptual processes (Duschl, 2008; Sandoval & Reiser, 2004).

Pedagogical practices that allow students opportunities to discuss, evaluate, and revise their work allow students to take charge of their own learning, contributing to their critical consciousness. Students make informed decisions together, improving their ability to describe, explain, and predict natural phenomena. It is through these social interactions that children learn. The UK Governments Advisory Group for Education Citizenship (1998) argued that schools should provide young people with an "armory of essential skills, listening, arguing, making a case; and accepting the greater wisdom or force of an alternate view" (Newton et al., 2000, p. 571). In other words, students may consider another view other than their own based on evidence.

Communication is a necessary skill for all students in developing intelligent claims informed by evidence and reason (Eduran, Jimenez-Aleixandre, 2008). Argumentation is a scientific practice supporting science discourse in that scientists socially construct knowledge through evaluating claims, examining evidence, and assessing alternative explanations (Newton et al., 2000). The ADI instructional model supports students learning through sociocentric decision making allowing them to consider alternative views of science from their classmates. Focusing on the learner rather than the induvial content area being taught.

Allowing students opportunities to collaborate can improve learning outcomes (science knowledge). Talk enables students to develop meaningful understandings of science and scientists' ways of thinking (Lemke, 1990). Students participating in argumentation should play a pivotal role in the teaching and learning of science (NRC, 1996). Argumentation is an interactive formative assessment that can often change and be unpredictable depending on the dialogue occurring. The ADI model has four dependent factors which help students develop their understandings. These include the nature of the instructional model and how it is used, the complex nature of an existing setting, the nature of content, and how these factors interact with one another (Cobbet et al., 2003).

1.6 The Eight Steps of Argument Driven Inquiry (ADI)

The Argumentation Driven Inquiry framework incorporates eight stages to support scientific literacy, strengthen writing, and enhance social cues. It also allows students to develop academic mindsets and apply critical thinking skills through seven steps. Each stage is of equal importance to achieve the learning goals. Through these stages, students build content knowledge and develop abilities that are needed in arguing from evidence along with developing written arguments as they work (Sampson et al., 2011). Developing scientific understandings is a main goal of the ADI instructional model (Kutluca & Aydin, 2018). These eight stages allow students to have their voices heard as well as grow in their ability to craft quality written investigation summaries that are peer reviewed by fellow classmates.

Stage one is the *identification of the task*, stage two is the *generating ideas/ data*, stage three is the *production of an alternative argument*, stage four is the *argumentation session*, stage five is the *creation of the written investigation report*, stage six is the *double-blind peer review*, and stage seven is the *revision of the report*, stage eight is the *student revising and submitting their report* (Sampson et al., 2010).

Stage one, *identification of the task,* usually consists of the teacher introducing the research question or topic. The focus is to “hook” or capture students’ attention making the connections to students prior and future learning experiences. Students are provided with a reading that includes information, and a list of materials that can be used in the investigation. Students discuss evidence from the article they feel can assist them in forming a claim to explain the phenomena or “hook” they observed. At this point the teacher discusses what counts as evidence and a high-quality argument in science (Sampson et al., 2010).

Stage two is the *generation of ideas/ data.* Students develop and implement a method that will address the problem or answer the research question. The main goal of this stage is for students to learn to develop and design an investigation, collecting, and analyzing appropriate data. Students will learn to reflect on which part of the procedure worked best during the investigation and how their investigation method was “based on the nature of the research question, the phenomena under the investigation, and what has been done by others in the past” (Sampson et al., 2010). Research questions have several key components. A research question should be “(a) feasible in that students can design and perform investigations to answer the question; (b) worthwhile in that they contain rich science content that aligns with national or district standards and relates to what scientist really do; (c) contextualized in that they are real world, non- trivial, and important; (d) meaningful in that they are interesting and exciting to students; (e) ethical they do not harm or marginalize individuals, organisms, or the environment" (Krajcik et al., 2013, p. 4).

Stage three is the *production of tentative argument*. Students begin to construct their argument centered around their claim, evidence collected during their investigation, and reasoning to support how the evidence supports the students' claims. Evidence must meet all of the following criteria: (a) a trend over time, (b) a difference between groups or objects, and (c) a relationship between variables (Sampson et al., 2010, p. 220). Evidence can range from quantitative to qualitative data. This step stresses the importance of scientific claims being supported with specific evidence gathered from the investigation and research. This step allows students' ideas, evidence, and reasoning to be visible to each other, and this display provides students the opportunity to evaluate each other's ideas.

Stage four is the *argumentation session* in which members of the groups explain their ideas to other groups for critique and validation of their findings. A focus on types of discourse has centered around students talk, scientific argumentation and multiple purposes of classroom talk. Students learn from each other, and this stage allows students to hear and visually see the ideas of other groups. This stage provides students an opportunity to take a critical look and view and "create a need" (Kuhn & Reiser, 2006, p. 1008). It also teaches students critical social cues when critiquing others. This removes the teacher as the knowledge source and places students in the key role. Students' communication skills are developed by the teacher "to make sense of talk that surrounds them" (p. 44), and in doing so connect the concepts under discussion to their own community experience and ways of thinking (Driver et al., 1996).

Stage five of the ADI instructional model is the *written investigation report*. In this stage, students communicate their learning and findings using written communication. Scientists and engineers must be able to read and understand the writing of others and evaluate its contribution (Zembal-Saul, 2009). Requiring students to write supports metacognition and improves students' understating of the content (Wallace et al., 2005). Students learn how to write as well as how to write using a non-traditional persuasive rubric as a guide. This format challenges students to think about what they know, how they know it, and why they believe it over other information (Sampson et al., 2010). The guidelines for the rubric center on three questions: What are you trying to do and why? What did you do and why? What is your argument? (Sampson et al., 2010). These three questions give students awareness of their audience, non-narrative structures of scientific text and shows students the importance of using evidence to support scientific arguments (Wallace, Hand, & Yang, 2005).

Stage six is a *double-blind peer review.* Students turn in three typed copies of their lab investigation reports. Then they are randomly issued to each group of students. Using a rubric for the peer review, students provide feedback to the anonymous reports. Groups also must be specific in their feedback when evaluating their peer review. Students specifically focus on the evidence collected and whether it supports their claim. The protocol asks, "Did the students provide and follow a detailed step or logical progression during their investigation" (Sampson et al., 2010, p. 53). Students also provide feedback detailing how the author can improve their argument. This step of the framework is vital to showing students how to give and revise their work for quality, helping them understand the difference between strong and weak critiques. Students are actively discussing and learning social cues while offering critique. This step also raises students' metacognitive awareness as they discuss the validity and the acceptance of scientific claims, and the process of critiquing claims increases the quality of the students' written work. The revision process during this stage allows students to provide well-articulated responses and grow in their understating of scientific argumentation functions and criteria (Reznitskaya et al., 2007). This also builds and creates learning communities in the science classroom.

Stage seven of the ADI instructional model involves *revision of the report* using peer critiques from step six. The students are given opportunities to revise and rewrite their investigation write up using feedback from their peers. Students in this step may revise their paper until it meets the guidelines and shows a high level of quality and correct writing mechanics. Students become "individuals who are flexible, adaptable, and effective communicators, rather than individuals with a detailed knowledge of science curriculum" (Newton et al., 1999, p. 571).

Stage eight is the final stage in the ADI instructional model. Students are given the opportunities to revise their lab investigation based on the suggestions given to them during the peer review. When the student feels all the criteria have been met, they submit the paper to the teacher with the original draft and peer review sheet guide.

1.7 Underrepresented Gender and Race: Female African Americans and Latino/a

The number of women in science and engineering is growing, yet men continue to outnumber women (Burke, & Mattis, 2007). However, African American women and Latina women continue to be underrepresented in the science, technology, engineering, and math (STEM) fields (National Science Foundation [NSF], 2009; National Center for

Science and Engineering Statistics, 2015; White House Council on Women and Girls, 2014). In 2015, 35.4% of Black women intended to major in biological fields and or agricultural science, 14.3% in behavioral science, and 3.2% in engineering/ mathematics, statistics, and 1.4% computer science (NSF, 2015). Individuals who work in science fields, such as physics, are typically white, and middle-class males (National Center for Education Statistics [NCES], 2009).

Using the phrase "science for all" has become interchangeable with present science education reform curriculum. Twenty-first century schools offer students the opportunity to embrace technology and prepare for careers that do not currently exist. Despite tremendous jumps in instructional practice and science reform, gender gaps exist in elementary, middle, and secondary science especially among women of color (e.g., African American and Latino/a). Female students tend to score well on state and standardized testing in science, consider it boring, and of little interest (Csikszentmihalyi et al., 1993). This may be a result of cultural conflicts between their country of birth and country of immigration, gender non-conformity, and language barriers (Pinder, 2013). Other reasons may include obstacles such as low expectations from teachers and their placement in low-track science programs that lack rigor, critical thinking in science and engineering, and creativity, providing the girls with little interest for science (Pinder & Blackwell, 2013).

Evidence points to children ages 10-14 as an important time for creating and maintaining children's interest in science (Lindahl, 2007). Identities are developed and shaped in relation to intersections such as gender, ethnicity, and social class which can contribute to the belief, "what is/is not appropriate for people like me" and shape individuals' educational choices (Bourdieu & Passeron, 1977). Students' sense of self identity is a major factor in how they respond to science (Head, 1985). Gender underrepresentation may stem from females of African American and Latina background goals, self-conception, and identity (National Science Board, 2016). This change in goals, identity, and self-conception may be attributed to two existing gaps between teaching and learning science and gender stereotypes in learning science (Hong et al., 2011). Science teachers tend to stress content knowledge rather than the process of clarification, evaluation, and justification of a phenomenon, especially at the middle school level (Sampson et al., 2016). The second gap may be attributed to gender stereotypes and differences in communication styles which may impact argumentation ability (Jeong & Davidson-Shivers, 2006).

In middle school, biases and inequities in the science classroom may contribute to achievement gaps among girls of color (African American and Latina). African American girls are often marginalized and may often experience racism report not feeling a valued part of their science class and feel that their voice is not valued (Hanson, 2009). Females of color may be subjected to gender harassment, which encourages gender conformity and is often overlooked (Jones & Warner, 2011).

1.8 Critical Need for Studying the Sampson ADI Model with Two Particular Populations of Focus: African American Females and Latina Females

African American females and Latina Females also benefit from non-traditional instruction in the same way that this instruction benefits student populations in general (Warren et al., 2001). In addition, studies have shown that non-traditional classroom instruction has a positive impact on these two student populations in increasing their science career interests (Barton, 2003). While the Sampson ADI model has research support for student populations, in general, this model has not been studied with the population of interest: African American females and Latina females. This intersection of race and gender particularly is important and timely because these two populations are underrepresented in science career fields.

1.9 Relevance to Personal Experience as a Middle School Science Classroom Teacher

At the beginning of the year, I always started off having students complete a pre-interest survey titled, "How do I feel about science?" Some examples of the generic questions include:

- What are some things you remember learning about science in other grades?
- Is there anything you dislike about science?

Following this survey, students would draw what a scientist looks like to them. This aligns with the "*Draw-a-Scientist Test*" (DAST) (Chambers, 1983). DAST evaluates students' conceptions of scientists while overcoming obstacles of oral and written tests by requiring students to draw their perception of a scientist. The drawings are then analyzed using specific indicators to determine if an image is stereotypical. The DAST indicators included the following: "(a) laboratory coat (usually, but not necessarily white), (b) eyeglasses, (c) facial hair (such as beards and moustaches), (d) symbols of research (scientific instruments and laboratory equipment), (e) symbols of knowledge (books and filing cabinets), (f) technology, and (g) relevant captions (such as formulae or taxonomic classification)" (Meyer et al., 2018, p. 2). The more indicators that are present in a student's drawing the more stereotypical the image. Usually, students drew a stereotypical white male as a scientist. Some studies showed when females were drawn, they were usually in secondary roles assisting a male scientist (Chambers, 1983). Research shows that the stereotypical male scientist emerged in students' images as early as second grade. Elementary and middle level girls held the opinion men were more likely to pursue a STEM career than females (She, 1998). Reasons for these perceptions stem from influences such as social and cultural factors, including those found at home and by parents, teacher, and peer views (Barton et al., 2001).

It was interesting to observe an overwhelming majority of my students had no interest in science and tended to draw white males for their scientist. Throughout the year, I would implement labs and hands-on explorations that engaged students. Students also seemed to enjoy drawing conceptual models to explain concepts they observed. They appeared to enjoy the labs; however, when they completed the post-interest survey in science, very few had acquired an interest in a science field.

The topic of science career interests and self-efficacy with students in grades sixth through eighth came to me during a sixth-grade science class. Students in sixth grade still seemed enthusiastic in science, and at this age, many had an interest in science as a career. In eighth grade, there was a vast difference in students' attitudes and interest in science. One student in particular Ximena (pseudonym) caught my attention. She was looking through her art portfolio, and one of her illustrations caught my attention (see Appendix G for the picture) as I walked by her table. In the picture, there was a young Latina girl (shoulders slumped over and her head dropped) being supported by strings attached to her wrist. Each of the strings were tied to a mask. When I asked her to explain the picture she said, the mask represented her struggles in understanding science and English Language Arts. She struggled with reading the labs, as well as understanding the science terms and concepts being taught. I wondered, "How could I as a teacher help students such as Ximena connect to science and reduce their struggles?"

I began probing to search for instructional "best practices" embedded in constructivist theory that would promote higher interest while raising students' critical thinking skills in science. This led me to begin my PhD in the Department of Teaching and Learning. Through this endeavor, I was introduced to sociolinguistic theory, cultural relevant teaching, and how they contribute to learning and equity.

During this process, an instructional practice called ADI and argumentation was introduced to me by the head professor of my panel. ADI and argumentation are grounded in constructivism, cultural relevant teaching, and sociolinguistic theory. Students are provided opportunities to communicate using evidence, present their findings to classmates for critique, and use multiple ways to explain a phenomenon. It was then I began attending professional development opportunities on using ADI as well as becoming a trainer in this methodology.

I began using the ADI earth science lessons in my classes. Students were introduced to the introduction labs that progressed toward the application labs. Through scaffolding and practice, my classroom atmosphere seemed to transfer from a teacher-led class to a student-led class. Students were actively engaged, working as a team to revise models and collect their data. It was of particular interest to me to see growth in students' writing and oral communication. Through the introduction of ADI, students appeared to be listening to one another, exchanging ideas, and using the peer critique prompts to provide detailed edits for peers to make their work stronger. However, even though students saw science as fun, they had no interest in pursuing it as indicated by my post-course survey.

There is literature that shows correlations between high academic performance and decreasing interest in science and engineering fields particularly the cut-off at the middle school level. It is well-known (as supported in the literature) that females and African American and Latina individuals are two underrepresented populations in STEM fields; when race and gender are combined, African American females and Latina females are severely underrepresented populations. Nevertheless, few studies have examined how performance and interest correlate for underrepresented populations in STEM (i.e., African American and Latina females particularly in sixth grade). Previous literature supports the impact of ADI on the academic performance (participation – authentic engagement – and ability to use evidence for argumentation – oral argumentation skills) of middle school students, in general. However, to date, the use of the ADI instructional approach has not been examined with this specific population which represents an underrepresented population in science fields. There is a critical need to identify ways to increase this population's (African American/Latina females) interest in science fields to increase representation in STEM fields to be more reflective of the population, in general. This gap in the literature between what is known and what is unknown for this population forms the basis of my study which is designed to address two research questions.

1.10 Research Questions

Research Question 1: In what ways did implementing and scaffolding the ADI instructional approach influence the classroom experiences, interest, and self-confidence for female students of color (i.e., non-White) in middle school (sixth grade) science?

Research Question 2: In what ways did using the ADI instructional approach impact female students of color (i.e., non-White) written argumentation skills (including peer review) and scientific voice in middle school (sixth grade) science?

Chapter 2: Literature Review

This chapter provides a discussion of the literature concerning the underrepresentation in STEM fields among African American and Latina females and how the intersections of race, gender, and identification impact females in science. Specifically, the declining interest in STEM fields among African American and Latina females and the importance of peer interaction in science education is discussed. Also included is a review of existing programs that generate interest in science for elementary, middle, and secondary African American/ Latina female students. This chapter concludes with a review of the literature detailing studies that have been conducted to examine the effectiveness of argumentation and ADI on engagement for middle school students. While such studies have been conducted for middle school students, in general, this review will show that studies have not been conducted with middle school girls of color (i.e., African American/Latina).

2.1 Theoretical Framework

Sociocultural Theory

Educational researchers in the 1980's witnessed discussions that detailed the importance of language in the science classroom (Lemke, 1990). For decades, researchers have considered the role and importance of language, conversation, and dialogical exchange in educational environments. Socio-linguistic theory defined learning as the social and cultural process bridging language and learning (Newton et al., 1999). Knowledge and learning are framed through social and cultural interactions (Lave, 1988). Understanding how learning is framed through social and cultural interactions draws upon the research of Lave (1988) and Vygotsky (1986). They described when language is utilized, the "cultural tools and ways of seeing" can enhance and stimulate the learning environment (Vygotsky, 1978; Lave, 1988; Lemke, 1990, p. 2). Teachers who draw upon their students' unique cultural and linguistic diverse experiences in their classroom as a resource for opening up ideals of scientific meaning and dialogue (Warren et al., 2001), contribute to students' learning though their active participation in discussions, writing, reflection, and making sense of scientific phenomena through the use of explanations and experimentation (Driver et al., 1994). Mastering an academic subjects-specialized pattern of language requires students to acquire the "norms" of the language unique to that subject area by being active participants through collaboration, writing, and talking.

Active student participation through talking allows learning to occur through argumentation, challenging viewpoints, and speculation (Newton et al., 1999). Argumentation and debate are two key language features contributing to developing a student's understanding of science. Social interactions can expand conceptual learning by way of students challenging other students' viewpoints, refuting claims, and presenting an alternative viewpoint. Using language, students' unique cultural experiences contribute to understanding in argumentation. Developing students' content knowledge requires students to practice and actively participate in the implementation of the "synaptic," linguistic, and practical components required in using the discourse range in structured classroom activities (Lemke, 1990, p. 81). Discourse range is the student's increased use of certain ways of using language that will lead to learning and conceptual understandings in science. The term synaptic refers to changes occurring in the brain according to the number of stimuli received during a learning process. Argumentation and debate support social construction of knowledge by making students' thinking visible and allow students to critically evaluate views held by their peers (Newton et al., 1999). This peer feedback informs the next steps of learning, bridging the gap between what students currently know and what they need to know.

Language and written communication provide the groundwork for teachers and students to learn the unique language and social skills necessary to engage in scientific dialogue. Actively acquiring and understanding new information through social discourse and previous experiences contribute to learning (Piaget, 1989). The socio-linguistic perspective described successful learning as outcomes that can be achieved by students when they were able to master the academic subjects-specialized pattern of language use by adopting the standard norms of the language in the academic subject (Lemke, 1991).

"Literacy is culture specific and socially constructed" (Langer & Applebee, 1987, p. 3). Social interactions and reasoning are two elements of language (Halliday and Mathiessen, 2004). Authentic scientific practice, as a form of collaborative inquiry, supports learning through engaging students in grappling collaboratively with tasks. Collaborative environments provide opportunities for students to use their home language and life experiences to gain understanding of scientific content and assist students in learning the language of science (Warren et al., 2001).

"In recent years the influence of constructivist thinking has required changes in teachers' stances toward classroom conversations. Inquiry-based teaching and collaborative groups in classrooms require that the teacher step outside the role of academic authority and take part in the "finding out" (Barnes & Todd, 1977, p. 126). Gallas (1995) describes classroom science talks as follows: "The children co-construct and build together ideas about seminal questions through real dialogue, and the teacher listens and reflects without immediately agonizing over what ought to be said" (p. 11). However, we must acknowledge that, even with this more open stance toward science discussions in constructivist classrooms, cultural differences exist. These need not be seen as a detriment to learning but as a resource on which teachers can rely to open up views of scientific meaning and discourse (Warren et al., 2001).

Empowering learners to be active in classroom dialogue and investigations supports a strong learning environment. Participation in discussions provides opportunities for students to articulate reasons for "supporting particular understandings as they attempt to justify their view" (Newton et al., p. 554) through speculation, arguments, and questions. Students' learning and cognition are supported through meaningful contexts as they challenge and offer various alternative views of topics. Conceptual understandings become clearer during collaborative involvement which leads to continuous use of scientific discourse by students and teachers alike, which are essential to understating science practice (Roth, 2002; Warren et al., 2001).

Toulmin's Argumentation Model

Toulmin's argumentation model (1958) provides a framework and serves as a guide for education research in argumentation practice, as well as supporting student- and teacher-lead discourse (e.g., Jimenez- Aleixandre et al., 2000; Drucker & Chen, 1998). This model describes the components and structure of an argument showing how they correlate with one another (Duschl, 2011). Toulmin's book *Uses of Argument* (1958) provided a means to assess the strength and quality of arguments. The components mentioned in Toulmin's books serve as the progression for arguments.

Toulmin (1958) described a model for a sound argument. His model identified the four types of statements that support an argument: *claims,* a conclusion that Toulmin (1958) expressed as "controversial in nature," *grounds/ data,* evidence that answers the one overarching question, "What evidence do you have to support your view?" (Brockreid and Ehninger, 1960, p. 44), *Warrants,* the bridge or reasons that justify the connection between the claim and data, and the *backing,* the justification for certain warrants (Jim´enez-Aleixandre et al., 1997). Not all the components are essential for argumentation. In fact, some components will be absent depending on the type of argument (Toulmin, 1958). Science educators and other core disciplines utilize Toulmin's Framework to construct arguments in education (Druker et al., 1996).

2.2 Underrepresentation in STEM Fields among African American and Latina Females

There continues to be an underrepresentation of females from ethnic and racial minority groups in the science fields (physical and natural sciences) despite decreasing achievement gaps (National Science Board, 2016). This underrepresentation is pronounced among women from African American and Latina backgrounds. There is a wide body of literature exploring African American and Latina female students' identity, engagement, and interest in STEM and STEM related careers (Kang et al., 2018). Factors that influenced adolescent female attitudes, interest, and identification in science included gender, culture, peers, family background, self-esteem, and life experiences (Archer et al., 2014). Studies also showed a correlation between students' self- perceptions and career interest and how they impacted students' feelings and self-efficacy in science (Bamby et al., 2008). Girls forming a sense of self through the lens of peer influence, identity, gender, and race due to missed opportunities may contribute to the underrepresentation of girls of color (African American/Latina) in STEM careers (Ladson-Billings, 2006).

The gap between women and men in science and engineering fields seem to rely on the belief held by gender roles, including a belief that there are masculine careers and feminine careers. For example, Simmons III (2020) found that undergraduate students held very specific gender beliefs about occupational roles such as nursing is for women and engineering is for males. These stereotypes were likely to affect career choices and subject preference.

Women have been well represented in both undergraduate and master-level programs in the fields of biological science and medical science programs (Kang et al., 2018). This is attributed to the content area of biology which is concerned with the nurturance and study of life (Jones et al., 2000). The Latino population's underrepresentation in STEM increases as they progress through K-12 schooling. In 2006, seven percent of Latino students received PhD's in Physical Sciences. Their total representation in occupations in physical science was four percent for the same year (NSF, 2010). These students were less likely to earn degrees in STEM, including undergraduate degrees in biology and life sciences (Young, 2005).

2.3 Declining Interest in STEM Occurring in Middle School

Alexakos and Antoine (2003) described how the intersectionality of gender and race can play an important role in students' interest toward science during the middle school years. Although academically successful in science, many females of color do not identify with STEM and often feel their contributions are not recognized. Gender and racial achievement gaps in science emerge during eighth grade, and by the tenth-grade female (Black and Latina) students' attitudes toward science were found to be increasingly negative (Alexakos & Antoine, 2003). Farenga and Joyce (1999) describe that the gender achievement gap may be socially influenced to by gender stereotypes as males are usually encouraged to engage in building models, fix objects, and read science related texts while females are more often pushed who lean toward life science topics and experiences.

The middle school years are a crucial time when students begin to focus on possible career interests and identity (Blackhurst & Auger, 2008). Personal behavior and interest are influenced through the interactions between the individual student and their environment (Lewin, 1938). Murray (1938) described how additional factors, such as personality and the external environment could affect an individual's behavior. Because of these influences, girls are not self-identifying as scientists which contributes to the underrepresentation of females (African American/Latina) in STEM fields which may give rise to them not feeling welcomed for who they are and what they can bring to STEM (Archer et al., 2013). Stern elaborated further by describing how the differences of an individual's perception, group perceptions, and the other observers in an environment impact the environment.

2.4 Science Identity

The research of Caroline and Johnson (2007) explored relationships between racial, ethnic, and gender identities and science identity development. They suggest there are three interrelated dimensions of science identity development: (1) demonstrating competence; (2) performing scientific practices; and (3) recognition as scientist by oneself and their peers (Caroline & Johnson 2007). Tan and Calabrese Barton (2007) argue identity appears from the limitations and resources available in a local setting. Science identity considers how women make meaning of their science experiences and how society structures reasonable meanings. Their study sought to understand the science experiences of 15 successful graduate and followed them six years later in their science career. An individual's science identity is both situational and persist over time and conditions (Caroline & Johnson, 2007).

In a study that focused on women's experiences as science majors in a predominantly white setting, Caroline and Johnson (2007) interviewed 13 women of color asking them whether they wanted to persist in science and why, and whether they felt successful in science, and how their ethnicity formed their experiences. What they found was participants in one group who received repeated positive recognition from the science community had stronger identification with research science. Women of color who could not form science identities for themselves felt their recognition was due to them being part of a marginalized group, rather than for their science achievements. Six of the 13 women fell into this category.

2.5 STEM Career Interest Survey (STEM-CIS)

To further assess interest and STEM career awareness among rural students, people of color, and middle school students, the Science, Technology, Engineering, and Math Career Interest Survey (STEM-CIS) was developed (Kier et al., 2014). The STEM-CIS is grounded in social cognitive career theory and is psychometrically sound (Kier et al., 2014). This survey is a predictor aimed to investigate factors that influence students' interest in STEM classes and careers. It also may inform researchers about STEM career interest, subjects, and careers and help raise interest in science and engineering fields at the middle school level (Hill et al., 2010).

2.6 Classroom Environment Influence

There have been countless studies on the classroom environment and how it affects students' emotional and learning outcomes. Walberg and Anderson (1968) developed the Learning Environment Inventory (LEI) which was used to classify certain components of an environment. The environment was classified into relationships, personal development, and system maintenance change (Moos, 1974). This would lead Moos (1979) to focus on the Classroom Environment Scale (CES) which would connect his work to the school environment. The research of Wubbels and colleagues would further examine the classroom environment by examining the interactions between teachers and students using the Questionnaire on Teacher Interaction (QT) (Fraser & Walberg, 1968).

Fraser and Walberg (1968) used the Individualized Classroom Environment Questionnaire (ICEP; Fraser, 1990) that first focused on student centered classrooms. These surveys investigated the relationships between students' cognitive and affective learning outcomes and students' perceptions about their beliefs (Fraser, 2001). These studies showed the relationships between students' classroom environment and their affective and cognitive outcomes.

Other studies conducted focused on the relationships between students' cognition and affective learning outcomes and students' perceptions of psychosocial characteristics of the classroom environment (Fraser & Fisher, 1982). The interactions that occurred in the classroom environment were further explored using the Individual Classroom Environment Questionnaire (ICEQ; Fraser, 1980). Other surveys developed to research the interactions in learning environments included the Science Laboratory Inventory (SLI; Fraser et al., 1995), the Constructivist Learning Environment Survey (CLES; Kim et al., 1999), Test of Science- Related Attitudes (TOSRA; Fraser, 1981) and the What Is Happening In This Class? (WIHITC; Anderson & Kim, 2006). These studies have shown that learning outcomes are affected by students' classroom perceptions, in relation to students' past experiences.

2.7 Collaborative Classroom Environments

Inquiry activities that required students to be interdependent held students accountable for sharing information gathered, so when one student benefited the entire group benefited (Colburn, 1998). Brewer and Daane (2002) described the science classroom environment that provided high social interactions encouraging each student in a group to participate equally with their peers. Students' sharing of ideas, asking questions, and participating in dialogue contributed to their learning success and increased interest in the content. Students' interactions and interest increased when students competed with other students to solve a problem (Brewer & Daane, 2002). The competitive component and involvement of teacher questioning heightened motivation levels in students. The involvement of the teacher set in motion students' curiosity, pushing them to research topics in the content area in greater depth (Krajcik et al., 1998). This is supported with three techniques including "Abell's (1999) four questioning practices, Colburn's (1998) reflection upon the impact of questioning during inquiry, and Dalton and Morocco's research of inquiry-based practices among students with learning disabilities" (Wolf-Fraser, 2008, p. 4). Teachers' use of questioning, student exploration, and reflection have been shown to assist students developing new ways of learning (Beisser & Gillespie, 2003). The crucial point of students engaging socially is to ensure equal opportunities for all students (Dalton & Morocco, 1997).

In another study that focused on middle school students' interest in STEM careers, STEM classes used two instruments: the STEM Semantics Survey and the STEM Career Questionnaire (Tyler-Wood et al., 2010). This study focused on 12 items that measured students' awareness of STEM careers and their interest in pursuing classes that would lead to a STEM career, and students' personal interests in pursuing a STEM career. A 7-point Likert scale was used to score each subject area in STEM careers from "fascinating (1) to mundane (7)" (Tyler-Wood et al., 2010, p. 3). Even though both surveys were not grounded in a theoretical framework, the results showed students' interest in STEM increased following implementation of an after-school STEM program that was designed primarily for low-SES students to increase their awareness of STEM careers, engage the students in STEM through emersion experiences, and expose the students to STEM professionals through Skype who represented their same minority races. In fact, as part of this after-school program, students were allowed to maintain contact with the STEM professionals through Skype.

Middle school peer interactions have made tremendous impacts on student's science interests, science encounters, educational values, and outcomes (Furman & Buhrmester, 1992). The term peer refers to social networks and friends located in neighborhoods, schools, and classrooms. Peer influence is particularly strong in African American/Latina youth (Clark & Watson, 1995). Students' identities are strongly influenced during the middle and high school years from their peers (Kang et al., 2018). For example, peers can influence a person's attitude toward the enjoyment of science, attitudes about science careers, and courses taken in science (Simpson & Oliver, 1990). Researchers found a strong correlation that increased during adolescence between friends' attitudes about science and one's own attitudes about science that often transferred into higher education (Talton & Simpson, 1985).

Kinny (1993) found that young people wished to avoid negative stereotypes and labels associated with STEM careers, such as STEM being for old white males, men only environments, and the perception that STEM careers are boring. Other barriers for the underrepresentation of African American and Latina females in science were low classroom expectation by teachers and "not wanting to act White" (Belluck, 1999). Inaccurate stereotypes and barriers were found to begin as early as elementary school where students commonly drew scientists as white men in a "draw a scientist" assessment (Capobianco et al., 2011). Other labels associated with students who take interest in science include labels such as geeks and nerds (Betz, 1997). These stereotypes continue to transfer to middle and secondary STEM. Many of the students held an image of an engineer as males who were mechanics, fixing cars, and repairing things such as electronics (Capobianco et al., 2011). Technology careers were viewed by students as people who worked in isolation with few social skills (Thomas & Allen, 2006). These stereotypes are not appealing to students especially female students.

High achieving African American/Latino students in a merit-based STEM program were isolated with other high achieving students who enjoyed science and engineering and established networks with other high achieving underrepresented populations creating positive views of STEM (Fries-Britt, 1998). The study showed having other students who were interested in STEM fields allowed them to blend in and excel. This is the opposite of placing students in mainstream classes where the pressure to fit in often decreases students' interest in science (Fries-Britt, 1998).

2.8 Student Interest and Motivation

Research on student interest and motivation has been conducted based on an interest theory perspective (Renninger, 2009). Students' knowledge in content areas "influences their interest, and the content area influence students' knowledge" (p. 3). Teachers can assist and develop students' interest in science by "providing support and possibilities that offer challenges, ensuring students obtain content knowledge needed to pose and solve questions in the content domain providing models of how to connect knowledge, and developing students' skills to recognize and make use of opportunities and resources" (Osborne, 2011, p. 19).

There is a mutual relationship between students' interest and motivation and students learning and achievement. Two types of interest described by Hidi and Renninger (2006) included situational interest and enduring interest. The students' situational interest is described as short term and teacher managed which can impact student engagement with learning particular topics in academic areas (Hidi & Renninger, 2006). Students' interest has been shown to influence and be a predictor of students' interest in career choices and subject selections (Boyd et al., 2007). Situational interest can be influenced and manipulated by instructors. Lamb et al., (2012) described science teachers who were creative, innovative, and created highly exciting lessons positively influenced student learning and interest. This is due to situational interest being temporary, "environmentally activated, and context specific" (Osborne, 2011, p. 19). High levels of engagement positively influenced students' situational interest and their learning.

Students' self-concepts, past achievement, perceived difficulty in a subject area, and the usefulness of a subject area (e.g., science and math) were four factors that influenced students' relationships in their interest, knowledge, and achievement (Hay & Simmons, 2011). Students interest may be decreased if they view school to be in conflict with their interest in their peers (Hay & Ashman, 2003).

Instruction that had low engagement and was teacher directed tended to contribute to students' lack of interest and low self-beliefs in a content area and was attributed to students' lack of understanding and inability to keep up with the pace of the content (Hattie, 2009). This was also attributed to students being bored and unchallenged (Bridge et al., 2006). Schiefele and Csikszentmihalyi (1994) described a correlation between students' interest and learning. High levels of students' engagement were positively related with achievement academically, deeper levels of cognitive processing, the use of self-regulatory learning strategies, and providing opportunities for students input on the worth of their learning encounters (Schiefele & Csikszentmihalyi, 1994). Students' level of interest also impacted them engaging further in opportunities that allowed higher engagement with their objects of interest.

2.9 Self-Efficacy

Beliefs and academic achievement are often used to investigate students' self-concept in academic areas. For example, more general responses such as "science is my favorite subject" are often recorded to measure students' beliefs. The more generalized the students' response, the lower the correlation with the students' academic measure

(Hay et al., 1998). Beliefs and students' self-concepts are past-oriented tasks where students reflect on past experiences rather than considering future achievements (Hay et al., 1998). Research has described mutual relationships between motivational and self-system variables. These include self-regulation (Hidi & Ainley, 2008) self-concept (Nieswandt, 2007), and students' achievement goals (Hullerman, 2008). Unlike students' self-concepts that are past-oriented, self-efficacy beliefs are considered future oriented because of its connections with students' task completion, students' engagement, time on learning task, and their self-beliefs regarding their capabilities (Bandura, 1997). Self-efficacy is defined as "beliefs in one's capabilities to organize and execute the course of action required to produce given attainments" (Bandura, 1997, p. 3). Self-efficacy is assessed through test items or self-assessments using Likert-type surveys that specify students' level of confidence achieving specific academic tasks (Bandura, 1997). Robbins et al. (2004) described self-efficacy among all the psychosocial and self-system factors to be an effective predictor of academic achievement. Measuring self-efficacy in science was a significant predictor of achievement showing a correlation between students' levels of interest and their levels of self-efficacy.

2.10 Current Programs Designed to Increase Students Interest in STEM Careers

Learning communities such as STEM SISTA and I AM STEM provide young ladies opportunities that "validate the strengths, experiences, and abilities, that girls of color bring to STEM classrooms and the workplace" (Ashford et al., 2020, p. 28). Cultural and linguistic diversity does enrich the learning environment and the social interactions among students, especially when the teacher uses students' existing knowledge and non-traditional approaches in science (Hudicourt-Barnes, 2003). The federal government has funded over 200 programs with the help of the National Science Foundation and National Institutes of Health focused on increasing the number of underrepresented students pursuing STEM related fields, and improving programs in science, technology, engineering, and math (U.S. Government Accountability Office, 2005). These programs focus on moving underrepresented populations in elementary through high school by affecting student achievement and graduation rates.

Creating equitable spaces that encourage and increase positive self-perception in science includes programs such as after school programs and community outreach programs. In order for these programs to acquire students' interest, the teachers must have a strong background of cultural relevance (Ashford et al., 2020). Evaluating statistical data and test scores only point out the dissimilarities among students, doing little for teachers who want to gain an understating about the students and the barriers students encountered in the classroom (National Science Foundation, 1996). Teachers need an understanding of language, race, social class, gender, and religion. Integrating gender and culturally relevant approaches that connect science in school to the lives of girls at home and their community as scientific can contribute to positive experiences of how girls view science. "To have knowledge of another culture does not mean to be able to repeat one or two words in a students' language, nor is it to celebrate and activity or sing a song related to their culture. To acknowledge and respect is to be able to understand and apply this knowledge to everyday classroom activities" - Lizette Roman (Nieto, 1999, p. 4). In fact, Frierson et al. (2002) recommended the following strategies for making programs and their evaluation culturally relevant: "(1) women experts in science fields (women of color) with shared lived experience, (2) evaluators that engage critical stakeholders, (3) multiethnic evaluation teams that magnify the voices of historically underrepresented audiences, (4) evaluation teams that consider experiential findings as concrete truth, and (5) evaluators that maintain openness to new approaches" (p. 28).

Researchers stress the importance for changes to be made in the way teachers teach science and in what science curricula students are expected to learn. Specifically, suggestions have been made for teachers to modify their goals, science content, and instructional practices to make science courses more engaging and inviting for all students, particularly women and ethnic minorities (Banks, 1999). Two examples of these changes included the "I AM STEM" and the STEM SISTA (Sisters Informing Sisters about Topics on AIDS). These programs were spaces created where young girls of color could embrace their strengths. "Spaces are defined by the individuals who come together for particular reasons….and are shaped by the rules and expectations for participating together" (Barton, 2003, p. 39). The *Detroit Area Pre-College Engineering Program* (DAPCEP) is another program that focuses and seeks to motivate African American/Latina females not only to do well in STEM related classes, but prepares them for STEM related careers (Hill, 1990). DAPCEP prepares the students for careers by cooperating with corporations, non-profit organizations, and universities such as IBM, University of Michigan, Black United Fund, and The National Science Foundation (Simmons, 2020). Not surprisingly, students of all ethnicities enrolled in DAPCEP schools tended to outperform students who were taught using traditional instructional models on science tests. The DAPCEP reform model proved to be effective among urban (African American and Latina) school communities, captivating students interest levels enabling them to become leaders of their own learning and encouraging students to think of their science classroom as part of their community (Berger, 2013).

2.11 Argument Driven Inquiry

In the learning environments such as the programs highlighted above, females of color share cultural experiences such as language, values, ways of communicating and beliefs (American Evaluation Association, 2011, para 9). Programs such as these provide chances for young girls to meet and interact with female STEM role models and receive mentoring using intervention strategies, and culturally responsive strategies targeting their interest. These opportunities allow girls of color to see how science impacts their own experiences at home, school, and their community. Students are offered the opportunity to be active participants in hands-on experiences which involve them in deep science enrichment, authentic instructional practices, and innovative opportunities in their community and school, allowing them to become active members of their local area and make meaningful contribution to their local neighborhoods. Collectively, these programs focused on generating interest in STEM fields by bringing in local professionals who were of the same race and gender as the students, gave a voice to students who are traditionally underrepresented through the structure of classroom activities that used science emersion experiences, and incorporated the use of argument-driven discussions.

The Argument Driven Inquiry (ADI) template can be used by teachers to design authentic laboratory investigations. (Sampson et al., 2009). The term authentic refers to lab activities that engage students in scientific practices such as argumentation and leads them to a better understanding of their abilities to understand science concepts (Sampson et al., 2009). Several studies using the ADI approach have shown increases in students' level of engagement, scientific writing, and sufficient scientific explanations after engaging in ADI. Another study working with middle and high school students (Sampson et al., 2012) showed increased results in students' engagement, writing, and crafting arguments. This study showed a meaningful shift in what students can do using the ADI instructional approach; further, students' abilities are improved when they learned how to generate and develop a claim, carry out an investigation, generate data, and write using evidence.

2.12 Engagement

Talk enables students to develop meaningful understandings of science and scientists' way of thinking (McCarthy, 1993; Lemke, 1990). The ADI instructional model is grounded in socio-constructivist theories of learning focused on classroom discourse occurring from different student viewpoints in elementary and middle schools. In a semester long (18 weeks total) study, Sampson et al. (2009) found the level of participation (student engagement and communication) in groups became more balanced during the 15th lab of the intervention using the ADI instructional model. Students' participation increased among individual students. The increased engagement was noted from group members discussing ideas, being more willing to talk with one another, and evaluate and revise their ideas as the intervention progressed. In a similar study, Sampson and Clark (2007) also noted an increase not only in student engagement but in students challenging each other's ideas and claims. When 168 students in another study (Sampson & Clark, 2007) had previously experienced minimal opportunities that allowed them to engage or experience lab instruction in using the ADI instructional approach were given the opportunity to participate in ADI, not only did the level of engagement increase but their collaboration with other students began to contribute to their learning and understanding of science content (Sampson & Clark, 2007). After students participated in the ADI intervention, students' discussions were more in depth (Sampson et al., 2012). For example, students did not reject or accept explanations from their peers, but rather produced a more in-depth discussion of the core science issues involved in the problem. The study showed students were more engaged and willing to talk about, evaluate, and revise ideas. Most of the comments made by the students were exposition (i.e., proposing, clarifying, or justifying one's own idea). After the intervention, students were observed in the 15^{th} investigation adopting more rigorous criteria to distinguish between an explanation and justification of their claim (Sampson et al., 2012). Sampsons et al. (2012) data showed students relied on rigorous criteria 43% of the time and informal criteria 53% of the time.

2.13 Writing

Students' written argumentation skills improved especially in the quality of evidence and an increase in students' written reasoning (Sampson et al., 2012). Using ADI in another study (Sampson & Clark, 2009) showed an increase in the average score of students' written arguments by 158% at the end of the intervention among 160 high school students. Before the ADI intervention, students were scoring an average of 3.6 points out of 12 points for their science written lab reports. After the ADI intervention, the average score was 9.3, representing an increase of 158% in the students' written response scores in the average overall quality of the written arguments produced by these groups. In addition, after participating in 15 ADI lab experiences, students were able to construct a higher quality of argument in the areas of adequacy, conceptual quality of the explanation, and the quality of evidence and reasoning (Sampson et al., 2009). The data also indicated that students engaged in arguing from evidence that was reflective of the discipline of science after the intervention. Significant learning gains were made by students in writing, among other areas. Thus, post-intervention data showed students abilities to generate higher level written arguments, more sufficient explanations, and use specific evidence in their reasoning to support their ideas. In a similar study (Sampson et al., 2012), content assessment gains following the ADI intervention included students writing of scientific ideas and crafting explanations of different science scenarios. The authors concluded that writing such a response with a high level of structural quality improved their understating of science content and their ability to write in a scientific manner.

2.14 Summary of Literature Review

Students should be actively interacting with, discussing ideas, and sharing their learning with others so that they can develop the skills needed to read scientific articles in the popular press with understanding and to discuss the soundness of the conclusion presented (Driver et al., 2000). Revising instructional practices to meet the learner where they are intellectually through scaffolding and modeling promote science literacy by harnessing students' strengths as instructional starting points, providing creative and nurturing collaborative environments, and setting high behavioral expectations (Morrison, 2008). Scaffolding allows students to build on their prior experiences and move forward toward more difficult knowledge and skills (Ladson-Billings, 2009). Equitable learning experiences exist when school programs value and respect students' home experiences, communicate effectively, and provide instructional resources that support science learning (Lee & Buxton, 2011).

The review of the available literature proposes that both content and understanding the standards of scientific argumentation can affect how students participate in argumentation (Grooms et al., 2018). Some of the research reported students struggle when attempting to engage in argumentation due to a lack of understanding of the nature of argumentation occurring in other circumstances (e.g., home, school, non-science disciplines). The research supports teachers supporting students' understating of the criteria and structures of argumentation that are used to judge the quality of an argument in science and how to propose, support, and evaluate claims during argumentation.

Argument Driven Inquiry (ADI) is one instructional approach that allows students to develop an in depth understanding of the world and local community around them and gives students' voice value through communication (Eduran & Jimenez-Aleixandre, 2008). Students learn to take an active stand for change, think critically, and engage in authentic discourse. Student learning and academic success depends on teachers having high expectations for their students' learning without compromising any student's cultural identity (Johnson, 2010). ADI allows students the opportunity to participate in discussions with others; draw on their own expertise; elaborate, expand, and consider their own ideas; and gain exposure to the habits of mind exhibited by scientists and engineers (Sampson & Walker, 2010). This literature review shows that while studies on the benefits of the ADI instructional approach have been conducted for middle school students, in general, studies have not been conducted with middle school girls of color (African American/Latina). This gap in the literature supported the need for this study of the effectiveness of ADI on middle school girls of color’s classroom experience, interest, and self-efficacy in science, written argumentation skills, and scientific voice.

Chapter 3: Methods

This chapter starts with an overview of the methodological approach and the research design used for this qualitative study. The research questions are specified. Following this section is a description of the setting, the participant population, and the selection process of the participants. Following the selection process for the participants is an explanation of the researcher positionality and the protection of human subjects, including parental consent and student assent. Next is a description of the data collection procedures, including the stages of the Argument Driven Inquiry (ADI) instructional approach that constituted the focus of this study. Then, the instruments and materials that were used in this study are explained in detail, including the psychometric properties (e.g., reliability and validity) of the instruments. This is followed by a description of the data coding process and the analysis plan, detailing how the data were coded and analyzed. This is followed by an overview of the first nine-week plan describing the weekly goals and how students were introduced to the ADI instructional approach. Finally, a timeline of the implementation of the instruments is provided.

3.1 Methodological Approach and Qualitative Research Design

Qualitative methods are intended to give an in-depth holistic understanding of a population by ensuring that the knowledge gained is representative of the population from which the sample was drawn (Cresswell & Plano Clark, 2011). The goals of this study were aligned with Creswell's qualitative goals (Cresswell et al., 2007). To understand the experiences of four sixth grade girls of color, the investigator implemented a case study research design. Merriam (1998) defined qualitative case study as an "intensive, holistic description and analysis of a single entity, phenomenon, or social unit" (p. 27). As a research tool, a case study is useful when the researcher needs to understand the specific group of people in great depth. The qualitative case study provided a better basis for understanding what occurred with each participant personally; this qualitative case study research design was essential for understanding the students' own words to achieve a deep understanding of their experiences. Using the student's own words developed understanding from the student's point of view and glimpse into the student's everyday life providing rich data and information within this group. Such an approach provided the appropriate methodology for exploring an important subpopulation of individuals in a middle school science setting.

The following research questions guided the qualitative case studies.

Research Question 1: In what ways did implementing and scaffolding the ADI instructional approach influence the classroom experiences, interest, and self-confidence for female students of color (i.e., non-White) in middle school (sixth grade) science?

Research Question 2: In what ways did using the ADI instructional approach impact female students of color (i.e., non-White) written argumentation skills (including peer review) and scientific voice in middle school (sixth grade) science?

3.2 Description of Setting

This study took place in an inner-city urbanized public middle school in the Southeast United States. Located in the middle of an urban community, the school was surrounded by small businesses, restaurants, and varieties of new and traditional homes. Built in the 1970's, the school had a faculty make up of 60 teachers. The middle school from which this sample of students were drawn was a racially/ethnically diverse school middle school in a Southern city. The school feeds into a high school with an International Academic Magnet.

3.3 Description of Participant Population

As described above, the study took place in an urban public middle school in the Southeast inner-city school. Sixth grade students comprised 50% of the student body, and 50% in the school are from low socioeconomic backgrounds. A profile of the school's 812 students indicates diversity in race/ethnicity: 43.7%, Caucasian, 38.4% Black, 6.9% Latino/a, 5.9% two or more races, 3.4% Asian, 1.1% Native Hawaiian or other Pacific Islander, and 0.5% Native American. Further, 48.6% of the students received free/discounted lunch. In addition, 45% of the students scored proficient in math in the year 2018-2019 school year (which is equal to the state's average of 45%), and 42% of the students achieved a score of proficient whichn reading /language arts (which is lower than the state's average of 45%). The school placed in the state's bottom 50% of all schools for overall test scores. The student teacher ratio was 13:1 which is lower than the state level of 15:1. It is a state-wide requirement that all sixth-grade students take a general science curriculum. In the first semester of this sixth-grade science course, instructional units focused on the conservation of energy.

3.4 Selection of Participants

There was a total of four female students in sixth grade science classes representing one African American and three Latina females with low socio-economic status ranging in ages from 11-12 years. Thus, the criteria for eligibility for participation was as follows: (1) female, (2) African American or Latina, (3) sixth grade, and (4) low socio-economic status, defined by their qualification to receive free/reduced lunch. Inclusion criteria was that the female students were in regular education classes and was in one of five sections of general science that will be focusing on physical science during the data collection period. Exclusionary criteria were applied to special education students whose IEPs included diagnosis related to cognitive impairments who were all mainstreamed. The researcher used purposeful sampling procedures to select the female participants to represent each race (i.e., African American and Latina) and interest in science levels (i.e., low and high). The reason for purposeful sampling was to select information-rich cases whose study would bring clarity to the questions being investigated. In the study, there was one female student who was African American with low interest in science, two Latina female students with low interest in science and one Latina female student with a high interest in science. Interest in science was determined by ratings on an instrument that assessed their interest in science (explained in the instrument section) completed by the students at the beginning of the school year.

3.5 Researcher Positionality

I was the researcher in this study and was also the classroom teacher for the students who participated in the study. Being the teacher of the students in this study could have had a positive or negative impact on the student participants. Specifically, the students had a familiarity with me as their teacher. If they were comfortable with me, then they could have been more likely to be honest with their responses during the individual interviews and the focus group. If they were not comfortable with me or if they wanted to please me, they might not have been as honest in their responses in order to provide information that made my teaching seem all good rather than providing any negative feedback. For this reason, I used a triangulation of various data sources (e.g., written work, individual interviews, focus group, and questionnaires) that helped in making inferences about the students' experiences in science. In addition, several data sources were used to form the basis of the interviews which helped students be more honest in their interview responses: ratings on science interest and self-efficacy questionnaires completed at the beginning of the school year as a regular part of classroom procedures. Another potential problem with my being the teacher and researcher, was bias in my grading on the ADI rubric and in coding the transcriptions. To mitigate potential bias in the grading, the students' academic performance was measured by the repeated-measure teacher team-completed ADI Rubric for each individual student for each lab and their written lab reports. In order to reduce bias in coding participants' interviews and their peer-to-peer lab interactions, two independent coders coded the transcribed data independently of the researcher.

3.6 Protection of Human Subjects

Parental consent was obtained through active parental consent in which a letter was sent home via email and directly with the students to let the parents know that a research study was being conducted in the classroom, and that their daughter was being invited to participate because she is a female of color (see Appendix A: Parental Consent and Student Assent Form). This letter also accompanied a phone contact informing parents about this study and the invitation for their daughter to participate. The phone contact provided an opportunity for me to explain the research study and allowed me to answer parents' specific questions. As part of my regular classroom procedures, within the first week of the school year, I administered two student-completed instruments: the Germann Interest in Science Survey and the Middle School Self-Efficacy in Science Survey (see a complete description of these instruments in the Instruments section). I scored these and identified eligible female students of color as candidate participants for this study that represented both high interest in science as well as low interest in science. I sent home the parent consent form to six eligible female students of color (to allow for less than 100% return rate for parental consent). Parents had the option to consent or not to their daughter's participation (see Appendix for Parental Consent form which includes Student Assent). Students of parents who provided consent had the option to provide written active assent or not to provide assent. I extended the invitation to participate to six students via email as well as a phone contact, with the hope that at least four signed consent forms would be returned. All six forms were returned, allowing me to select the four that best represented that eligibility criteria, particularly the representation in diverse scores (high and low) on the interest in science measure.

3.7 Data Collection

The entire study took place during the first nine-week period of school. It was during the first week of school that two student-completed surveys were administered to all students as part of the regular classroom procedures: one to ascertain their interest in science and the other measured their self-efficacy (or confidence) in science. Student ratings were used to select the four female students of color that participated and represented varied levels of interest in science (i.e., two with low interest ratings and two with high interest ratings). After parental consent and student assent were obtained, a combination of three semi-structured individual interviews, one focus group interview and classroom observations were conducted. Participant observations involved my systematically experiencing and intentionally recording in detail many aspects of situations as I constantly analyzed my observations for meaning and personal bias (Glesne & Peshkin, 1992). I used the observations as a means for listening to participants and observing them in their natural settings; therefore, observation data in this study was collected from the students' academic setting (e.g., science labs), interviews, and written science lab checklist.

To understand the participants' experiences in science, I took the students through all eight stages of ADI and collected data from the specific ADI stages that allowed for the greatest amount of student collaboration and discussion: Stage Two (Developing a Method to Gather Data), Stage Three (Develop a Tentative Argument), Stage Four (The Argument Session), and Stage Seven (The Double-Blind Peer Review). These ADI stages allowed me the opportunity to experience and intentionally record in detail the participants' interactions with one another. Stage Two engaged participants in developing a method they used to gather data needed to answer the guiding question. This stage involved participants carrying out their method as a collaborative group. The third stage of the instructional model allowed participants the opportunity to develop a tentative argument in response to the guiding question as a group. It also required each group member to make sense of the data, measurements, and observations collected during the second stage. Stage Four of the instructional model was the argument session. This stage was highly interactive and allowed participants to share and evaluate the merits of competing ideas (Duschl, et al., 2007; NRC, 2011). Stage Seven was the double-blind peer review. In this stage, each participant submitted four typed copies of their investigation. These copies did not have the participants' names on them, but rather an identification number to maintain anonymity. Each participant received four different reports from other members of the class and the peer review rubric. The rubric served as a guide that listed specific criteria to be used by the group as they cooperatively evaluated the quality of each investigation report. Participants also provided written feedback about how to improve the report. This stage provided the participants with an opportunity to read good and poor examples of the science reports.

The participants' interactions during the labs with other students were recorded to ascertain peer-to-peer interactions. The participants were not in the same group and interacted with other classmates. Specifically, I looked at the interactions occurring during the following steps of the ADI instructional approach: Stage Two: Designing a Method and Collecting Data, Stage Three: Data Analysis and Development of a Tentative Argument, Stage Four: The Argumentation Sessions, and Stage Seven: The Double-Blind Peer Review.

Three in-depth formal individual interviews were conducted and allowed me an opportunity to interact with the students while also observing their interactions in science classes for an extended time documenting their interactions with other students and who interacted with whom. See Appendix B for the Individual Interview Questions. These observations and interviews along with the students' final written papers provided a more comprehensive picture consisting of open-ended questions designed to explore a few general topics in order to gain information directly from the participants and develop insight on how using the ADI instructional approach influenced the students' interest, self-confidence, and their personal experiences through science interactions. Formal individual interviews occurred once a month (August, September, and October during the course of a school day) with the first interview focusing on getting to know the students and building relations within the groups. I engaged them in more focused research questions across the interviews over the nine weeks. The questions from the individual interviews were meant to provide details for an overall question of how girls of color in sixth grade experienced science, and specifically how the ADI instructional approach impacted their experiences. This allowed me the opportunity to examine important complex and interwoven contextual factors that lead to marginalization of girls of color in science. Using the participants' voices and experiences provided a deep insight into the students' experiences in science when the ADI instructional approach was used.

At the end of the nine-week period, I conducted a focus group with all four participants (see Appendix C for the Focus Group Questions). This focus group served the purpose of generating discussions among the four participants to see what their shared experiences were and where their experiences differed.

3.8 Instruments and Materials

Attitudes Toward Science in School Assessment (ATSSA)

Germann defined attitude as “affect for or against science in school” (Germann, 1985, p. 7). See Appendix D for a copy of this instrument. The ATSSA was used to assess students’ attitudes toward science before and after the intervention. It was a 14-item survey questionnaire Likert scale with five response options ranging from strongly agree to strongly disagree. Germann (1985) described that the 14 items that were used in the final instrument (reduced from 34 items) had the highest intertotal correlations because of the way they fit the desired construct of the general attitude toward science. All 14 items were retained to maximize reliability. Descriptive statistics of four studies were used to determine the reliability and validity (Germann, 1985). In this study, this first instrument was given at the beginning of the school year (pre) and end of the first quarter (post). Responses to this instrument were used for three primary purposes. First, they provided guidance in choosing participants (based on high and low pre-scores). Second, they were used during the individual interviews as prompts to solicit additional information from the participants about why they indicated that they either were or were not very interested in science. Finally, responses were used during the data analysis as a way to determine how much, if any, participants’ interest in science changed as a result of the ADI instructional approach.

Middle School Self-Efficacy Scale

The second instrument was given at the beginning of the school year (pre) and the end of the first quarter (post). See Appendix E for a copy of this instrument. The Middle School Self-Efficacy Scale was used to determine students’ self-efficacy in science (how well they think they could do science or their confidence in doing science). Similar to the Germann Science Interest Instrument, this Middle School Self-Efficacy Scale was used during the interviews to obtain qualitative information about how ADI influenced their responses to these scales, and responses were also used to determine any changes in self-efficacy in science that occurred from pre- to post-, indicating changes due to implementation of the ADI instructional approach. This instrument contained a total of 12 items that were originally adapted from the CDMSE (Career Decision-Making Self Efficacy Scale) for middle school students (Taylor & Betz, 1983).

Individual Interviews

Three in depth formal interviews were conducted in the school's media center with each of the participants in this study (individually) and me (as the researcher). Each individual interview took approximately 15 to 20 minutes per student. The first interview was conducted the first week of school. The second interview was conducted the fourth week of school, and the third (final) formal interview took place on the ninth week of the first quarter. These interviews consisted of open-ended questions designed to explore the participants' science experiences during the ADI lab investigations. Such questions helped me to define the boundaries of the study and focus the investigation. Examples of unique questions from the first interview included the following: "How would you describe your previous experiences in science classes when you were in elementary school?" "In elementary school, did you have opportunities to collaborate with your classmates or work in groups? How did you feel in this process?" "What, if anything, are you looking forward to the most this year in science? What is something that concerns you about science this year?" The second individual interview was designed to have the students explain their responses to the interest science survey and the self-efficacy survey that they completed at the start of the nine weeks. Sample unique questions from interview two included the following: “On the survey you indicated science is (fun/not fun). Please explain why you think this.” The second interview also involved showing the students their first draft of their first lab report and then their final version: “I’d like you to look at these – first and final versions – of your FIRST lab report (name the lab). What changed and why? (This helps answer both research questions). Please talk out loud about how you have learned and improved (or not) and why.” The third individual interview was designed to ask about comparisons between their pre- and post-survey responses: “I am comparing your responses on the final survey and your first survey. You said science was (fun/not fun), and on the first survey you said science was (fun/not fun). Please describe what influenced your answer.” This interview was also designed to understand how they felt about the actual ADI instructional approach. Unique sample questions included the following: “What was it like to design your own experiment and collaborate with your peers during an investigation?” “Please describe what it was like to participate in a blind peer review. Do you think this helped your understanding and writing skills in science?”

Focus Group Interview

The participants took part in one 40-minute focus group session at the end of the first nine weeks in the media center. The goal of this focus group was for the participants to offer their perspectives and share their science experiences past and present. The focus group followed the following sequence opening two minutes, introduction two to three minutes (focus on topic), ice breaker (team building activity two through three minutes), question and answer 15 minutes (clarifying probes), and closing two minutes. During the introduction the participants were introduced to the topic in a means to get them comfortable with the discussion. The icebreaker allowed participants the chance to get to know one another and feel comfortable. The exploratory questions and answer segment was designed to get to the heart of the participants' experiences in science. The closing provided the opportunity to see if any angle was missed during the discussion; for example, "Is there anything else anyone would like to say about science?"

3.9 Data Coding

The process of coding and analyzing all documents was informed by the works of Miles and Huberman (1994). During coding, data such as audio recordings, transcripts, and student presentation boards were closely examined to identify similar patterns, themes, recurring ideas, or phrases, relationships, and commonalities or differences among segments of data. Scanning and labeling the data with codes allowed me to view the data from multiple points of view. The initial coding stage was followed by an examination of single instances in the data collected, where meaning was drawn from the data without looking for multiple instances. Coffey and Atkinson (1996) indicated that using this strategy moves the data analysis process toward interpretation as "coding is thus about breaking the data apart in analytically relevant ways in order to lead toward further questions about the data" (p. 31).

The next stage of the data coding and analysis involved examining the data through a layout of diagrams of the codes in order to explore the composition of each coded data set (Huberman & Miles, 1994). A layout such as this helped structure the information into a compact, accessible format to better analyze the data. The next phase of the analysis, the establishment of patterns and the search for consistency between two or more patterns or themes within the data, was determined. Little by little, generalizations that explained the consistencies in the data emerged. To conclude the analysis, these generalizations about the participants' experiences were contrasted with current published literature on girls of color and their experiences using the ADI instructional approach.

Along with transcribing interviews with the participants, the review of formal and informal documents provided a clear picture of the students' experiences and interest in the science concepts and content being examined in the labs. The documents that were reviewed included samples of their written work, specifically, this included all of their presentation boards containing graphs, analyzed data, justification of data and the final versions of their lab reports.

In this study, two doctoral-level school officials (two administrators) in the middle school who were familiar with Qualitative Inquiry methods assisted me (as the researcher) with verification of the coding and analysis by testing meanings drawn from the data for their soundness and confirmability. I provided the two coders with three training sessions. The approach to training the coders was to scaffold them toward independence. The first session was an orientation and explanation to the study. I provided coders with an overview of the study and introduced them to the research questions, followed by a discussion of the coding instructions; I sent the coding instructions to each coder prior to the first training session. The second training session focused on a guided group practice of coding one of the participants recording. The coders listened to a segment of the participants' discussion and stopped the audio recording. The coders were then asked, “What would you code or not code?” I played segments from one of the participants’ audio files. This session focused specifically on their coding skills. The coders received the actual transcript. During this session, I was looking for the coders to score on a criterion of 85% accuracy. I then provided examples of patterns to accept any response where a participant voices agreement with the speaker, supports the proposal, or incorporates the idea into the group product but did not result in further discussion. In between training sessions two and three, each coder was provided with two five-minute audio recordings. I sent coders two five-minute recordings and asked them to listen to them and independently practice coding the audio recordings. The coders then sent me their coding. I evaluated how close they were to my answer key. Coders needed to score a criterion of 85% reliability with my answer key and with each other. Training session three was a discussion of the results of the coders’ independent practice. I then provided another five-minute recording that they listened to as a group and practiced coding together. The discussion then focused on responses to code as “agreement” (i.e., statements that demonstrate collaboration and further the discussion), “accountable talk” (i.e., statements that express disagreement but that prompt further discussion), or “disagreement” (i.e., statements that reject an idea without discussion or shuts down collaboration and any further discussion on that topic). For example, they coded “agreement” for any response in which a participant voiced agreement with the speaker, supported the proposal, or incorporated the idea into the group product but did not result in further discussion. Examples of responses to “agreement” include “the data supports the claim,” “according to the evidence,” “yeah, that makes sense,” “you’re right,” and “let’s write that down.” Coders then coded “disagreement” for any response that made a claim that an idea was incorrect or voiced disagreement with the speaker that did not allow room for further discussion. Examples included "That's not right," "You're wrong," "That isn't possible." Coders coded "accountable talk" for any response that prompted and/or resulted in further discussion of an idea. Examples of this type of response included questioning the rationale behind an idea, challenging it with new information or a different idea, asking for clarification, and revising the idea with sample statements such as "What do you mean by that?" "Are you sure?" "But why does…?" "But why does the water rise when the candle goes out?" "What if we say…?" The third training session included more practice to ensure coders reached 85% reliability.

I recorded the individual interviews, the focus group discussions, and interactive lab discussions using the SONY ICD-PX333 audio recorder. I transcribed all the interviews, the focus group discussions, and all the interactive lab discussions by listening to the audio recordings and typing the words word for word. Then, I served as the primary coder and coded all of the transcribed interviews from each of the four participants, including the individual interviews and the focus group discussions. I also coded all the transcribed interactive lab discussions. Then, I examined all the formal and informal documents, such as the graded lab reports and the accompanying ADI rubrics, as well as the peer reviews for the lab reports. In addition, I reviewed field notes that I had recorded which represented observations of the students' interactions during the lab conductions and discussions.

The transcripts of the individual interviews that I coded were then coded by one of the two independent coders. Coders were divided such that each coder "followed a student." For example, Coder 1 was assigned to code Allie (participant 1) and Maria (participant 2). Coder 1 coded the first, second and third individual interviews conducted with Allie (participant 1) and Maria (participant 2). Coder 2 was assigned to code Paulina's (participant 3) first, second and third interviews, as well as Amanda's (participant 4) interviews. Coding occurred immediately following completion of each interview. That way, the coders and I were able to confer after independent coding was completed and resolved discrepancies in coding, adding examples to how certain responses should have been coded, and clarified any questions. In cases in which there were vast disagreements between the coding of the researcher and the independent coders, the other coder was asked to review and provide input on coding to help resolve the discrepancy. I made final decisions about coding, but I did note cases for which there were unresolved differences in coding among coders and me. (There were very few differences, as seen in Chapter 4 Results.)

The focus group discussion transcript was coded by one of the coders and me. The other coder was reserved for coding any audio-recorded segments for which there were vast differences in coding between the independent coder and me (which there were very few). The same process was followed for the focus group discussion as the individual interviews, such that coding took place immediately following the interview, the independent coder and I then coded the audio recording, the coder and I then meet to resolve any discrepancies in coding, and the other coder coded any segments for which there remain unresolved coding differences (very few).

Regarding the lab interactions, there were five recordings per participant for each of the three primary labs: a recording for Stage 2, Stage 3, Stage 4, Stage 5, and Stage 8. Thus, there were 15 recordings per participant for a total of 60 lab interactive recordings.

Each of these stages took one classroom period which meant each recorded session was approximately 50 minutes. I coded all the lab interaction transcriptions. In addition, a sampling of 25% of the transcribed interactions was coded by an independent coder. The two independent coders coded 25% of the transcripts such that each independent coder coded a 12.5-minute segment of the 50-minute session that represented the most robust portion of the interactive discussion for each stage; the 12.5-minute segment was identified by me after I coded the whole transcript. Coders were divided such that each coder followed the same student for which they coded the individual interviews.

In addition to coding the individual interview audio transcripts, the focus group interview transcript, and the interactive lab discussions for Stages 2, 3, 4, 5, and 8, the independent coders were provided the other formal and informal documents as a way to serve as a reliability check for the researcher's interpretation of those data pieces. This process is described in the Data Analysis section below.

3.10 Data Analysis

Inductive analysis served as the strategy for analyzing and interpreting the data collected. This approach involved closely examining the data to search for categories and themes within the questions being researched (Huberman & Miles, 1994). This was followed by a search for relationships among the categories to explain the phenomena being investigated (Glaser & Strauss, 1967). The process of coding and analyzing all formal and informal documents, observations, transcribed student lab interactions, and transcribed interviews was informed by the work of Miles and Huberman (1994). In coding, the data was examined to identify similar patterns, themes, recurring ideas or phrases, relationships, commonalities, or differences between segments of data. In this first stage of data analysis, the documents that the two independent coders and I used to code the transcripts were examined by me. Then I compiled the information and documented the process that occurred for agreement and disagreement among coders. I retained a detailed account of the meetings, the discussions, and the resolution among coders for each interview, the interactive lab transcripts, and the other formal and informal materials. Then, I compiled a written profile description of each participant from all the data sources. The coder who followed the respective participant reviewed my descriptive profile and provided a reliability check for accuracy of the descriptive profile and input for any major components that I might have missed.

The initial coding stage was followed by an examination of single instances in the data and meaning was drawn from them without looking for multiple instances. This strategy helped move the data analysis process toward interpretation to break the data apart in analytical ways to lead to further questions about the data (Huberman & Miles, 1994). The next stage of the process involved the coders and my examining the data through a diagram of codes. The coders and I examined these to explore the composition of each data code. Doing so helped structure information into a compact accessible format to better analyze the data.

In the next phase of analysis, the establishment of patterns and the search for any consistency between two or more patterns or themes within the data was identified. I looked for generalizations about the participants' experiences and contrasted them with published literature. Along with transcribed interviews from the three individual interviews, the focus group, and the interactive labs, the review of formal and informal documents, such as the students' samples of their written lab reports, and data from lab investigations provided a clear picture of the participants' science experiences. Written profiles were developed for each participant based on the compilation of all coded data sources, and direct quotes were included to support the inductive conclusions drawn. For example, "Charlene indicated from the very beginning that she was highly interested in science and was confident in her abilities to perform well in science. Data from all three individual interviews showed a consistent pattern of her maintaining a high interest and self-efficacy. Her argumentation skills were high as indicated by her numerous contributions during the lab interactions and her high scores on her lab reports. She expressed that she liked the ADI approach because it 'gave her an opportunity to take the lead with her peers in her lab group.' In contrast, as supported by direct quotes, Susie expressed not being interested in science and having low self-efficacy at the beginning of the year. However, through the progressions of the interactive labs, she gained argumentation skills as seen in her increase in contributions during the interactions. In her final interview, she said that this ADI approach was the most fun way that she had ever learned science, and even though her grades are good this year, she still doesn't have an interest in pursuing science. However, her self-confidence in science has increased."

From the individual profiles, an inductive analysis approach was used to develop a comprehensive description of the students' experiences. I highlighted consistency in the patterns among them, and I highlighted individual discrepancies. Through their analyzed data, I was able to determine to what extent the ADI approach increased their argumentation skills and resulted in an improved science class experience.

3.11 First Nine Week Overview Introducing Students to the ADI Instructional Approach

The goal for the first week was to prioritize establishing procedures for entering the lab, building community among the students and myself, and teaching them about accountable talk (how to provide constructive peer-specific feedback). First, the 55-minute class began with a 15-minute morning meeting introducing participants to the science lab, accountable talk, tools, and materials that would be used during the research. Time spent in this first week also fostered the development of a classroom community where students learned to collaborate and listen to each other using accountable talk, investigate phenomena, and solve problems through inquiry. Students were also placed in groups of three. Team building games occurred to build relations with the students. It was during this time during the first week, I administered the ATSSA and the Middle School Self-Efficacy Scale.

The ADI instructional framework and rubric were introduced to the students on the first Monday of the first nine weeks. Three ADI lab investigations occurred during the first nine weeks. The labs I used in the study included the following investigations from the Argument-Driven Inquiry in Physical Science Lab Investigations for Grades 6-8 (Grooms, et al., 2016): Lab 14 Potential Energy: How can You Make an Action Figure Jump Higher? Lab 13 Kinetic Energy: How Do The Mass and Velocity of an object Affect Its Kinetic Energy? Lab 11 Design Challenge: Which Electromagnet Design is Best for Picking Up 50 Paper Clips?

I used scaffolds to support students' analysis of expository text and peer-specific feedback (accountable talk) during lab investigations. Scaffolding was defined as breaking learning into chunks with tools, frameworks, and or structures. During Stage One of lab investigation 13, I introduced students to a reading scaffold known as "Squeepers" (Echevarria, 2011) which is designed to support students as they read expository text. This framework scaffolds metacognitive strategies used with proficient readers (e.g., predicating, self-monitoring, evaluating/synthesizing and summarizing). The introduction of this scaffold provided students with practice when facing challenging text. During the first reading scaffold, I modeled with the participants my thoughts as I read the first ADI text passage to assist participants toward independent use of the technique. The scaffold allowed participants to survey, question, predict, read, respond, and summarize the passage as a whole group.

During "Squeepers," participants were given 1-2 minutes to skim the text paying close attention to text structures such as bold print, graphs, pictures, diagrams, and captions. "Questioning" had participants formulating questions about the text they had just skimmed. "Read" involved the participants reading from the expository text in pairs and/or small groups. The "scaffold response" had students discussing the information they had gathered in the first four scaffolds. "Summarizing" allowed students the opportunity to highlight key concepts learned from the reading which could be done orally in groups, with a partner, individually, or as a large group.

During the ADI investigations, students explored phenomena and constructed models and developed arguments to explain the observed phenomena. The length of each investigation occurred over a ten-day school week taking place in a daily 55-minute class. Laboratory investigations introduced students to theories, laws, and/or concepts in science. ADI lab investigation 14 introduced the lab titled, "Lab 14- Potential Energy:

How can You Make an Action Figure Jump Higher?" This lab introduced students to the types of energy, specifically potential energy. During the investigation, students had the opportunity to explore cause and effect relationships. The goal of the second and third investigations was to allow students to revise and refine their argumentation skills developed in the previous investigation so they can explain a different scientific law. Another goal of the third lab was for students to evaluate and write a scientific explanation.

The eighth steps of ADI included the following: identification of the task, the generating ideas/ data, the production of an alternative argument, the argumentation session, the creation of the written investigation report, the double-blind peer review, and revision of the report (Sampson et al., 2010). The ADI rubric assessed science argumentation skills as determined by two groups of reviewers through the double-blind review process: student peer reviews and teacher team reviews. The original drafts of the lab reports and the revised versions were reviewed and scored using the ADI rubric. The ADI rubric had four sections: Introduction and Guiding Questions, Method, The Argument, and Mechanics. The section that was used for this study was the "The Argument" section as a way to determine the students' science argumentation skills which was a primary outcome in this study.

The students participated in a variety of activities that were designed to give them experience with the science and engineering practices (SEPs) such as collaboration and modeling and that were designed to introduce and reinforce important science practices before and after each of six class period labs during the intervention. Some examples of the activities were listening to mini-lessons, Squeepers, paired share readings, participating in class discussions, engaging in group work, writers workshop, completion of practice problems, observing demonstrations, Virtual Learning, and reading articles selected from Science Daily, www.livescience, and www.nationalgeograhic. These practices are widely used in middle school classes.

Students also completed several formative assessments and three summative assessments throughout the quarter in addition to the lab investigations. These instruments were used by me for both formative and summative purposes and were not deemed suitable for research purposes. Any information about the students' learning and understanding was not included as a data source in the study.

Chapter 4: Results

In this study, I examined two research questions. The first research question was, "In what ways does implementing and scaffolding the ADI instructional approach influence the classroom experiences, interest, and self-confidence for female students of color (i.e., non-White) in middle school science? The second research question was, "In what ways does using the ADI instructional approach impact female students of color (i.e., non-White) written argumentation skills (including peer review) and scientific voice?" In this chapter, I provide a description of the context of the study conditions considering the atypical influences of the Covid pandemic on classroom instruction, followed by a general overview of the results across the participants. Next, I present results for the first research question for each of the four participants, specifically introducing the participant's scores from their science interest and self-efficacy surveys, key findings and themes from the three interviews (i.e., pre-, mid- and post-intervention), findings from the peer interactions during the ADI laboratories, and performance on their science end-of-unit exam. It is important to note that a second focus group interview was conducted because there was very little discussion by the participants in the first focus group. Therefore, I (as the researcher) decided to conduct a second focus group interview in an effort to increase overall participation, which was helpful even though discussion levels were still lower in the focus group than in the individual interviews. The chapter ends with a dedicated section presenting findings for indicators of high-quality written argumentation skills and voice (aligned with the school's "high-quality peer review protocol"), which is the second research question.

4.1 Context of Study Conditions and General Overview of Results Across Participants

Due to the continuing disruptions in traditional instruction due to the Covid-19 pandemic, gaps began to emerge during the first ADI lab in terms of the number of students who were in the classroom at a given time. This led to disruptions in the instructional flow and the lab investigations. Specifically, instructional content required repeating when quarantined students were able to return to the classroom and data collection was disrupted and needed to be repeated or conducted at later dates due to the shortage of students within groups. In addition, due to the virtual instruction restrictions imposed because of the Covid pandemic, data collection procedures were not able to be taught in-person last year. Because of this, students in this class missed the opportunity last year to be taught these data collection skills and procedures; thus, I (as the teacher) had to include in-person instruction for these procedures. This resulted in more scaffolding during the first quarter labs than is customary.

None of the participants were allowed to do science investigations (i.e., working in collaborative groups) in elementary school during the 2020-2021 school year. COVID restrictions prevented students from doing "normal" science lab investigations (i.e., no group work of any type was allowed due to social distancing guidelines); instead, if science was taught, students did online virtual assignments. The virtual assignments included click and drag vocabulary words matching them to the correct definition, some consisted of a Google Doc that had simulations of science phenomena and questions. Students watched the simulations and filled out the questions on a Google Doc.

During the first ADI Lab Investigation in this study, I noted many students experimenting with the materials but not recording their data on their data tables. This was an area that I provided scaffolds or mini labs to practice data collection. The first mini lab had students predicting the number of water droplets that would fit on a penny head. Students developed a claim to answer the guiding question and began testing their claim. All the participants began testing six to eight times without being told. As they completed each trial, I showed the participants how to record their data on a table in Google Sheets. Their data collection skills began to improve in other mini labs such as "How many drops of water will fit on the head of a dime, nickel, and a quarter?" As the participants' data collection skills improved, I repeated the first ADI Lab Investigation because the students' written justifications provided evidence that the students were not able to connect the science content to the laboratory investigation.

I was able to conduct the pre- and post-individual interviews in the media center, as planned. However, as a result of the unanticipated disruptions in instruction due to the quarantines related to Covid during the middle of the quarter (e.g., sometimes, there were only four students present in the classroom), I was not able to conduct the mid-intervention interview in the media center. Instead, I had to conduct the mid-quarter interview through an individual conversation in the classroom with each student to collect information from them. One participant withdrew from the study within the first couple weeks of school due to her number of suspensions and expulsions. As a result, another student, a Latina female who scored low on the pre-ATSSA and self-efficacy fit the original participants' demographics and pre-survey scores and thus was enrolled in the study just as we were starting the first lab.

4.2 Participant Results: Allie

Introduction to Allie. The first participant was Allie. She identified as a Black female who enjoyed sports (basketball) and being with her friends at school and her family. Allie had a quiet, reserved manner until she talked about sports. She became energized as she talked about her current team and her position on the team. Allie could be found after school practicing for her community basketball league team at the community center. She identified a goal to play for the middle school team in her 7th grade year. During the interview, Allie was the only participant to have engaged in a science lab type activity outside of school. Specifically, she was invited to a science birthday party where the children did science demonstrations for the "wow" factor. Allie did recall having a few science experiences in her elementary school, but there was not a specific science class that met daily. There was one specific time she recalled collecting weather data with thermometers outside for her classroom. She also remembered her teacher would sometimes pass out a worksheet and ask them to complete it in elementary school. Although these experiences were described as interesting to her, she did not engage in any data collection during these few elementary science experiences.

Scores on the Science Interest and Self-Efficacy Surveys.

Pre-Intervention. Allie scored two of a possible five on the ATSSA Interest Instrument, indicating a low interest in science. She scored a one of five on the self-efficacy instrument, indicating that her confidence in doing science was very low.

Post-Intervention. Allie scored a three out of five on her post ATSSA interest Instrument, indicating a moderate interest level in science and a three out of five on the science self-efficacy instrument, indicating a medium level of self-confidence.

Results from the Individual Interviews with Allie.

Pre-Intervention Formal Individual Interview. Allie recalled her science experience in the elementary school prior to the pandemic (2020-2021) which shut down all schools in the state in March 2021. Allie described how her elementary school did not have science as a dedicated, daily class, and she did not recall being taught science content as its own subject; much of the instruction was centered around mathematics and reading. She did not like having to learn virtually in any of her classes. At the beginning of the 2021-2022 school year, Allie was concerned about getting adjusted to her middle school science class. She did not spend a lot of time outside of school studying for any of her classes during previous school years. She also felt science would not be necessary in her future but viewed science as entertaining. She did however indicate that she would take the required science classes in high school.

Mid-Intervention Informal Interview. Midway through the first quarter, Allie stated she liked the ADI lab investigation; however, she commented that the work had gotten more challenging and difficult. She felt her work with her team went well during the second ADI laboratory investigation. She also thought that the collaboration with her group members helped her understand the investigations. She enjoyed science and wanted to earn an A because good grades were important to her. Despite her increased engagement and discussions with her group members, Allie did not see how science was significant in her community or to her. She said, “Science is important because I got to do it cause I want to get to seventh grade." She described how she was looking forward to engaging in more lab investigations a "little bit." Thus, despite her increased interest in the ADI process, Allie and her group did not make the expected content connections (Justification of Evidence) in lab 1 on their white board arguments. See Figure 1 for the picture for Allie's groups presentation Board.

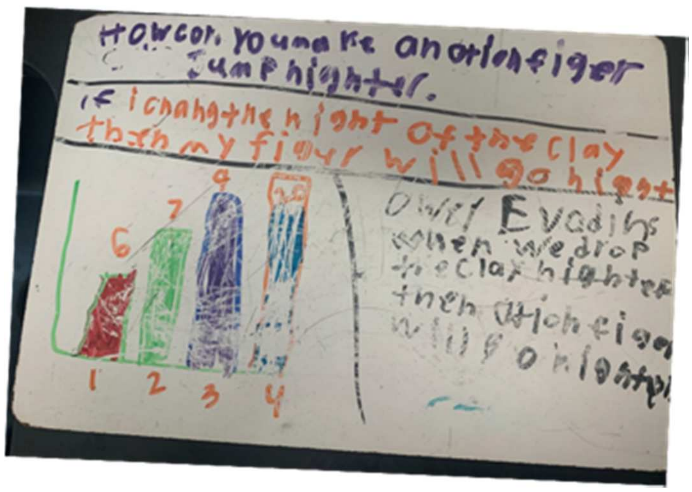

Figure 4.1 Allie's Group Presentation Board

Note. Photograph of Allie's group's first attempt at generating evidence to support the claim on their presentation board.

In the first lab, Allie's group recorded the following justification for evidence: "Our evidence when we drop the clay higher then the action figure will go higher." The statement did not include connections to the science content explaining how energy was being transferred from the ball of clay to the action figure. Also notice there was no analysis of data from the graph, nor were there any title or labels for the x and y axes, and there was no analysis or explanation of the meaning of the data. Allie's group did not use a scientific explanation as a tool to solve the problem or to evaluate their claim.

Post-Intervention Formal Individual Interview. Allie's concerns expressed in the pre-interview regarding the structure and expectations in middle school had noticeably reduced in the post interview. She developed a more positive outlook for science and did not have her original pre-interview concerns with adjusting to the sixth-grade science class.

Allie: *Let's do some more labs on energy, that stuff is the bomb!*

Me: *What type of investigations would you like to do with energy?*

Allie: *Anything, it all is neat.*

At the end of the study, she felt science was "okay," and she was looking forward to studying about animals in the life science unit this year. Allie said that she especially "liked the energy unit investigations." For example, she said stage two was fun because her group had to figure out a way to support their claim. Stage three and four of the ADI approach were two stages she also enjoyed because they were able to look at the other students' presentation boards and listen to students discuss their results and compare their data with that of other groups. Allie liked designing and conducting the investigations (stage two) and enjoyed collecting evidence to support her claim and using it to construct the presentation board that contained the argument (stage three). Allie did state she felt more confident with collecting data and analyzing data in investigations during the second stage of the ADI instructional model. She also stated that she liked stage four which involved both presenting the argument through the presentation board to other students in other groups and also in walking around to hear other group's arguments and see their presentation boards. She felt stage four (being able to see other group's presentations and having an opportunity to present her group's board) helped her organize her information and data: "I was able to see how the graph backed up what we thought." However, she did not feel the ADI instructional model helped her in understating the content. Allie said trying to justify her evidence was hard and difficult to understand. One piece of evidence to support this was seen during stages three and four of the lab investigation 1 in which her group wrote the following in the justification of evidence section of their white board: "Our evidence when we drop the clay higher then the action figure will go higher." There was no mention of energy being transferred during their investigation. During the second lab, Allie and her group analyzed the graph and provided no science content in the justification of evidence section; rather, she filled in the area with vocabulary words and definitions they had found on Google searches (Figure 2).

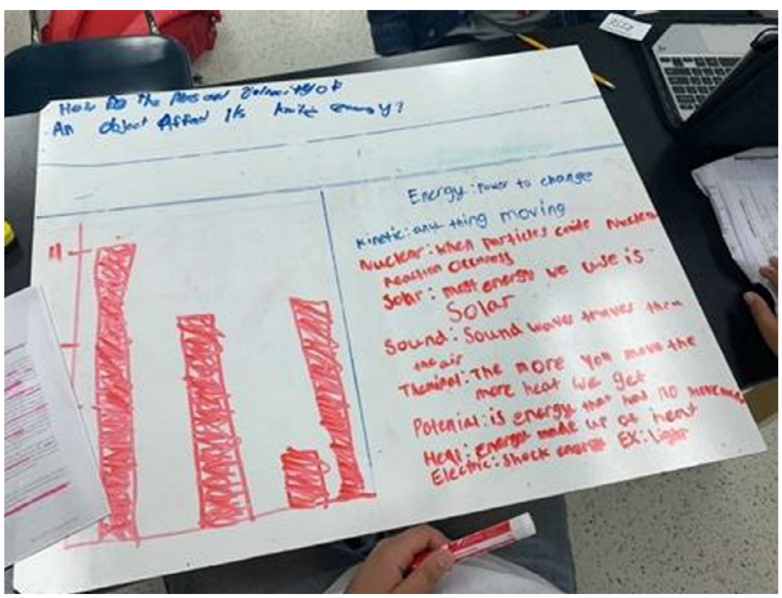

Figure 4.2 Allie's Group Justification of Evidence

Note. Allie's group placed definitions in the justification of evidence section of the presentation board in lab two.

She described that she liked doing the experiments during this study rather than having to complete a worksheet as she did in elementary school. She felt the investigations helped her understand how to collect data accurately. Allie felt when she was given the chance to design her own experiment it was difficult in the first two ADI lab investigations. Although she stated that overall, she enjoyed working in groups and collaborating during the experiments, she recalled that her team did not always work together well or listen to everyone's ideas. Her group consisted of one white male, one black male, and two black females. She recalled being uncomfortable to talk and communicate her ideas in the first lab investigations because two male group members wanted to take over the investigation and would not listen to the other two group members. One example she provided was that the two males were dominating the conversation and ignoring the two black females' suggestions for setting up the experiment and developing a claim, as can be seen in the following exchange among the students in Allie's group.

White male: *I already know if you drop the clay from the ceiling it will throw the figure higher!*

Allie: *That isn't saying* (interrupted by Black male)

Black male: *Yeah, I've done this befor*e, lets drop it from the ceiling.

Allie*: I still…* (Interrupted by White male)

White male: *Let's set it up. I already know how to do it the right way.*

Allie: *What about us and what we think?*

Black Female: *Yeah, I think we should hold the clay this high*

(1 meter high and drop it.

White male: *No! We already got this.*

Allie: *loud sigh and eye roll. Crosses arms and sits back in her chair.*

The boys in the group were deciding the point at which to make the clay fall without listening to Allie or the other female. When asked how she began getting her ideas heard in lab group discussions, she said that she stated, "I just said, we aren't working together! Y'all aren't even listening to us (Allie and black female)." and "I just had enough and stepped in and took over. I was tired of them."

Findings From the Transcripts of the Peer Interactions During the Labs.

As the researcher, I first examined how often group members contributed to the discussion. These data were generated from myself (as the researcher) and the independent coders transcribing the peer interactions during the labs. Figure 3 provides the number of total comments recorded by each student in Allie's group during all three of the lab investigations. These data indicate the level of participation and how Allie began to be an active member in her group, especially during lab 3. The graph below shows Allie's contributions to her group increased during lab investigations two and three.

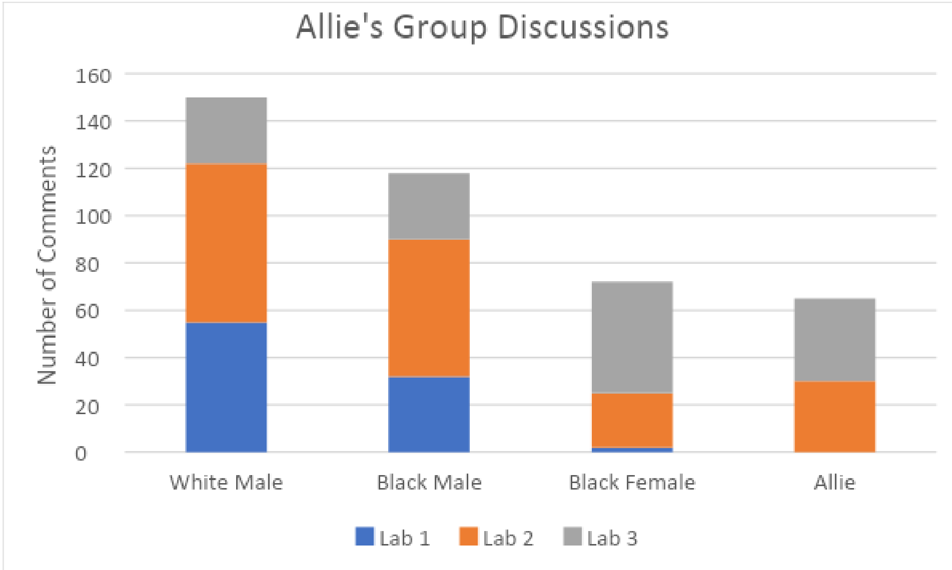

Figure 4.3 Allie's Groups' Discussion

Note. Number of comments contributed to each group member.

Also noted through the transcripts of the peer interactions was how often group members discussed an idea when it was proposed as a second measure of engagement. Sampson et al. (2015) used a table like the one below to show how group members responded to other group members' ideas when they were being introduced into the conversation. Table 1 and Table 2 combined provide the number of four different types of responses during the group's dialogue in the lab investigation (i.e., discuss, ignored response, reject response, and accepted response) in Allies group. "Discuss" involved when Allie was providing a comment that contributed to a group discussion. "Ignored response" (abbreviated in Table 2 as IR) occurred when Allie verbalized a comment, but none of the group members responded to it. "Rejected response" (abbreviated in Table 2 as RR) occurred when Allie verbalized a comment, but it was rejected by the other group members. “Accepted response” (abbreviated in Table 2 as AR) occurred when Allie verbalized a comment, and it was accepted by the other group members.

Table 4.1 Allie’s Group Discussion Comments

Group Members	Discuss During Lab 1	Discuss During Lab 2	Discuss During Lab 3
Allie	1	27	40
Black Female	3	21	39
White Male	19	14	31
Black Male	23	16	37
Total across students	46	78	147

Table 1 shows the group discussions that occurred in Allie’s group during the three lab investigations. The increase of discussion responses indicated the students were highly engaged and willing to talk about, evaluate, and revise their ideas. Overall, this analysis suggests that Allie’s group members were more willing to engage in argumentation after participating after the three lab experiences designed using the ADI instructional approach. These data also show that the students were challenging each other’s ideas and claims more frequently as evidenced by the increases in total “discussion” comments (i.e., 46 in lab one, 78 in lab two, and 147 in lab three) and in the following excerpt from lab three that was missing from lab one.

Allie: (to the group) *That wire sure is loose. Ok, first of all, let’s make it neater.*

Black female: *I wonder if it makes difference how tight the wire coils are wrapped around the nail?*

White male: *I don't think so because we are picking up the same amount of paper clips, right? I don't think the tightness of a wire would affect our magnet/ I don't think it makes a difference.*

Black male: *If we try it then we can rule it out. Let's try it just to be sure because we could use this in our evidence.*

Allie: *I am in. What about you guys? So y'all we want to see how the tightness and looseness of the wire around the nail effects our magnet?*

Black female: *Sure, but we must be sure to make the number of coils the same.*

Black male: because that would be another variable.

White male: *Your right, let's make sure our controls are there.*

Allie: *So, we want to say the neatness of the coil make a difference?*

Group: *Yeah*

These totals in Table 1 for Allie provided evidence that ADI had a positive impact on her ability to engage in discussion during labs as the number of comments increased from just one in lab one to 27 in lab two to 40 in lab three. This pattern of discussion comments could also be seen in the comparison black female in her group. Further, the totals for combined males verses females provided evidence that ADI had a positive impact on females' ability to engage in discussion comparable to males: female discussion comments increased from four in lab 1 to 48 in lab two to 79 in lab three; males actually decreased slightly from 42 in lab one to 30 in lab two, and then increased again in lab three to 68. This showed that by lab three, there was no longer a gender difference. In addition, these totals across all four students in this group provided evidence that ADI increased the students' ability to engage in a high volume of discussion during labs, with an increase from 46 in lab one to 78 in lab two to 147 in lab three. In addition to these quantitative data in Table 2, the excerpt from the transcription among the students in Allie's group showed the nature of true discussion among students who are "thinking like scientists" in that they were providing suggestions for controlling the variables, demonstrating understanding of independent and dependent variables, and the importance of being able to use their findings as evidence. In addition to their understanding of the science concepts and scientific practices, they were using their student voice and demonstrating equality among group members as seen in that they were each providing suggestions and then responding to each other with support "for" or "against" based on science concepts and how they could use these pieces as part of their ADI approach (i.e., "If we try it then we can rule it out. Let's try it just to be sure because we could use this in our evidence."). In this excerpt from lab three, there was evidence of multiple student interactions with questions posed to the group and ultimately coming to agreement but through discussion rather than one student's domination.

Table 4.2 Allie's Group Comments for Ignored Response (IR), Rejected Response (RR), and Accepted Response (AR)

Response Type	Ignored Response (IR)			Rejected Response (RR)			Accepted Response (AR)		
Lab Number: one, two, three	one	two	three	one	two	three	one	two	three
Allie	8	2	1	2	4	3	0	10	23
White Male	0	6	20	0	15	75	54	3	8
Black Male	2	10	15	30	20	48	33	4	3
Black Female	15	5	3	4	12	5	2	13	19

Table 2 shows how group members responded to an idea as it was introduced during the lab investigations. This table showed how the group members' communication changed from lab one to lab three. For example, they moved from little discussion to a lot of discussion in two visible ways. First, the students moved from ignoring comments to providing feedback to peers through rejection or acceptance. Secondly, and more importantly in science, their comments became more of "how about we do it this way" or "what if we tried it that way," rather than simply accepting or rejecting a comment for "here's how we're going to do this." In addition, in the initial labs, it was top-heavy with the males providing the oral contributions and then by the latter labs, the females were providing equal or greater oral input. In particular, see Allie's growth from having none of her input accepted in lab one to having 10 input contributions accepted in lab two to having 23 of her contribution statements accepted in lab three.

Allie: *Hey, let's twist the wire a lot around the nail.*

White male: *Ok, I bet that the more twist the. Stronger it will be.*

Allie: *Hey yawl do you think the size battery has anything to do with strength of the magnet?*

Black female: *Well, the battery. Doesn't change, but the coils do.*

White male: *Oh, yeah.*

Allie: *So, lets first test the number of wire coils, then after we finish, we can ask to test different batteries.*

Black male: *That's tight! Yeah. We got this.*

The fact that the males ignored all of the comments from both females in lab one but accepted or discussed the females' input by labs two and three, showed growth in equality in scientific voice as seen in these groups of students with various gender compositions. This table of data helped to show the overall group dynamics; specifically, that some students' voices were ignored early on while others were clearly dominant. However, by the middle and final labs, equality in scientific voice emerged regardless of gender or race. This emergence of equality of voice allowed each student to participate in the discussion, address any disagreements if there were any, and arrive at their final arguments. Table 2 also shows a shift from one primary student being the dominant speaker to every student contributing to the discussion during labs two and three. During lab three, Allie and the other black female in her group were contributing more to the conversation and the discussion. This finding supported that the group was being more attentive to Allie and the other female in her group. In the conversation excerpt below from lab three, there was a high agreement between Allie and the other female. This was a shift from Lab One where Allie did not voice her ideas.

Black female: *Let's use the same size paper clips. I think it makes a difference if we use different sizes.*

Allie: *Ok, so what about the small one?*

Black female: *I want to use the large. What about y'all?*

White male: *uhh?*

Allie: *Let's do it! That would show we have a good magnet if it can pick up a bunch of large clips?*

Results from Writing Rubric. During stage six of the ADI instructional approach, students wrote a lab report that followed a specific outline from the ADI writing rubric. Then, during stage seven students were given other students' papers with no identifying criteria to the student to read, rate, score, and provide feedback with evidence to support their feedback and their score. Students might have received a rating of "no" meaning they did not meet the criteria for Lab Investigation One, "partially" meaning the student met the average requirements, and a "yes" meaning the student successfully met the criteria. Students could receive scores of 0, 1, or 2 that aligned with the rating scale (i.e., no, partially, and yes). Students could receive a total score of 8 if they received a 2 for the four components of the Introduction: "Did the author provide enough background information," "Is the background information correct," "Did the author make the goal of the investigation clear," and "Did the author make the guiding question clear?"

When Allie learned that students were going to be reading and scoring each other's lab reports, she was recorded as saying to her group she did not like to write. Further, she asked, "Why do we have to write in science?" The first scaffold for this was for students to craft a beginning paragraph or introduction (section one of the ADI writing rubric) and focus on introducing their lab investigation. While the students wrote an introduction for each lab, Lab One's writing assignment was only to write the introduction; writing the other sections were required in subsequent labs. Having the students write only the introduction for Lab One, provided me an idea of their writing skills. The objective for this first paragraph was to provide sufficient and accurate background information on the lab content and purpose. The peer review asked: "Did the student make the goal of the investigation clear?" If any of the reviewers scored the paper as "no" or "partially," they had to provide specific examples for why they gave the student that rating. Four students used the ADI rubric to score Allie's beginning paragraph in Lab One. Three students gave her a score of 3 out of 8 (a score of 1 on the first three components, and 0 on the fourth), and one student gave her a score of 0 out of 8. Thus, three students rated her paragraph as "partially" meeting the guidelines. The reasons stated were these: "There is only a claim written under the Introduction and nothing about energy or the Law of Conservation." The fourth peer reviewer said she did not meet the criteria and suggested she "use her presentation board to help her improve her score." [Note that for the first lab, only the introduction was included for the written report. This was an example of how the instructional strategy of scaffolding was applied to writing in science class. Specifically, the students only wrote their introduction section for lab one's report, and the subsequent lab reports (lab two and then lab three) would require them to write the additional sections (i.e., body and conclusion) until all three sections were written in their reports. lab two's report contained their introduction and body, and lab three's report contained their introduction, body, and conclusion.]

Allie chose not to revise her written Introduction in lab one, because she stated that she did not see how writing would help her in science. In lab two, students were to focus their writing on the introductory paragraph and the methods used (part of the body). The methods section required students to provide clear descriptions of what they did to collect data during the investigation, describe how the data were analyzed, and use correct terms to describe the investigation. Allie was peer reviewed by three classmates who gave her a rating of "no." Their feedback suggested that Allie use her investigation proposal to help her fill in the information. One of the three provided no feedback. When Allie got her peer review paper back, she crumpled up the paper and refused to revise it. "Why we got to write?" was her response. For Lab Three, she refused to write any report even though her presentation board and oral presentation contained a strong argument claim and evidence, and she engaged fully in those aspects of the lab requirements. Unfortunately, due to Covid restrictions, I was not allowed to retain the written reports from the students. Instead, students had to place their reports in a Ziplock bag, and the students were only allowed to provide peer comments on sticky notes.

Evidence of Learning through Scaffolding of ADI. I, as the teacher (and researcher), conducted a mini lab to help the students learn the skill of how to record data. The data in my results showed that the students learned this skill. Evidence to support this learning as the result of this specific scaffolding technique was seen in Allie's second and third lab presentations when she was able to accurately display data from their experiment on her presentation board in stage three and present it orally in stage four. Another example was seen in formulating claims (i.e., hypothesis generation). In the beginning of the study, I started off asking the question, “What do you know about claims? What is a hypothesis?” in order to determine their baseline knowledge. Allie struggled a great deal with this skill as seen in the fact that she could not answer these questions. As a scaffold, I provided the students with a fill-in-the-blank sentence starter of “If I do _______, then ______ will happen.” Allie demonstrated learning with this scaffold in two ways. The fill-in-the-blank sentence starter helped her develop her independent and dependent variables, and then by the second lab, she was able to develop her own claims without the need for the fill-in-the-blank sentence starter: “If we add more mass to the playdough, then this will make the action figure jump higher.” Another scaffold provided was the reading scaffold. For this one, I read to them a sentence or two at a time and then modeled what I was thinking as I read. We used the “Squeepers” scaffold for students to interact with the text by using strategic thinking and reinforce their reading skills. This scaffold allowed students to use metacognitive strategies such as predicting, self-questioning, evaluating, and summarizing/synthesizing text. As an example, if the heading was “Energy,” I would turn that into a question: “What is energy?” Then, I explained that the author wanted them to be able to explain what energy was with certain characteristics and descriptions. In the beginning, Allie particularly struggled with this skill of reading to gain knowledge and understanding of science concepts. She was encouraged to reread the article in the Argument-Driven Inquiry in Physical Science Lab Investigation manual for grades 6-8. She then accurately pulled the information about energy transfer from the written text that demonstrated her understanding that energy is not being lost or gained in the experiment but transferred from one form to another.

Impact of ADI Approach on Written Argumentation Skills. The evidence that showed that Allie learned how to use the reading scaffolds to inform her science lab arguments was seen in Lab Three. On her first read of the lab handout reading on energy, she showed that she did not gain accurate understanding of energy because she initially provided a statement that a ball of clay that is still does not contain energy. However, she then re-read the article and used the reading scaffolds and was able to extrapolate the meaning accurately. As an example, Allie was guided to turn the heading "Potential Energy" into a question: "What is Potential Energy?" Then, she also was guided with scaffolds to find specific examples of this from the reading. She began to ask questions such as, "What is the Law of Conservation? Can energy be stopped?" After using these scaffolds, however, she did not reference the Law of Conservation on her presentation board for her justification of evidence. Although the scaffolds helped her find the information about potential energy and the Law of Conservation this content knowledge did not transfer to the lab presentation board. Specifically, while she was reading, she paused after the Law of Conservation definition and said, "That seems important." This pause with verbal comment showed that she was using the scaffolds to take her time while reading by keeping active questions in mind that she anticipated the reading would provide.

Impact of ADI Instruction on Student Voice. Evidence from multiple sources supports that ADI had an impact on Allie's student voice. As seen in Table 1, the group discussions that occurred in Allie's group during the three lab investigations showed an increase of discussion responses for Allie indicating she was highly engaged and willing to talk about, evaluate, and revise her ideas. Overall, this analysis suggested that Allie's group members were willing to engage in argumentation after participating in the three lab investigations designed using the ADI instructional approach. This data also showed that the students engaged in challenging each other's ideas and claims more frequently as evidenced by the increases in total "discussion" comments (i.e., 46 in lab one, 78 in lab two, and 147 in lab three) and in excerpt from lab three that was missing from lab one (provided in the narrative description following Table 1). As seen in Table 2, group members responded to their group's ideas as they were introduced during the lab investigations. The data in Table 2 showed how the communication among the group members changed from lab one to lab three. For example, first they moved from little discussion ignoring group members comments to providing ideas and developing claims together as a team. The males ignoring the females' contributions to listening to each other, and the females provided equal or greater oral input. In particular, see Allie's growth from having none of her input accepted in lab one to having 10 input contributions accepted in lab two to having 23 of her contribution statements accepted in lab three. The fact that the males ignored all of the comments from either female in lab one but accepted or discussed the females' input by labs two and three, showed growth in equality in scientific voice as seen in these groups of students with various gender compositions. This can be seen in the first and second excerpts from the transcripts of the robust student discussion in her group where the group members discussed the neatness of the wire coils versus the loosely bound coils and the impact this may have on their magnet's strength. It also shows the group gaining more confidence in their scientific discussion concerned with the control variables.

Science End-of-Unit 1 Exam. At the end of each science unit taught, there was a school-wide multiple-choice exam that was administered to all students in sixth grade. Allie scored in the average range of her class of 24 students. She scored 80% of a possible 100%, which is a B. Her high score provided evidence that Allie was able to demonstrate learning for the science content tested. It is noteworthy that she was quarantined due to COVID exposure for 20 days that hindered her ability to participate in all the lab activities. Despite her absences from class, she scored an 80%.

4.2 Participant Results: Maria

Introduction to Maria. Maria was a Latina female from Guatemala. She enjoyed working hard and attending school. She stated that every summer her family returns to Guatemala and helps her grandparents farm and harvest crops. Maria enjoyed school and helping her cousin (who spoke very little English) during school day and after school. She had never participated in science before. She did enjoy math which was her favorite subject. She had a very close family whose members were very active with her at home. Her family enjoyed playing soccer, cooking together, and spending time together on the weekends. At the beginning of the study, Maria was often by herself, and at recess, she would sit at the tables under a tree and wait for recess to end.

Maria entered sixth grade science with little experience in science and data collection. This was evident even from the first ADI investigation focused on kinetic energy in which the guiding question was, “How Can You Make an Action Figure Jump Higher?” Maria was observed holding the clay balls of different masses and letting them drop on the sea saw with the action figure. She was not recording any data with her group nor measuring the height of the clay balls she was dropping. I approached her and asked:

“How is the investigation going?” She replied, “good,” and when she was asked if she noticed how the height of the ball was affecting how high the action figure was going when she dropped it, she said, “It doesn’t really. It just makes a mess.” I also noticed there was no data being collected from any groups; rather, students were dropping the balls of different masses randomly and not recording the height of which the balls were dropped and the depth of the impact. The minilab scaffold was implemented. Maria was observed being very careful to place the droplets on the penny and count each one. I approached her to see how things were going.

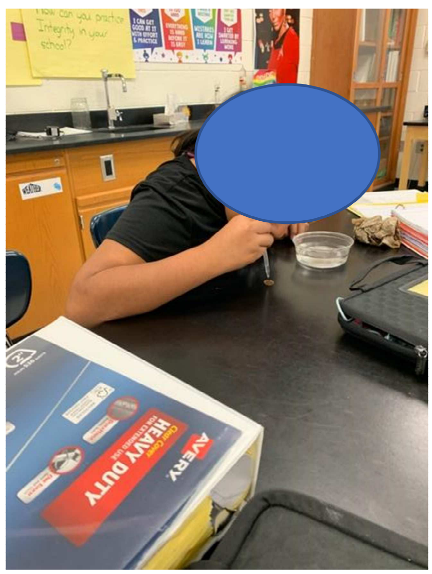

Figure 4.4 Maria Controlling and Placing and Counting

Note. The picture above shows Maria carefully controlling and placing and counting each drop of water on the penny.

Maria: *This is so cool! Look how it bubbles up on the penny!*

Me: *Oh wow! I wonder why that is?*

Maria*: maybe it's me being very careful placing the drops on it, or the size of the drop of water. If you squeeze the dropper bulb too fast, it just gushes out. If you are careful though, you can get more drops, of its data! I want each drop to be the same*. Thus, through the minilab experience, Maria was able to demonstrate controlling the variable.

During the beginning of the year, she often did not interact with the other students during recess. After the first ADI Lab, she began searching me out at recess and asking questions about kinetic energy. Maria asked me to name all the things that were moving. As I named several things moving with kinetic energy, she listened intently. When I was done, she asked me about the clouds, the wind, and the planet Earth moving and using energy. During the second interview, her views about science changed. This was obvious during her data collection and creating her argument after the mini lab scaffold (How many drops of water will fit on the head of the penny?). After this experience, she became very cautious collecting data and recording data on the data chart for the subsequent ADI investigations. After the first investigation, she got very excited when she learned we were doing another ADI lab investigation. She also made sure not only to collect her data, but also to take her time in collecting her data accurately.

.. After the first lab investigation was complete, Maria would wait for me to come outside. During recess, Maria would often come around and stand behind me. It was at this time she would often have science discussions with me. These discussions would center around energy. Some of the examples of our conversations included discussion of the trees, students and the planets moving. Our conversation would then begin to include kinetic energy. Her knowledge and application of the science content being learned in the lab was now being applied to her school surroundings. Conversations such as these continued throughout the course of the study.

Scores of on the Science Interest and Self-Efficacy Surveys.

Pre-Intervention. Maria scored a two out of five on the Science Interest Survey, indicating that her interest in science was low. On the Self- Efficacy Survey, she scored a one out of five, indicating she did not believe in her abilities to do science.

Post-Intervention. Maria scored a five out of five on the Science Interest Survey. On the Self-Efficacy Survey, she also scored a five out of five, indicating a tremendous increase in her beliefs about herself in being able to do science and an increase in her interest in science.

Results from the Individual Interviews with Maria.

Pre-Intervention Formal Individual Interview. Maria did not enjoy science and expressed she was nervous about taking it this year. She had always enjoyed math which was her favorite subject. Math was also taught every day in her elementary school. She did not feel science was very important in her life and felt it was not used around her home. When asked, the first interview question: How would you describe your previous experience in science classes when you were in elementary school? For example, what were some things that you liked, and what were some things that you didn't like? Maria, replied, "I don't like it, we never had to do it, but I do like math. I made good grades in math." In her elementary school there was little opportunity for collaboration with other students. When asked what she was looking forward to studying in science this year. She stated that she did not really know, possibly due to not having experienced much science in elementary school.

Mid-Intervention Informal Interview. During the mid-intervention interview, Maria described how she liked her group to remain small "because it made it easier for me and my partner to communicate and accomplish our goal." She also felt it was important to keep the group small because this allowed the work to be neat, and not risk being messed up, especially stage two, three, and four of the ADI instructional model. Along with collecting and analyzing data, Maria enjoyed designing her presentation board for the other students to view.

Maria: *you hold the ruler and keep it straight.*

Me: *would you like your group member (Black male) to hold it instead?*

Maria: *no, he had a chance and so know he is reading the data to me. He was messy! Our board can't be messy, I love this part of science.*

On the survey she indicated science was "kind of fun." She explained, "Science is kind of fun; I did not like it at first because I did not know what it was, but I liked learning about the different things in science like energy." Maria at the mid intervention interview liked science and felt comfortable especially in the labs. She especially liked collecting the data and analyzing it. She also enjoyed when she prepared her board for the argument session and could explain it to other students. Her interest in science began to increase, especially when she realized the connections to energy and the weather. She felt this was very important because her grandparents lived on a farm in Guatemala, and the weather was very hot and important for growing crops. This began to show her connecting the science content to her home community, and her grandparents' farm. She also valued doing well in school and learning as seen when she said, "It is important to earn an A in science, because this shows I am learning."

Post-Intervention Formal Individual Interview. She liked learning about energy and electricity, especially making an electromagnet in the design challenge. She reported feeling very comfortable in science, because she could explain her findings to her classmates and parents. She was looking forward to studying the next unit on weather. She enjoyed the ADI approach, because "it was more interesting to do your own experiment and create the graphs to show her classmates." She liked the independence and being able to revise her design. For example, the following conversation occurred in which Maria described her feelings about making revisions.

Maria: *I thought it was cool how we could come up with our own design and even test it! Even when something went wrong, you didn't give us a bad grade but gave us time to make changes to our work.*

Me*: So, being able to revise your work was something you enjoyed?*

Maria: *Yeah, this is the way it's done by a real scientist! Usually, we get a grade on something and move on, now we can really work on the challenge and be the best of the class.*

Maria and her group focused on accuracy as well as keeping the variables the same. Maria became very competitive when it was time to make the presentation boards. The conversation below shows Maria and her group in the planning stages of their board in lab one.

Black Male: *Let's make start on the board*.

Latin Male: *I'll draw the lines.*

Maria: *No! I don't want it sloppy! I'll draw the lines, and you (Latina female) can start writing the guiding question. The other groups will see this, and I want it to look good.*

Black Male: *While you do that, I can sketch out a graph on scratch paper. You* can *copy it.*

Maria: *Okay.*

Findings From the Transcripts of the Peer Interactions During the Labs. As the teacher/researcher, I first examined how often group members contributed to the discussion. These data were generated from the researcher and the independent coders transcribing the peer interactions during the labs. Figure five provides the number of total comments recorded by each student in Maria's group during all three of the lab investigations. These data indicate the level of participation and how Maria was an active member in her group, especially during lab one and three. It is important to note how high the levels of communication are in all three labs. Maria's group worked well together and listened to each other's ideas as shown in the data. I also examined how often group members contributed to the discussion. Although Maria decreased in her comments during lab two, she focused on the data collection and concentrated on data accuracy. The graph below shows Maria's contributions to her group increased during lab one and three and decreased during lab two.

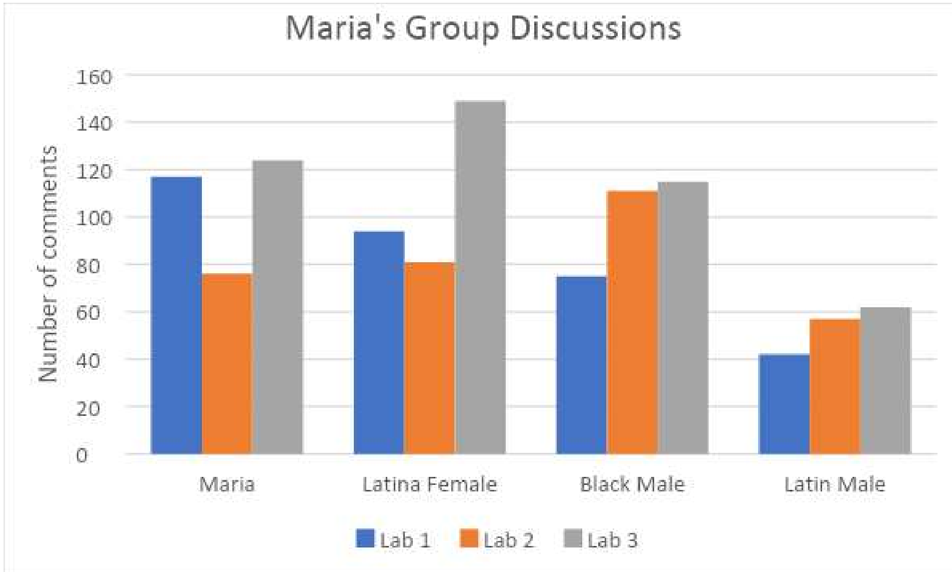

Figure 4.5 Maria's Group Comments

Note. Number of comments contributed to each group member.

The transcripts of the peer interactions showed how often group members discussed an idea when it was proposed as a second measure of engagement. Sampson et al. (2015) used a table like the one below to show how group members responded to other group members' ideas when they were being introduced into the conversation. Table 3 and Table 4 combined provide the number of four different types of responses during the group's dialogue in the lab investigation (i.e., discuss, ignored response, reject response, and accepted response) in Maria's group. "Discuss" involved when Maria was providing a comment that contributed to a group discussion. "Ignored response" (abbreviated in Table four as IR) occurred when Maria verbalized a comment, but none of the group members responded to it. "Rejected response" (abbreviated in Table 4 as RR) occurred when Maria verbalized a comment, but it was rejected by the other group members. "Accepted response" (abbreviated in Table four as AR) occurred when Maria verbalized a comment, and it was accepted by the other group members. Notice in lab two, Maria's comments decreased; when I asked her why she did not talk as much she replied, "I just wanted everything to look good and be accurate, it's cooler when you take your time and really think about what you're doing"

Table 4.3 Maria's Group Discussions

Group Members	Discussions during Lab 1	Discussions during Lab 2	Discussions during Lab 3
Maria	73	38	74
Latina Female	63	41	67
Black Male	59	67	70
Latin Male	25	32	37

Table 4 shows the group discussions that occurred in Maria's group during the three Lab investigations. This group's members had a high number if interactions that were maintained across the three labs in terms of discussing ideas, evaluating, and making revisions as evidenced in the high number of interactions among the group members that were maintained across the three labs. Overall, this analysis suggests that Maria's group members engaged in argumentation during lab one and grew in their level of participation after the three lab experiences designed using the ADI instructional approach. The data also shows that the students were accepting each other's ideas and claims as evidenced by the increases in total "discussion" comments (i.e., 220 in lab 1, 178 in lab 2, and 248 in lab 3) and in the following excerpt from lab two that was missing from lab 1.

Latina Female: *Let's move the fulcrum closer to the load.*

Black male: *If we do that it will not go as high?*

Maria: *We can't guess, we need to have the proof. What proof do you have if the fulcrum is moved closer it will make the figure jump higher?*

Black male: *Well, we know the closer the fulcrum is to the load the less work is used.*

Latina*: true, but will less work make it jump higher?*

Maria: *We can try, but we should also try it in the fulcrum in the center.*

Black male: *Yeah, let's do both.*

Latin male: *Let's do our first test with the fulcrum in the middle.*

The conversation above shows Maria and her group members having a conversation about setting up the experiment. In this discussion, they are using science content terms for simple machines such as fulcrum and the load. They are also applying that repositioning the fulcrum to the load will impact the experiment and how high the action figure will go. It shows a true collaboration and the students listening to each other.

Lab three interactions:

Maria: *Okay this is a challenge; we need to be the best.*

Black male: *I want to pick up 100 of those paper clips with our magnet.*

Maria: *Let's do some sketches and look at each other's designs for ideas.*

Latina: *if we put our ideas together, we can test each one then takes out the bad parts.*

This conversation shows the collaboration occurring between Maria's group members during the final design challenge (lab three). They were willing to all make a design and test each other's design in order to create a strong electromagnet. Table 4 shows how Maria's group members responded to an idea as it was introduced during the lab investigations.

Table 4.4 Maria's Group Responses

Students	Lab 1: IR	Lab 2: IR	Lab 3: IR	Lab 1: RR	Lab 2: RR	Lab 3: RR	Lab 1: AR	Lab 2: RR	Lab 3: AR
Maria	0	0	0	1	0	2	19	35	48
Latina Female	0	0	0	0	1	1	11	39	32
Black Male	0	0	0	1	3	3	15	41	43
Latin male	1	0	0	4	0	2	12	23	23

Results from the Writing Rubric. Throughout the study, Maria showed progression in her written argumentation skills as evidenced by her ADI rubric scores for writing, especially argumentation, and by her peer reviews. Consistent with the rest of her classroom peers, Maria's writing ability was scored a 10 out of 16 on Section 1 and on the mechanics portions of the Investigation Report Peer-Review Guide: Middle School Version. In the first lab, we focused on writing the introduction paragraph. Maria's introduction paragraph in the first lab contained strong background details with the science content, but it contained many grammatical mistakes. Following the feedback from her first report in lab one, Maria and I had the following discussion on her revisions:

Me: *So, what do you think was your strengths in your writing?*

Maria: *My background information.*

Me: *Can you give me an example?*

Maria: *Yeah, so I did good at talking about how we held the clay ball 24 cm high and transferred the energy from potential to kinetic when we released it. So, I wrote my group held the clay ball 24 cm to increase its mechanical potential energy. This was stored energy. When we let go of the ball that energy was transferred into kinetic energy and even sound energy when it hit the sea saw.*

Me: *Wow! You write like a physicist.*

Maria: *Cool! That was my best work.*

Me: *What is one area you could improve on?*

Maria: *Watching my spelling. I have never had to worry about my spelling before.*

Me: *So, what is one way you can improve your spelling?*

Maria: *I can re-read my work and I like the other students helping me. They caught a lot of stuff. that I hadn't thought of.*

Maria evidenced her determination to perfect her written lab report so that it matched the other components in which she excelled. The evidence for this includes the following: she revised her lab report eight times, getting feedback for each version by multiple students, and she took her notebook with her during out-of-class times such as lunch and recess and asked to work with the teacher to get point-by-point input for how to use her data as evidence to include in her written report.

By the third lab, her writing for her entire lab report contained very few grammar mistakes, was composed of cohesive thoughts, and showed good paragraph structure with an overall score of 400 out of 400 total points. She also progressed in using the peer reviews to revise her written lab reports. Specifically, for the first lab, she did change some of her lab report based on her peer review feedback and scored a total of 14 points on the Rubric. By the third lab report, Maria used her peer reviews to rewrite her report which led to a higher quality of writing and a higher grade. Some examples of the peer feedback included, “You have a great paper, but you need to use your graph to explain you’re how your evidence supported your claim,” “great work on organizing your lab report, you may want to use a variety of sentences.” Evidence of this improvement in writing was seen in her ADI rubric scores of 180 points on her first lab report, 300 on her first re-write of lab one, 300 on her initial lab two report, 380 on her lab two final revision, 380 on lab three initial report, and 400 on lab three final report.

Evidence of Learning through Scaffolding of ADI. Students feedback to each other grew in sophistication as students engaged in more ADI investigations. For example, during stage four of the argumentation session in lab one, the researcher noted Maria providing feedback to another group during the argument session:

> Maria: *So, I noticed in your justification, you have “the higher we go the more potential energy increase.” Can you explain this further? I would add in “the higher the object is the more potential is stored. When you drop the clay, the energy is transferred from potential to kinetic”.*
>
> Group member: *Okay so we should add in more information about energy transfers.*
>
> Maria: *Yes, but can you tell me what types of energy were used? And where the transfers happened.*
>
> Maria: *Yes, and you also need to analyze your data. This is a good graph, but no explanation.*

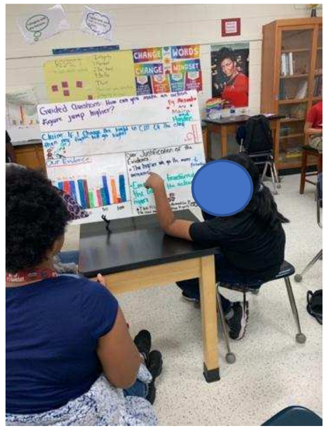

Figure 4.6 Image of Maria
Providing Peer Critique

Note. Maria providing peer critique to another group during the argumentation session.

The lab three, the final lab, I noticed Maria's responses getting more detailed. Maria began to give feedback such as "Can you tell me more about your justification of evidence and how it relates to your graph, your graph was good can you explain the data trends you observed? I like your justification because it tied the science stuff we learned about, and I think you should revise your axis labels on your graph, they do not match your data table."

Impact of ADI Approach on Written Argumentation Skills. The impact of ADI on Maria's written argumentation skills could be seen in her steady progression on sophistication in the types of evidence she used in lab reports by her final lab three report. One peer review comment in lab three's report shows this nicely: "Your writing is very detailed, and you did a great job connecting the lab with your Justification."

Science End-of-Unit 1 Exam. On the district science unit test that all students must take at the end of the quarter, Maria scored a 100%. Clearly, this perfect score shows that Maria was able to demonstrate learning of the science content tested. Note that the only two students in the sixth grade to score 100% were Maria and Amanda. Not even any of the honor's students' district-wide scored 100%; the average score for the honor's students district-wide was an 88% (B+).

4.2 Participant Results: Paulina

Introduction to Paulina. Paulina was a Latina female from Honduras and was a very quiet student in class. During our interview, she said she was very nervous about science, until our first day when I introduced myself to the class and showed a picture of my husband and I to the class. She said she felt like we had a connection, as she also has two mothers. She showed me a picture of their pride flag with a flag of Mexico in the middle. When I introduced my family, it made her comfortable with me supporting the LGBTQ community. Paulina did not enjoy elementary science but loved to write and she described how her favorite subject was English Language Arts (ELA). When reflecting on her prior science classroom experiences, she felt science in elementary school was okay. She recalled her elementary science classes primarily consisted of worksheets, there were no laboratory investigations, and it was very rare for any kind of formal science instruction to be taught in class by a teacher.

Me: *What was science like last year and elementary school?*

Paulina: *We didn't really do it (science), but sometimes we did a science worksheet and turn it in. It was kinda boring.*

In the interview, she showed me a journal she called her writer's notebook. In this journal were memories with her family, sketches, and observations she made around her home and community. Paulina stated that she was not involved with community sports or activities. She did say that she enjoyed coming to school and seeing her friends. When asked what she was looking forward to most this year she replied, “ELA, because I love reading and writing in my journal.”

Scores of on the Science Interest and Self-Efficacy Surveys.

Pre-Intervention. Paulina scored two of a possible five on the ATSSA Interest Instrument, indicating a low interest in science. Her score on the self-efficacy instrument was a two out of five, indicating that her confidence in doing science was very low.

Post-Intervention. Paulina scored a five of a possible five on the ATSSA Interest Instrument, indicating a high interest in science. She scored a four of five on the self-efficacy instrument, indicating that her confidence in doing science was high after the ADI instruction was implemented for the first nine weeks of sixth grade class. A primary reason for this huge improvement seemed to be that she enjoyed stage one, two, three, four, and six of the ADI Instructional approach because she was able to design an experiment and design a board to show her group’s results. She also really enjoyed the chance to write and provide peer feedback to her classmates. For example, in the interview Pauline stated, “*I loved when we got to write and talk to each other about our experiments to the other groups. It was neat to be able to give my friends ideas to help their writing and mine.”* She felt this gave her an opportunity to discuss in depth what she learned and help others improve their lab reports. Evidence to support this claim is provided in more detail in the following sections.

Results from the Individual Interviews with Paulina.

Pre-Intervention Formal Individual Interview. In the pre-intervention individual interview, Paulina stated, “Science is okay.” She described that this was because she had been taught science through worksheets in elementary school. She liked being on a team and working together with classmates to help each other out during class. Being able to work together in small groups was one thing she was hoping to do this year. She also was nervous about receiving actual grades on her science work this year because in elementary school, they also only received a “satisfactory” or “unsatisfactory” remark based on whether they had turned in a completed worksheet or not. During the pre-intervention interview Paulina said, “Science makes feel a little uncomfortable this year because I have to take it every day. It just seems like a lot more classes.” She will have to take it every day as opposed to the occasional science worksheet assignments that was used to having in elementary school. She also felt that science was not important to her community and home; rather, it was something that was required by the school, and it was important for her to move to the next grade.

Mid-Intervention Informal Interview. During the mid-intervention interview, Paulina said that being in a science class was fun and made her feel good. She said she “looked forward to science each day, especially the lab investigations because they were so fun.” She did say that she was comfortable in science when people were working hard together and helping each other out during the investigation. She said that she liked the ADI instructional approach because it challenged her, and she enjoyed the collaboration with her group members. Paulina remarked that the challenge was coming up with a design from the claim and seeing if the claim was supported. Several stages in ADI emerged as her favorites: stages one, two, three, four, and six. Paulina loves to read, and she enjoyed the reading in stage one and how it made her think about her claim. I also observed her searching on the internet for the science content she had read about in the ADI lab handout. The following exchange took place between Pauline and me:

Me: *So, I notice you are looking up examples of energy.*

Paulina: *I am interested in how energy is not destroyed when something stops moving. Uhh- I think it's the Law of Conservation?*

Me*: Good!*

Paulina: *It's so neat, and I just want to find some more examples, so when we come together and use it in our justification, and I know what I'm talking about.*

This conversation shows here to be interested and wanting to learn more than the reading had discussed. In the other labs she also researched topics such as mass, mechanical potential energy, and electrical energy. After our reading, in stage 1 the students and I would form a class circle to discuss the reading and any key points they felt were important. It was during this time Paulina would take out her writer's notebook and read questions she had during the reading, as well as what she was wondering about. She called the questions her "fierce wonderings." Fierce wonderings were a term introduced to Paulina in her elementary ELA class during the writer's workshop. One of her fierce wonderings after reading about the Law of Conservation and energy was, "Why are the hills on a roller coaster different size?" and "If energy is not created or destroyed where does it go when the roller coaster stops?" (Her mothers had taken her to a theme park during the weekend, and after reading about potential energy being the energy of position, she developed these "fierce wonderings" for herself). I also observed illustrations in her notebook about the material being learned in science. One example included a picture of a coffee table with a book on the table and a book under the table. The book on the table was labeled greater potential energy and the book under the table was labeled less potential energy. I asked her why did she have this drawing? Her response was, “my notebook is a place to help me understand things I am learning. Sometimes a picture will help me understand.” I asked, “Where did you see this example?” She replied, “I did it when I got home after we read and talked about energy. I was showing my mom.” This connection provided evidence that she was beginning to see the connection between science and the world around her, which was a change from her initial interview in which she articulated that science was “not important to my community or home; rather, it was something added in school, and it is required to move to the next grade.”

She especially enjoyed being able to design her own investigation (stage two) and writing her lab report (stage six), followed by being able to review classmates in other lab groups’ lab reports and provide feedback (stage seven). In fact, she stated that it made her feel important to be able to provide that feedback and that the other students listened to her feedback in making their revisions to their lab reports. There was a huge change even just between the pre-intervention interview and this mid-intervention interview in that Paulina felt it was very important to make an A in science this year because it showed that she was a “hard-worker” and that it “made my (her) parents proud.” During the interview she shared this connection with me:

Paulina: *So, I told my mom we need to save energy so we can save money and do more stuff.*

Me: *And what happened after you told her this?*

Paulina: *We unplugged things we were not using, you know electric stuff not being used, and even went to the hardware store to look at some solar lights!*

This was a bridge showing how she began making connections to science outside of school to her home. She showed that she was even more driven to perform well because when she makes bad grades, it makes her want to work harder to get better grades.

Post-Intervention Formal Individual Interview. Paulina's favorite ADI lab investigation was lab three the electromagnet lab. She enjoyed learning about electricity and its relationship to magnetism. She said, "It was cool when we coiled the wire around the nail and were able to pick up 25 paper clips. I didn't know electricity produces a magnetic field." "I want to know what would happen if I changed the battery size and used a thicker nail size if we could pick more than 50 paper clips? I bet we could." Paulina also enjoyed making the whiteboard presentation and presenting them to the other groups. The graph and justification were her favorite part of the board. She felt it made her results and learning easier to talk about and present to the other groups.

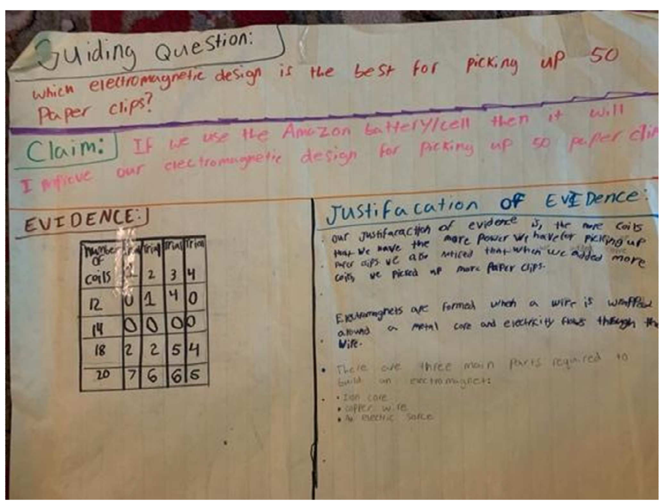

Figure 4.7 Paulina's Group Presentation Board for Lab Three

Note. Paulina's group's presentation board from the third and final lab.

The justification read: The more coils that we have the more power we have for picking up paper clips. We also noticed that when we added more coils, we picked up more paper clips. Electromagnets are formed when a wire is wrapped around a metal core and electricity flows through the wire. The justification shows her group's connections of the lab activities to the science content. Her group members put her in charge of the justification for their presentations. They also were observed asking her to proofread their lab reports before the peer feedback. Paulina would circle misspelled words, as well as use the accountable talk prompt "Can you tell me more about this?" when she felt her group did not provide enough details or evidence.

Paulina described that her good science grades made her happy and she looked forward to science the rest of the year. Being recognized in science for her grades on the honor roll and science achievements in school would "help her be a good scientist." This was the first time in the interview she stated wanting to pursue a science career. She also felt science was important for her community: "without energy, my home and neighborhood would have no lights, power, or stuff. I would not feel safe, it is also important for the plants and animals to get energy to survive." Paulina also shared, "I am talking with my mom about getting solar cells for our home it would save us money and be cool to be the only house with solar cells." She was looking forward to learning about animals at the end of the year and would like to take biology in high school. She said that she felt she was "good to go" in science this year.

Findings From the Transcripts of the Peer Interactions During the Labs. I first examined how often group members contributed to the discussion. These data were generated from the researcher and the independent coders transcribing the peer interactions during the labs. Figure 8 provides the number of total comments recorded by each student in Paulina's group during the lab investigations. These data indicate the level of participation and how Paulina was an active member along with her group members. The graph shows Paulina's contributions to the group's collaborations.

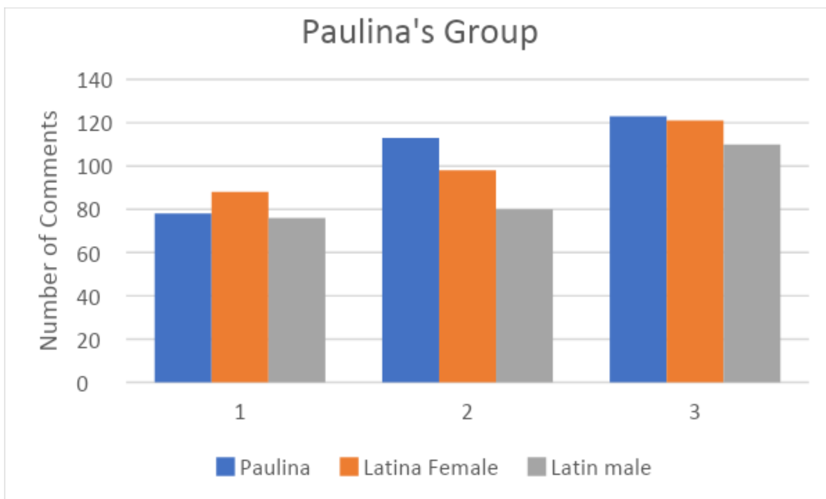

Figure 4.8 Paulina's Group Comments

Note. Number of comments contributed to each group member.

Also noted through the transcripts of the peer interactions was how often group members discussed an idea when it was proposed as a second measure of engagement. Table 5 and Table 6 combined provide the number of four different types of responses during the groups dialogue in the lab investigation (i.e., discuss, ignored response, reject response, and accepted response) in Paulina's group.

Table 4.5 Paulina’s Group Discussion Comments

Group Members	Discussions during Lab 1	Discussions during Lab 2	Discussions during Lab 3
Paulina	98	130	151
Latina Female	90	127	158
Latin Male	85	121	149

Table 5 shows a count of the group member’s discussions that occurred in Paulina’s Investigations. The increase of discussion responses indicated the students were highly engaged and that they evaluated each other’s claims, revised ideas, and discussed their ideas with each other. Overall, this analysis suggests Paulina’s group members became were increasing their discussions and engaging in argumentation through the stud. These data also show the students were challenging each other’s ideas and claims more frequently as evidenced by the increases in total discussions comments.

Table 4.6 Paulina’s Group Comments for Ignored Responses (IR), Rejected Response (RR), and Accepted Response (AR)

Students	Lab 1: IR	Lab 2:IR	Lab 3:IR	Lab 1:RR	Lab 2: RR	Lab 3: RR	Lab 1: AR	Lab 2: AR	Lab 3:AR
Paulina	0	0	0	0	5	0	88	101	123
Latina female	0	0	0	0	3	1	75	98	135
Latin Male	0	0	0	0	2	0	67	88	117

Table 6 shows how group members responded to an idea as it was introduced during the lab investigations. This table showed how the group members communication changed from lab one to lab three. For example, they had a significant increase from lab one to the final lab three. Secondly and important to science was the fact they listened to each other's' ideas, rather than rejecting them. In addition, there is a balance between female and male contributions.

I observed that the members of her lab group in the second lab (Lab 13: Kinetic energy: How do the mass and velocity of an object affect its kinetic energy?) were not initially able to make the connection between an outcome of the investigation and the science concept behind it. This was because Paulina corrected her group members when they were only going to put the conclusion without providing the evidence or the connection to the science concept, and said to them, "The bigger ball has the most matter because its bigger, so we have to use more energy to make it move; this is one way we can justifying our evidence". This provided evidence that not only was she the only one to make this connection from the lab experience to the justification herself, but that she was able to find her voice in science with her peers and articulate this important aspect of ADI to her peers. They listened to her and included that in their lab investigation report and presentation board.

Results from Writing Rubric. Throughout the study, it was evident Paulina enjoyed writing. Paulina's interest in writing and her high writing abilities came through in her individually written laboratory report. In the first lab, the students focused on writing the introduction paragraph only. Her first lab report received a score of 13 out of 16 total points due to her introductory paragraph contained a few spelling and sentence structure errors. During the peer feedback she received the following revision suggestions; “You may need to add some different types of sentences like an exclamation mark, quotes and that kind of stuff.” also in the conventions section under the mechanics portion of the writing rubric she was encouraged to check the spellings of three words. Her writing sample included the following introduction:

> “When our group increased the height of the clay, the potential energy (stored energy) was also increased. We dropped the clay transferring the Potential energy into Kinetic energy and the figure jumped off the sea saw. The more energy (potential) that was stored, the more motion was observed by our group. This is also the Law of Conservation.”

Paulina showed progression in her written argumentation skills as evidenced by her ADI rubric scores for writing, especially argumentation, and by her peers’ reviews. Her writing scores in lab investigation two increased with a total score of 350 out of 400 on the Investigation Report Peer- Review Guide: Middle School Version. Following the feedback from her first report in lab one, Paulina, like Maria, was determined to perfect her written lab report so that it matched the other components in which she excelled. On the second lab report lab 13) she wrote the following:

The more mass an object has, will need more kinetic energy to move like our clay ball with had a mass of 8 grams. So, our smaller clay ball with a mass of 3 grams will not need the same amount of kinetic energy to move at the same speed.

Paulina showed her understanding of the science content in the writing sample above by discussing the relationship between an object’s mass and velocity. She stated, “I felt the ADI writing challenged me to be more detailed with my writing, I wanted to get score a perfect score." She persevered and liked receiving the peer feedback so that she could achieve a perfect score which she did in her final versions of labs 1, 2, and 3. She utilized the peer review feedback and received more positive feedback with each subsequent lab report. Some examples of the peer feedback included, "I like the way you used specific details and science words in your writing," "good job on the data collection."

I observed Paulina's confidence increase through the second and third labs in multiple areas, including an increase in science content connections, an increase in her ability to communicate science accurately through oral and written forms, an increase discussing science content with her peers, and last an increase in her confidence to "do science" as seen in the post-assessment for self-efficacy.

Evidence of Learning through Scaffolding of ADI. During the mini lab in which students had to figure out how many droplets of water would fit onto the head of a penny, Paulina demonstrated a learning of the concept as well as the importance of independent, dependent, and controlling variables. The scaffold was a demonstration by the teacher of controlling multiple variables, such as the size of a droplet of water from the dropper onto the penny and the distance of holding the dropper from the surface where the penny was. I also used a scaffold of showing them how to develop a data table and record their data. For Paulina, use of these scaffolds, especially for the controlling variables, increased her learning of what those variables were and why they were important in being able to compare data class-wide.

Impact of ADI Approach on Written Argumentation Skills. As mentioned in the results from the writing rubric, Paulina showed progression in her written argumentation skills as evidenced by her ADI rubric scores for writing, especially argumentation, and by her peers' reviews. Also as previously stated. Paulina showed her understating of the science content in the writing sample referenced above by discussing the relationship between an object's mass and velocity.

Science End-of-Unit 1 Exam. She scored a 97% (A+) on her final district science unit exam. This score was the second highest score in the sixth grade. Recall that Maria and Amanda were the only two students in the sixth-grade district-wide who scored 100%, and this score outscored the average score for the honors students which was an 88% (B+).

4.2 Participant Results: Amanda

Introduction to Amanda. Amanda is a Latina female, who likes participating in class. In elementary school she did not remember doing a specific class for science. She does enjoy coming to school and seeing her friends. Amanda enjoys drawing and math which she identified as her strengths in school. Her elementary school was a STEAM magnet school, and she remembered some science experiences, including making elephant toothpaste, creating art using moss from the garden, and growing vegetable plants. She felt confident with attending sixth grade this year. She stated, "It is all new and we get to change for every class!" When asked if I could help her find her classes, she replied, "Nope, I've got this, it is a piece of cake finding my classes." In elementary school they did not change classes. On the second day of school, she handed me a note stating, "Science is cool." Amanda said she is looking forward to moving to Honduras at Christmas to be closer to her grandparents. She is currently on a community soccer team and enjoys being with her mother, father, and siblings.

Scores of on the Science Interest and Self-Efficacy Surveys.

Pre-Intervention. Amanda scored 4 out of 5 on the ATSSA indicating a high interest in science. On the self-efficacy survey, she scored a 5 of 5. This should Amanda had a strong confidence in herself that she could perform well in 6th grade science.

Post-Intervention. Amanda scored a five out of five at the end of the quarter showing her interest grew even more by the end of the study. On her post self-efficacy survey Amanda scored 5 out of 5 in science.

Results from the Individual Interviews with Amanda.

Pre-Intervention Formal Individual Interview. Amanda felt science was "okay" and "sort of fun" in elementary school. She recalled science was not done every day in her elementary school.

Amanda: *When we did science, we would do pages in our science book (textbooks). Oh, now we did a cool experiment last year (5th grade).*

Me: *Can you tell me about it?*

Amanda: *So we made this thing called elephant toothpaste, and it made this big pillow looking foam.*

Me: *Can you remember measuring anything, collecting data, or talking about what is happening*?

Amanda: *Naw, we just helped clean up the mess.*

Amanda described how it is very important for her to earn A's in all of her subject areas. She also felt doing well in high school would help her find a good job and nice house. When I asked her if she had ever designed her own experiment in science, she replied, "No, but I would like to learn how." Amanda felt what she does in school this year will make a difference for the upcoming school years. Amanda does like cooking, exploring outside, and growing vegetables in her yard with her parents. It was important for her to make A's in school because this helped her understand science around the world especially her family's home and garden. She felt this aspect of science was the most interesting in addition to looking at the stars at night. At the time of the interview, she did not plan on having a career that would use science.

Mid-Intervention Informal Interview. Amanda felt science was "sort of fun so far, and sometimes made her feel uncomfortable" Amanda elaborated," I like it when everyone works hard together, and it is quiet so I could learn." She was uncomfortable when people in her class and group did not work together and didn't listen to others' ideas. In the first ADI lab investigation she enjoyed seeing how high the action figure would jump and could not believe her group made it touch the ceiling. I asked her how it felt to design her own experiment with her group in which she replied, "I didn't realize we did it ourselves? I liked it when we had to go back and redo little things to make our sea saw work." In the first lab her group placed an illustration of their model in the justification of evidence section of the presentation board. Amanda decided the illustration helped people understand what their group did. "In science books they have pictures and captions so we should to." This was a connection Amanda made to her readings, her group was the first to add an illustration to show the science connections to the data.

Figure 4.9 Amanda’s Presentation Board for Lab Investigation One

Note. The picture shows the presentation board from lab investigation one along with the illustration Amanda included in her justification of evidence. It is an illustration showing her groups sea saw, clay ball dropping on the sea saw and the action figure at the end. During the third lab investigation, she also drew one nail on the justification with no labels on her model.

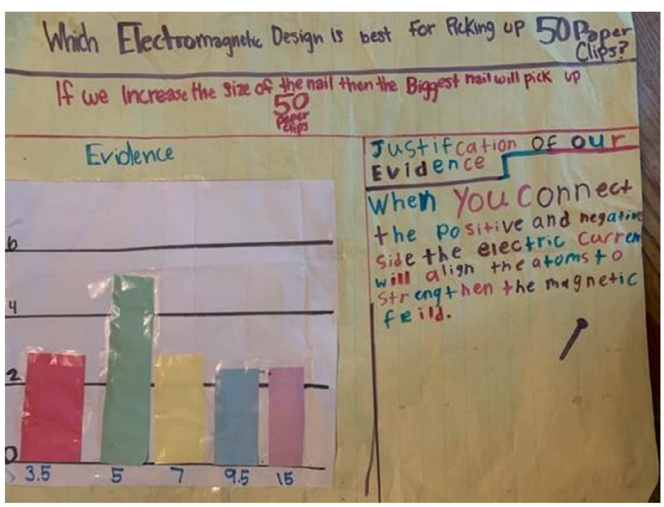

Figure 4.10 Amanda’s Lab Investigation Three Presentation Board

Note. This shows a picture of Amanda's groups presentation board from lab three.

She said, "Well the one nail is important because we couldn't believe we picked up all those paper clips with that one nail! I was going to put some labels and captions on it, but we ran out of time. So, I didn't put a caption on it." She also said she was very proud of her group's graph that showed how many paperclips they were able to pick up each trial. She said she was proud that her group's board was the only one that was complete and neat compared to the other groups in her class. When we were discussing her group's presentation board, she did share some of the peer feedback they received. The pictures in Table 1 shows some of the peer feedback received after Stage 4 of the argumentation session in lab three.

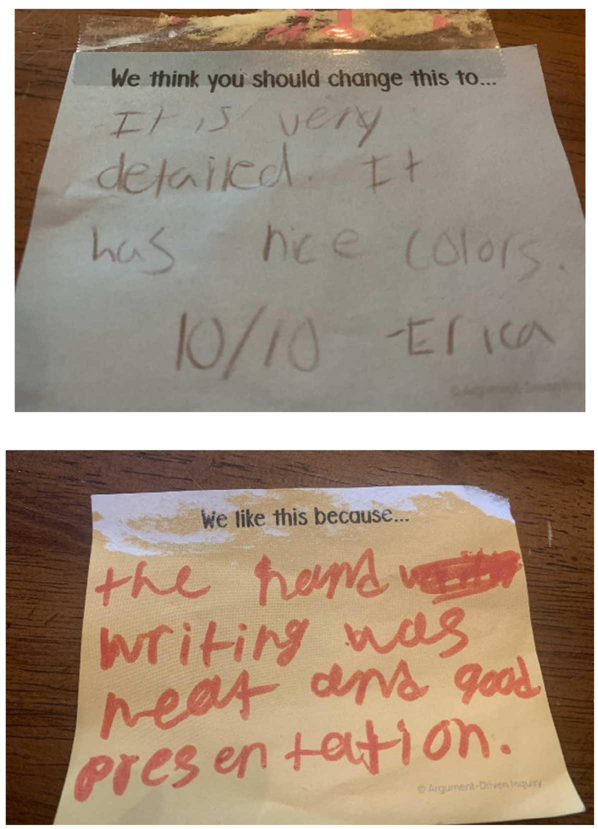

Figure 4.11 Amanda's Groups Peer Feedback

Note. Images of two students' written feedback for Amanda's group's presentation.

"The handwriting was neat and good presentation" reported one student, another student wrote "It is very detailed. It has nice colors." Amanda felt this feedback was nice but did not help them improve their board or design. She felt the feedback did not offer specific information in which her group could improve their presentation board for the next labs. The conversation below occurred in Amanda's group after the peer feedback was received.

Amanda: *I think we should add more about the electrons passing through the wire coils.*

Latina female: *Oh, and we could also talk about the energy transfers. We ain't said nothing about the energy and how it changed.*

Amanda: *Ohhh! I totally forgot!*

Black male: *Me to, we did good on the graph, but need to add a lot to that justification part.*

Amanda: *We could also add this to our reports.*

Latina female: *Yeah.*

This conversation showed Amanda's group clearly connecting the lab investigation with the science content and thinking in a very detailed fashion of how to improve their justification on their presentation board in lab investigation three.

Post-Intervention Formal Individual Interview. Science made her feel very comfortable. She mentioned how she would love to learn more about the stars and the planets. I told her that in her eighth-grade year she would be able to learn about stars, planets, and the solar system. Immediately she smiled and said, "I can't wait!" She also said how much she was looking forward to studying plants during the last part of the sixth-grade year. She had no concerns about science. Her favorite part of the ADI investigation was being able to work with a partner and present them to the class. Amanda stated, “I wanted to be the main presenter each time. I felt I could answer any questions the other groups had for us. I read and look up stuff at home and brought it back for my group to add to our board.” ADI helped her feel more comfortable with science because she was able to explain things more such as electricity and cooking with energy. Amanda stated, “I made them ask me questions. If I couldn’t answer it, I would look it up.” She also enjoyed being able to design her own experiment with her partner. She enjoyed making the models in the labs and testing them. She especially liked the double-blind peer review. Amanda said, “We were like teachers grading each other’s papers.” She enjoyed writing and being able to help others revise their work. Amanda shared that she had never been given a chance to redo her work. She is looking forward to doing more science the rest of the year.

Findings From the Transcripts of the Peer Interactions During the Labs. The table below (Tables 7 and 8) shows how Amanda’s group members responded to other group member’s ideas when they were introduced into the conversation. It is important to note how high the levels of communication are in all three labs. Amanda’s group members worked well together and listened to each other’s ideas and shared ideas as shown in the data. I first examined how often group members contributed to the discussion. These data were generated from the researcher and independent coders transcribing their peer interactions during the labs. Figure 10 provides the total number of comments recorded by each student in Amanda’s group during all three of the lab investigations. These data indicate a high level of collaboration occurring among Amanda and her group members. Figure 12 provides the number of total comments recorded by each student in Amanda's group during all three of the lab investigations. These data indicate the level of participation and how the group members interacted with one another. The graph below shows Amanda's contributions to her group increased during lab investigation two and three.

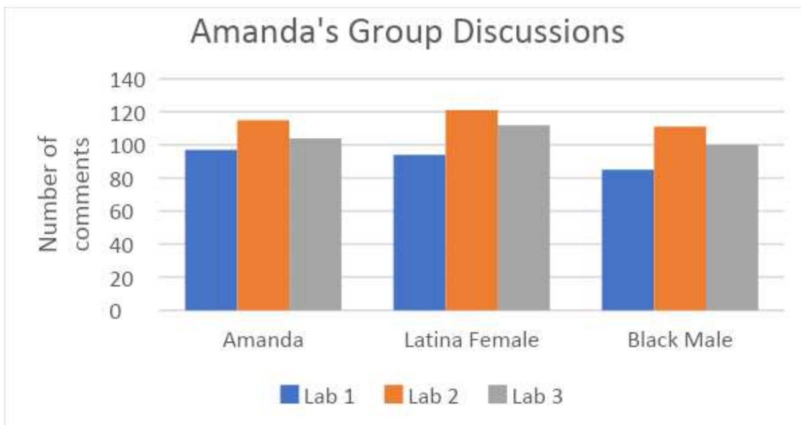

Figure 4.12 Amanda's Group Responses

Note. Amanda's group's progression from lab one to lab three.

Also noted among the independent coders through the transcripts was how often group members discussed an idea when it was introduced. For example, in the following excerpt, Amanda and her group discuss what type of graph would be appropriate to show their data. The collaboration shows them listening to each other's voice and working together as a cohesive team solving a question.

Amanda: *Me too, I think as a group we need to decide about our graph. Our results were 15 cms for trial 1. Right?*

Latina female*: Yes.*

Black male: *Yes*.

Amanda*: So, if our variable is the height for each trial would we need a bar graph?*

Black male: *I can't remember*.

Latina female: *I'm pretty sure the bar graph is correct, remember the temperature graphs we looked at? They were all line graphs.*

Black male: *I found it; this cite says bar graphs compare things.*

Amanda: *So we are comparing the height each time, right?*

Black male: *Yes.*

Latina female: *Yes.*

Table 4.7 Amanda's Group Discussion Table

Group Members	Discussions during Lab 1	Discussions during Lab 2	Discussions during Lab 3
Amanda	98	118	112
Latina Female	90	120	115
Black Male	85	115	100

The table above shows the discussions that occurred between Amanda and her two group members during the three lab investigations. The discussions remained high and consistent throughout the quarter. This group's members were always willing to listen to each other's ideas, make revisions during the lab investigations, and talk to each other about revising the investigation and what they would change in the next investigation. These data suggest that Amanda's group members were willing to engage equally in argumentation during all three lab experiences using the ADI approach.

Table 4.8 Responses for Amandas Group Labs One through Three

Students	Lab 1: IR	Lab 2: IR	Lab 3: IR	Lab 1: RR	Lab 2: RR	Lab 3: RR	Lab 1: AR	Lab 2: AR	Lab 3: AR
Amanda	0	0	0	1	1	2	48	49	67
Latina female	0	0	0	3	1	1	39	42	53
Black Male	0	0	0	1	2	2	42	44	59

This table shows how the individuals responded to each other in Amanda's lab group. The communications remained constant throughout the quarter with this group. For example, the discussions did not show increases between the labs. However, in lab three there was an increase in Amanda's responses followed by increases among the group members.

Findings from Writing Rubric. Throughout the study, it was evident Amanda was eager to make the best grade possible. In the first lab, the students focused on writing the introduction paragraph only. Her first lab report received a score of five out of 16 total points. Her introductory paragraph did not have sufficient background information according to the three student peer reviewers who scored her with a "no" in this category. They also scored a "no" (which translates into zero points) for not providing a clear goal for the investigation. Amanda agreed with these reviews and began to ask her group members for assistance. Peer suggestions included "use the information from the reading and the important facts we highlighted for background stuff." She then used her rubric score to help her in filling in details to her lab report and in building the background information. During the second peer feedback revision, she received the following revision suggestions: "your background information is good, but can you explain what you meant about how you added mass to the tennis balls? What was the mass after you added the rice inside the tennis ball? You just need to add the details." It was this feedback that pushed her to add further depth and produce the following background information:

"Mass is the amount of matter in an object. Our group changed the mass of the tennis ball by adding rice to it. We changed the mass from 5 grams to 15 grams. When we changed the mass, the ball needed more kinetic energy. When we dropped the ball from 30cm it left a deeper impact crater."

Evidence of Learning through Scaffolding of ADI. As Amanda was provided with additional opportunities to improve her writing, she demonstrated much learning for both her written skills and her ability to use evidence to support her conclusions. Amanda showed her understanding of the science concepts in her writing. In the quote above, she showed her understanding of when an electric current travels through a wire it is producing a magnetic field. Amanda also described her understanding with electrical energy, by detailing that the more coils her group placed around an iron core the stronger the magnetic force. This showed that by the end of the quarter, she was making the connections she had learned in the science concepts and connecting those concepts to reasons for their findings.

Impact of ADI Approach on Written Argumentation Skills. Amanda scored a 16 out of 16 on her 4th revision of her first lab report; thus, she kept rewriting until she received a perfect score. She showed progression in her written argumentation skills as evidenced by her ADI rubric scores and by her peer reviews. I later found out she was so driven to improve her writing she was meeting with the librarian during her free time in the morning asking her for feedback. On lab three she scored a perfect score on the second revision. The following is an excerpt from her lab report.

"Whenever an electric current goes through a wire, a magnetic field is created around the nail (made of iron). Electricity and magnetism are related because an electric current produces a magnetic field. This field can also produce an electric current. When electricity travels through the coils of wire, the magnetic field is stronger because each coil acts like one magnet."

Science End-of-Unit 1 Exam. Amanda scored a 100% on the district's end-of-unit science test. When she received her score she said, "Science is my jam!" She also did her version of a victory dance. Note that because Maria and Amanda scored 100% (and were the only two who achieved this district-wide), the district science coordinator arranged to meet with them to have them share what they learned and how they learned all this information in their science class. They were able to share the steps of the ADI approach, they showed her the materials and explained how they used those materials, they showed her their notebooks where they had documented their process steps for their experiments and their information that they put on their presentation boards. Incidentally, when Maria was designing her group's presentation boards, she did not want any students to "touch" the boards because she became protective of how their work was to be displayed. However, when the district coordinator met with her, she was proud to show her the work their group had done on their boards.

4.3 Post-Intervention Focus Group Interviews

As described earlier, the initial focus group including the researcher and all four participants was conducted at the end of the first fall quarter. However, during that initial focus group, the participants were very shy and quiet. When asked about things that came to mind in science, responses included "good, fun, yeah." They provided no elaboration. This contrasted with the individual interviews conducted throughout the first fall quarter in which students shared more of their thoughts beyond single-word responses. To increase the responses from the participants, a second focus group was conducted, approximately a week later. While responses were still limited compared to the individual interviews, this second focus group did result in more responses from the participants. Specific examples include the following.

> Paulina: *Science used to be okay, but now we can help each other and even change our experiment.*
>
> Me: *So, which one of the labs stood out most to you that we did in the first nine weeks?*
>
> Paulina: *The battery*
>
> Amanda: *Yeah, making that electromagnet was cool.*
>
> Allie*: Yeah, that was cool.*
>
> Me: *So why did you all like this lab so much?*
>
> Maria: *I made a good grade.*
>
> Amanda: *Oh snap! That was my highest grade in all the labs. It was neat that electric currents could produce a magnetic field. I took the compass you. Let me*

borrow home. Under electric wires. We have a whole bunch that go gone forever. My compass acted crazy because of the electric wires.

Me*: Are any of you still looking forward to science the rest of the year? If so, is there anything specific?*

Allie: *Animals. I want to learn more about different animals.*

Paulina: *Planets and animals. I wish we could study the planets, especially Mars. I want to go there one day, especially if I discovered something living up there. Not scary though.*

Maria*: Definitely electricity and energy. I don't want it to end!*

According to the participants, their elementary science instruction in the past was limited, at best, and for the ones who did have science in elementary school, it consisted of workbook sheets they completed with a textbook or other source of information. There were no labs conducted, so they did not engage in scientific discussion. There was no data collected to report, and there was no opportunity for presenting an argument or using data to support a conclusion. Maria and Paulina shared that their experiences during this first quarter sixth grade science class were better than elementary school because of the labs. All four enjoyed making their argument and designing the models. Maria stated that she, "felt excited knowing she was going to be able to carry out an investigation that day, and that she did not like others to mess up her work [i.e., presentation board]." Paulina said that "doing the labs were fun, especially because there were no worksheets, and we could talk with our group. It was like we were in. charge of our own class." Paulina also liked it because she could "mess up and try again" as many times as her group felt it was necessary.

Chapter 5:Findings, Discussion, Study Limitations and Recommendations for Future Research, and Recommendations for Teaching Practice

In this study, two research questions were examined. The first research question was, "In what ways did implementing and scaffolding the ADI instructional approach influence the classroom experiences, interest, and self-confidence for female students of color (i.e., non-White) in middle school (sixth grade) science?" The second research question was, "In what ways did using the ADI instructional approach impact female students of color (i.e., non-White) written argumentation skills (including peer review) and scientific voice in middle school (sixth grade) science?" The research presented in this study first showed the positive influence that the ADI instructional approach had on the classroom experiences, interest in science, and self-efficacy in science for four sixth grade female students (one Black, three Latina). Secondly, it showed that ADI positively impacted their written scientific skills as seen through argumentation and their science voice. In the Findings section, I will first review their interest and self-efficacy in science through the two surveys (ATSSA Interest Survey, and the self-efficacy instrument). Second, I will show their final test scores on the district science unit test given after the third and final lab investigation of the first quarter. Third, I will compare the argumentation skills over all three ADI lab investigations. Finally, I will explain the relationship between methods and findings in this study. I will then provide a discussion of the findings, present study limitations and recommendations for future research, and conclude with recommendations for teaching practice.

5.1 Findings

Students' Engagement in Scientific Argumentation

Participation in lab two when ideas were presented served as a starting point for a more in-depth discussion among the students. These trends were illustrated in the tables that showed the groups' discussions (i.e., Table 1 3, 5, and 7), with all four participants. This increase indicates students were more engaged and more willing to talk about, evaluate, and revise their ideas. This type of interaction is important because of the benefits of engaging in scientific argumentation to reject or accept ideas. These data also support that students were challenging each others' ideas and claims more frequently during the last two lab investigations. This analysis suggests that these four students were able and or more willing to engage in scientific argumentation after participating in the three ADI lab investigations using the ADI instructional model.

Two Survey Results

All four participants increased in their interest in science after completion of the ADI lab investigations. Three of the five participants scored a two out of five on the pre-ATSSA Interest Survey, and the other one scored a 4 out of 5. On the post-assessment, Maria, Paulina, and Amanda scored a high interest 5 out of 5, and Allie increased from a 2 out of 5 which indicated a low interest on the pre-survey to a 3 out of 5 on the post-ATSSA Interest Survey which showed a moderate increase.

On the pre-self-efficacy survey, Allie, Maria, and Paulina scored low on their belief they could do science. By the post survey, Allie had increased to a medium score

(3), and Maria increased from a score of 1 to a 5 indicating she had a high level of self-efficacy in her abilities to do science. Paulina increased from a score of a 2 to a 4, indicating her beliefs about her ability to do science increased after doing the Lab investigations. Amanda's self-efficacy for science remained high throughout the study and she had a strong belief in herself and abilities in science, which showed that the ADI approach did not diminish her high interest and self-efficacy. Thus, from the two surveys – interest and self-efficacy – the ADI approach resulted in an increase in both for the participants who started off low, and also increased or maintained a high level for the participants who started off in a higher range. In sum, the pre- and post-surveys showed support for the ADI approach as beneficial for these participants, regardless of whether they began with initially low or high interest and self-efficacy in science, which suggests that the ADI approach could be beneficial for all students.

District Science Unit Test

All four participants outperformed the sixth-grade class average of 74%, which was comprised of all students – those who were taught with the ADI approach and those who had traditional science classes that did not use ADI. Further, three of the four participants scored better than the average of the honors students at 88%. Maria, Paulina, and Amanda scored 100%, 97%, and 100%, respectively. Allie scored 80% which was high for her, especially considering that her pre-scores were very low and that she refused to write the lab reports. The participants' performance on the district science unit test compared to the entire sixth-grade class and to the honors students, indicates that the ADI approach had a positive impact on their ability to demonstrate their content knowledge on a multiple-choice science test administered at the district level. These outstanding test scores provide even further support for using the ADI approach with female students of color, considering that all four of them indicated in their pre-interview that their previous science experiences were either non-existent or they were "just ok" as Paulina said. We can conclude that even for students who did not begin the class with any enthusiasm for science the ADI approach was highly beneficial on their science content knowledge.

Written Scientific Skills Through Argumentation and Their Science Voice

The students' oral discussion totals during ADI labs for combined males verses females provided evidence that ADI had a positive impact on the females' ability to engage in discussion comparable to males. In this study, females' discussion totals increased from 4 to 48 to 79 across the three labs while males' discussion totals went from 42 to 30 to 68 across the three labs. In the research presented here, after having been taught with the ADI approach, the four female participants in this study had a strong belief in their ability to contribute to a healthy discussion with peers during science lab investigations.

The three participants Maria, Paulina, and Amanda increased their writing scores. Evidence of this improvement in writing was seen in her ADI rubric scores of 180 points on her first lab report, 300 on her first re-write of lab one, 300 on her initial lab two report, 380 on her lab two final revision, 380 on lab three initial report, and 400 on lab three final report. Paulina's writing scores in lab investigation two increased with a total score of 350 out of 400 on the Investigation Report Peer-Review Guide: Middle School Version. It is important to note Paulina received a perfect score on all three labs after using the peer feedback. Amanda also showed an increase from lab one to lab two. After four revisions using the peer feedback, she scored a perfect score in lab two. Lab three, she received a perfect score from her peers after the second revision. This progression in the girls written argumentation skills as evidenced by their ADI rubric scores after the peer review process showed a positive impact of using the written argumentation peer feedback.

All four girls enjoyed participating in and communicating with their group as well as designing their own experiments. For example, Allie's discussion totals during the ADI labs provided evidence that the ADI instructional approach had a positive impact on her ability to engage in discussions during the lab investigations. In the first lab her contribution to the group's discussion increased from 46 to 78 to 147. This shows the importance of doing more than one ADI lab with students. These totals provide evidence that ADI increased discussion among students during labs. Collectively, the evidence overall supports that the ADI instructional approach allowed students the opportunity to take advantage of its components, such as receiving peer and teacher feedback and revising written lab reports, to improve their grades, and to increase academic achievement in several subject areas, including reading and writing.

Maria, Paulina, and Amanda all showed increases in their communication, writing, and feedback to their group. Maria, Paulina, and Amanda showed increases in the areas of written argumentation, arguing from evidence, and justifying their evidence from lab one to lab three. Allie also showed an increase in communicating the information and the science concepts in lab two and three. This is a perfect example of the success that a student can have when they take advantage of the strengths of the ADI approach. The patterns for the participants are similar, showing strong evidence that ADI was effective for African American and Latina females, and was not just dependent on the group composition. ADI is effective for argumentation, writing in the form of lab reports, and student voice (as seen in “discussion” comments) and that ADI was effective in decreasing or eliminating the gap between race and gender for scientific argumentation and student voice in science.

Relationship Between Methods and Findings in this Study

The qualitative methods used in this study were intended to give an in-depth holistic understanding of a population by ensuring that the knowledge gained was representative of the population from which the sample was drawn (Cresswell & Plano Clark, 2011). The goals of this study were aligned with Creswell’s qualitative goals (Cresswell, 2003). To understand the experiences of four sixth grade girls of color, I implemented a case study research design. The case study was useful when I needed to understand the specific group of people in great depth. The case study provided a better basis for understanding for what occurred with each participant personally; this qualitative case study research design was essential for understanding the students’ own words to achieve a deep understanding of their experiences. Using the students’ own words developed understanding from their perspectives, and it provided a glimpse into the students’ everyday life. This approach provided the appropriate methodology for exploring an important subpopulation of individuals in a middle school science setting. Continuing to apply this type of methodology to future research studies would be appropriate in expanding the knowledge base in the field of science and the use of ADI as an effective instructional approach.

5.2 Discussion

Findings from this study suggest that the ADI instructional approach was beneficial in increasing science interest, self-efficacy, and academic success for sixth grade female students of color. Specifically, as seen in the lab investigations and final individual interviews, all the students indicated that they enjoyed science and carrying out the investigations. In the second and third labs, students were discussing ideas, challenging each other's claims, and using data to support their findings. Students seemed to be increasing in their level of engagement as they talked to and discussed with each other their ideas (Engle & Count, 2002). This was observed as students grew in their confidence in doing science (self-efficacy) and grew in their communication skills during the labs while proposing, clarifying, and/or justifying their own ideas. The fact that there was evidence that students began communicating their own ideas during discussions when they were in group activities such as the labs, provides support for the notion that when students understand the Nature of Science (NOS), it allows students to construct and make informed discussions regarding multiple perspectives and interpretations (Sadler & Zeidler, 2005). Students were open to revisions and considered new ideas. Students also began to address each other's questions about the natural world (their community). The ADI labs do support communication among students and as seen in the literature review (Sampson et al., 2012). As seen in this study, all four girls grew in their ability to communicate their findings about the claims and evidence. This finding further supports prior research showing the impact of ADI on students' communication skills (NAEP, 2009). This was true even for the two students who began the interviews stating that they did not enjoy science. Similarly, the interest and self-efficacy surveys supported these increases for all student participants, even for the three who started off with low scores. The only exception was for one participant whose self-efficacy in science started off with the highest score possible, and her post-score remained the highest score possible; thus, her interest in science maintained throughout the ADI instructional process. Even for the participant who started out with a very low score in interest and self-efficacy and ended up with a moderate level of interest in a career in science, she became very vocal about enjoying the class, and she continued to maintain good grades in science. In addition, evidence of academic success through scientific growth based on the instructional goals of ADI were evidenced in several ways. First, when the participants developed their scientific presentation boards, some of the participants were able to support their claims using scientific evidence as seen in the research of Sampson et al., (2012) and Nussbaum et al., (2008). Second, their use, presentation and discussion of their data collection, graphs and data analyses became increasingly more accurate as the quarter progressed (Driver et al., 2000). This could easily be attributed to the fact that with the ADI approach, students cycle quickly through repeated labs with accompanying written reports with teacher and peer feedback. Third, their approach to the way they carried out their scientific investigations increased greatly with accuracy. Specifically, they started out not controlling their variables and not using a systematic approach to conducting their investigations. However, when instructional scaffolds were implemented and they were given opportunities to repeat their labs, by the end of the quarter, they were using systematic approaches to conducting their investigations, and they made sure to control all variables except the ones being manipulated. Finally, their academic gains in science content were realized through very high scores on district-wide assessments.

While findings supported increases in many areas investigated, several learning issues persisted even when the ADI instructional model was used during the first quarter of sixth grade. The students in this study, for example, did not use scientific explanations as a tool to solve problems or to evaluate claims, and some students seemed to be reluctant to discuss a wide range of ideas when they participated in an episode of scientific argumentation. One quarter of a school year was probably not sufficient to see this gain. Sampson et al., (2012) designed 15 laboratory activities over an 18-week period. During their intervention, they observed an increase in students' engagement, challenging each other's ideas, and justifying their findings with evidence. The fact that this study was only nine weeks, and Sampson's study took place across 18 weeks, supports the notion that "sense making" (making sense of science in a way that students use it to support their claims) takes time. Another research goal in this study was to investigate the impact of ADI on student voice. Unfortunately, when interviewed at the final interview, none of the participants stated that their voice was valued. This was a surprising finding because the recordings from their actual interactions with their groups indicated to me as a researcher and science teacher that they were using their voices actively. However, their perceptions were that their voices were not valued. One possible explanation for this could be attributed to the multiple quarantines throughout the quarter which limited their opportunities for social interactions with their peers which likely hindered their ability to develop the same types of comfortable relationships with their peers that they would have under normal circumstances. Another possible factor is simply their stage of life. Middle school is a time of uncertainly in oneself, and this could have more strongly influenced their perceptions of their voice not being valued rather than their actual use of voice with their peers during lab discussions (Shemwell & Furtak, 2010). Findings from Rivera-Maulucci et al. (2014) support the notion that providing students opportunities to engage in authentic inquiry in science has positive influences on students generating ideas about what they could do in critical science scenarios. Further evidence of this occurred during the first post-study group focus group in which there were very few social interactions between any of the student participants. In fact, they looked at the teacher, but they would not look at each other. They also were unwilling to speak very much at all. This prompted me to conduct a second post-study focus group in an attempt to increase participation in discussion. While the discussion was better, it was still not as good as the discussions during the individual interviews.

5.3 Study Limitations and Recommendations for Future Research

The first limitation of this study was that this study only involved four participants. While this low number was appropriate for this initial study, it resulted in limitations in generalization of findings. Thus, it is recommended that a larger sample size should be used to see if it is beneficial for larger number of students and for students in different class periods. It is also recommended that more of these types of studies be conducted to determine consistency in findings across time. Closely related, this is only one study involving only a few participants in one school and with one teacher. Thus, it would be recommended to conduct additional studies with more female students of color involving more teachers. Much work remains to be done, however, to evaluate the efficacy of the ADI instructional model in a wider range of context at a larger scale and to identify other issues that might be barriers to student learning. One question that further research should focus on would be to systematically evaluate the application of the ADI instructional approach with other sixth grade female students of color across schools and with additional teachers.

A second limitation of this study was that it was conducted only over the first nine weeks rather than the entire year which would have provided a longer timeframe for the full benefits of the ADI approach to be realized. It is recommended that future research studies be conducted with greater numbers of female students of color, conducted for longer timeframes (e.g., the entire year, throughout the middle school grades), similar to Sampson's study (2009) which covered an entire semester rather than one quarter. In addition, collecting data and analyzing results for a semester or even better across the entire academic year, rather than just one nine-week grading period, would have allowed for patterns to emerge. Specifically, do the benefits result in a steady increase, or are there peaks and valleys in the benefits across content or differential student groupings that would occur throughout the year? Is it the case that once a student finds her voice, that she can apply it to a different student group, or does she have to "rediscover" it in each new group? Closely related, is the question of whether one quarter, especially the first quarter of sixth grade in which the students were new to each other, is sufficient time to see relationships develop fully and students to become as comfortable as possible with each other which is necessary for realizing the value of one's voice. In a study, Wiesselmann et al., (2020) points out that this may affect student performance enactments during research. His study tested only one unit of instruction; he supports including more units of study to investigate students' interactions. Thus, it is recommended that additional studies span across all four quarters of a school year rather than only the first quarter to allow relationships and comfort levels to fully develop.

Third, this study was conducted during a time of continuing quarantines with the ongoing social distancing requirements due to the Covid-19 pandemic. Covid pandemic restrictions hindered consistency in ADI application due to the high levels of student absences. The virtual participation in labs resulted in gaps in the otherwise fluid progression in labs. Permanent products that would normally be retained, such as written lab reports, were not allowed; this restriction hindered both the students in their ability to provide written feedback directly on the other students' papers, as well as the instructor's ability to collect the written lab reports. Thus, future studies of the application of ADI in multiple learning environments, including traditional and virtual contexts should be explored to realize the full benefits of the ADI approach in different educational contexts and with greatly levels of consistency in student attendance.

Finally, this study was conducted in sixth grade only. It is recommended that future studies investigate the benefits of ADI in elementary grades; this could allow for students to build their science backgrounds and foundational knowledge and skills (e.g., making observations, collecting data, etc.), their ability to communicate with others as scientists, and to be exposed to the fact that not all science is absolute in having one right or wrong answer, but rather the importance of using evidence to support findings and to be able to use experiments to revise ideas and conclusions. In order for ADI to realize its maximum potential, studies should be conducted with professional development for science teachers in all grade levels, beginning with elementary grades, continuing with middle school, and continuing into high school. Future studies should focus on administration (e.g., at the principal and superintendent levels) and teachers.

5.4 Recommendations for Teaching Practice

In closing, the findings in this study provide additional insight for science educators interested in promoting and supporting scientific argumentation for girls of color inside the classroom. This study also demonstrates what is possible in the classroom when science lab investigations are designed to be more authentic and educative (Rivera Maulucci et al., 2014). The findings contribute insights to science educators looking for ways to cultivate scientific argumentation inside the classroom and ways to improve students' knowledge and skills which can be seen even over a relatively short period of time (i.e., one quarter). Rather than teaching students specific discourse strategies or rules for engaging in argumentation or crafting arguments in a decontextualized and mechanical means prior to learning content, teachers can use instructional models, such as ADI, to provide a context for students to learn important content and how to participate in important scientific practices such as argumentation simultaneously. Having students construct an explanation or argument as part of an investigation, for example, requires students to clarify their thinking, to generate examples, to recognize the needs for additional information, and to monitor and repair gaps in their understanding (Archer et al., 2013). It also requires students to learn and use the criteria by which these explanations or arguments will be judged or evaluated. This type of approach, as I demonstrated here, can be an effective way to help students develop the abilities needed to participate in scientific argumentation, understand how to craft written arguments, learn important content, and increase their use of student voice with peers during science. To understand the goals of argumentation and ADI, extensive professional development in argumentation should be provided to teachers to support and promote student learning in this type of context: specifically, using the ADI instructional approach (Enderle et al, 2022). Enderle et al., (2022) suggest that teachers' beliefs, and contextual factors influenced their adaptations of the ADI model. Research found teachers knowledge and prior experiences played a key role in the way they delivered the curriculum (Davis et al., 2016). Professional development can also influence teachers' beliefs and prior knowledge of enacting the ADI model. Calbrese et al. (2021) showed that authentic science inquiry approaches that place the social and cultural context of knowing and doing science enhances student's individual learning and learning as a collective. Achieving a balance between what students currently know (connections to their community and life), and the science theories will need to be the target when using the ADI instructional model. The results of the study indicated that the participants in my study came into their science course lacking in specific understanding of what counts as valid or acceptable in the context of science such as general components of argumentation - the role of claims, the need to support claims with reasons, and the so forth. Based on the findings in this study, it is recommended that teachers establish and maintain a classroom culture and discourse environment inside the science classroom that is inclusive and more aligned with how knowledge is communicated, represented, and argued in science, in order to address the needs of all students, especially students underrepresented in science such as African American and Latina females that were the sample population in my study. One suggestion I propose is to revise Stage One of the ADI model which is where students read and become familiar with the task and guiding question. I suggest moving the reading to Stage Five and provide the squeepers scaffold to model note taking strategies as the students read the articles. In Lab 14, the students in this study could not make connections to the teeter tooter or picture of the circus performers on the teeter totter. In lab 13, the reading was about a car accident which may be hard for students losing a parent in an automobile accident. I recommend using the

OWL approach – Observation, Wondering, and Learning – for this stage. Students can make a three-column chart and label each column with an O, W, and L. Then the teacher can begin the investigation using an anchoring phenomenon (Worksky, 2017). This could be done in the form of a video, picture, or a guiding question. Phenomena first allows students and teachers the opportunity to give all students the shared experience to build their knowledge to begin the lesson and generate questions through the science processes (Krajcik, 2022). As the students develop more questions, they will place them in the W (wondering) column as a platform to guide their investigation. As the students learn and find the answer to their wonderings, they can record their answers in the learning section. Data collection scaffolds such as the mini labs discussed earlier would prepare students in developing a claim as well as collecting data during an investigation. This scaffold also provides an opportunity for the instructor to discuss variables. In addition to supporting students in developing investigation skills, the teacher can also scaffold student to student discourse. To ensure every voice is valued using the accountable talk scaffolds allow opportunities for students to learn how to comminate with one another in a respectful manner (Roth, 2002). They learn how to disagree, challenge each other's claims, as well as discuss their ideas. Preparing educators so they may be able to learn to teach in this manner will be a challenge facing science educators, but it will be one that is rewarding because it will help support all students in their full potential for learning in science. Thus, using these scaffolds in key areas related to the ADI approach, such as using the OWL approach for supporting students in making real-world connection with science, will help science teachers apply ADI in the post-COVID world (see Figure 5.1 below) (Enderle et al, 2022).

Stage 1-Identify the task. OWL (Observe, Wonder, Learn) students observe a phenomenon and will generate their own guiding questions (wonderings) to the phenomena they observed.

Stage 2- Design a method. (Design) 1st suggested scaffold- students independently design a model. Then they come together to collaborate as a group and view each other's designs. Students then design the model they will test as a group incorporating all their ideas. 2nd Scaffold Data collection- using a mini lab investigation "How many drops of water will fit on the head of a penny?" (This scaffold will show students how to record data using a table and control their variables).

Stage 3- Analyze data and develop a tentative argument

Stage 4- Argumentation session.

Stage 5 – Explicit and reflective instruction. Scaffold, this is where the reading from stage 1 would be moved. As students read the squeepers reading strategy would be used to help students read informational text and take notes.

Stage 6- Scaffold writing by focusing on the introduction the first investigation. The second investigation will include the introductory paragraph and the body. By the third lab have students begin completing the introductory paragraph, the body of the paragraph and the conclusion.

Stage 7- Double blind peer review

Stage 8- Revise and submit report.

Figure 5.1 A Model of ADI in a Post-COVID World

Note. This figure shows a model for the application of the ADI instructional approach in a post-COVID world, using scaffolds in key areas related to ADI.

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Appendix A. Informed Parental Consent and Student Assent to be a Research Participant

University of South Carolina

Informed Consent to be a Research Participant

Using Argument Driven Inquiry to Positively Influence the Experiences of Girls of Color in Sixth Grade Science

Please read the following consent form carefully before choosing to sign for consent to participate

Introduction and Purpose

You are invited to volunteer to allow your child to participate in a qualitative research study conducted by Paul Duggan. I am a sixth-grade science teacher at Crossroads Intermediate School and a doctoral candidate in the Department of Teaching and Learning at the University of South Carolina. The University of South Carolina, Department of Teaching and Learning is sponsoring this research study. The purpose of this study is to understand the experiences of four sixth grade girls of color, in a science classroom using the Argument Driven Inquiry instructional approach. You are being asked to provide permission for your child to participate in this study because your child is a student studying science and has important experiences to share. This study is being done at Crossroads Intermediate School and will involve approximately four volunteers.

The following is a short explanation of this study to help you decide whether to allow your child to be a part of this study. More detailed information is listed later in this form.

Description of Study Procedures

The purpose of this study is to understand the perspectives of sixth grade girls of color and their experiences in a science classroom using the Argument Driven Inquiry (ADI) instructional approach. ADI will be used throughout the science class to help all students to learn science content. During an ADI activity, student engage in regular science activities such as laboratories or readings in which they learn about scientific evidence that can be used to support scientific ideas. Students work with their peers to write scientific arguments through a collaborative process of writing and peer revision. Whether in the study or not, all students will engage in the same science activities to learn the SC science standards. Through this study, I will seek to understand the experiences of the students who participate in ADI. Through this research, I hope to be able to be able to find ways to better support and engage girls of color (Black, Latina, Native American) in science learning.

Students that agree to participate in the study will be asked to participate in a survey (20 minutes) three times during the first nine weeks and one focus group interview (30 minutes) together with the other three participants at the end of the study. The interviews will take place during non-instructional time during school hours or before or after school at a time convenient for the students. Students' interactions during labs will be audio-recorded and analyzed, and written classwork from the ADI activities will also be collected (peer review, initial and final written arguments) and analyzed for the study.

Confidentiality

The information that is obtained in connection with this research study will remain confidential. Any information disclosed will be with your expressed written permission. Study information will be securely stored in locked files and on password-protected computers. Results of this research study may be published or presented at seminars; however, the report(s) or presentation(s) will not include your child's name or other identifying information about your child or the student's school.

Voluntary Participation

Participation in this study is voluntary. You are free not to allow your child to participate, to stop participating at any time, for any reason without negative consequences. In the event that you do withdraw your child from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw your child from the study, please call or email the principal investigator Paul Duggan listed on this form below. The student's participation or non-participation in the study will not have any influence on their grade in the science course.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. If I have any more questions about my participation in this study, or study related injury, I am to contact Paul Duggan (803) 476-8300 or email pfduggan@lexrich5.org.

Questions about your rights as a research subject are to be directed to, Lisa Johnson, Assistant Director, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414, Columbia, SC 29208, phone(803) 777-6670 or email lisaj@mailbox.sc.edu

Parent Consent:

Please check ONE of the two statements below:

_____ YES, I give my parental permission for my daughter to participate. I confirm that I have read and understood the purpose of the study, the fact that my daughter's participation in this study is voluntary, and that I can withdraw her participation at any time.

_____ No, I do NOT give parental permission for my daughter to participate.

Please PRINT your name as the PARENT here: _________________________________

Please SIGN your name as the PARENT here: ________________ Date: ____________

Student Assent (if Parent Consent is provided):

Please check ONE of the two statements below:

______ YES, as the student, I agree to participate in this study.

_____ No, as the student, I do NOT agree to participate.

Please PRINT your name as the student here: ____________________________________

Please SIGN your name as the student here: ______________________ Date: __________

Appendix B: Individual Semi-Structured Interviews

Interview Questions

First interview questions:

1. What name (pseudonym) would you like me to call you during the research (our time together)?
2. How would you describe your previous experiences in science classes when you were in elementary school? For example, what were some things that you liked, and what were some things that you didn't like?
3. Have you ever participated in a science fair or carried out your own science project? Please describe if you have done so.
4. What were some things that stand out to you about science in your elementary science classes? For example, it could be types of learning content you worked on, or it could be how the classes were structured, such as doing hands-on activities, or watching movies about science or looking things up on the internet?
5. In elementary school, did you have opportunities to collaborate with your classmates or work in groups? How did you feel in this process?
6. a. Did you conduct lab experiments in your elementary science classes? If yes, then ask b, c and d

   b. Did you find the science experiments interesting?

   c. Please describe one that you remember.

   d. How would you describe yourself as a science student during lab experiments?
7. How would you describe your abilities in science?
8. What, if anything, are you looking forward to the most this year in science? What is something that concerns you about science this year?

Second Interview Questions

1. On the survey you indicated science is (fun/not fun). Please explain why you think this.

2. I noticed you said on the survey science makes you feel comfortable/ uncomfortable, restless, irritable, and impatient. Please describe a time in science that this occurred.
3. Is there a specific science topic you enjoy? (physics, astronomy, weather, animals, plants, etc.).
4. On the second survey you said it is/ is not important to earn an A in science. I would be interested to know why you feel this way.
5. Do you feel science is important in your community? Please tell me why you feel this way.
6. During the first time we spoke about this, you said you were looking forward to ______. Are you still looking forward to this? Has anything happened towards this? Has this changed?
7. During the first time we spoke about this, you said you were concerned about ______. Does this still concern you, or has that changed?

Final Interview Questions

1. I am comparing your responses on the final survey and second survey. You said science was (fun/not fun), and on the first survey you said science was (fun/not fun). Please describe what influenced your answer.
2. How did using ADI during the science labs make your feel during science?
3. Do you feel ADI made you less confident/ more confident during science? Explain.
4. Do you feel your science experience has changed this nine-weeks compared to your elementary science experiences? How?
5. What was it like to design your own experiment and collaborate with your peers during an investigation?
6. Please describe what it was like to participate in a blind peer review. Do you think this helped your understanding and writing skills in science?
7. Which stage of the lab investigation did you find most enjoyable? The most helpful?
8. Ask a follow-up question about what they were looking forward to this year in science (wording will depend on their responses from interviews one and two).
9. Ask a follow-up question about what concerned them about science this year (wording will depend on their responses from interviews one and two).

Appendix C: Semi-Structured Focus Group Questions

Research Question 1: In what ways does implementing and scaffolding the ADI instructional approach influence the classroom experiences, interest, and self-confidence for female students of color (i.e., non-White) in middle school science?

Research Question 2: In what ways does using the ADI instructional approach impact female students of color (i.e., non-White) written argumentation skills (including peer review) and scientific voice?

Note: Examples will be provided if needed, such as if there is a long period of silence, or if the students seem confused, or if they ask "what do you mean?"

1. You have been in my science class in middle school for nine weeks. How are things going? What are some things that come to mind about our science class? For example, "It's not my favorite class," "We get to do more experiments than we have in past science classes," "I like when we get to make models and test them," "I wish we didn't do so many experiments and were just told the information that we are going to have on the test."
2. How does your experience compare to the elementary experiences you had?
3. Where the writing scaffolds (Squeepers) helpful? Can you explain?
4. How do you feel when you know that we are going to have an experiment or an investigation in science class that day? (For example, excited or nervous.
5. What are some things you think are going well in the Lab investigations? For example, like to get to talk together and work on science together with other students, like that everyone gets to contribute, we all work together well.

6. What problems do you see when you are in the Lab investigations? For example, one person in our group controls everything, other people tell me I’m wrong, we can’t seem to agree,
7. How do you think that the way our science class is conducted – “arguing with evidence” – has contributed to your learning in science?
8. What do you like best about the way we do science class?
9. Is there anything about the way we do science class that you think would help you learn science better?
10. What are some things you would do differently in science class?
11. Do you feel science relates to your outside interest?
12. Is there anything else anyone would like to say about science class?

Appendix D: Science Interest Instrument: Attitudes Towards Science in School Assessment (ATSSA)

The *Attitudes Towards Science in School Assessment* includes the following 14 items and will include these instructions.

Please indicate the degree to which you agree or disagree with each statement below by writing the appropriate letter code to the right of each statement.

SA = Strongly Agree

A = Agree

N = Neutral

D = Disagree

SD = Strongly Disagree

1) Science is fun.
2) I do not like science and it bothers me to have to study it.
3) During Science class, I usually am interested.
4) I would like to learn more about science.
5) If I knew I would never go to science class again, I would feel sad.
6) Science is interesting to me and I enjoy it.
7) Science makes me feel uncomfortable, restless, irritable, and impatient.
8) Science is fascinating and fun.
9) The feeling that I have towards science is a good feeling.
10) When I hear the word science, I have a feeling dislike.
11) Science is a topic which I enjoy studying.
12) I feel at ease with science and I like it very much.
13) I feel a definite positive reaction to science.
14) Science is boring.

Appendix E. Middle School Self-Efficacy Scale

Indicate your ability to do each of the following statements below by writing the appropriate number to the right of each statement.

1 = Very High Ability

2 = High Ability

3 = Uncertain

4 = Low Ability

5 = Very Low Ability

1. Earn an A in science. (S)
2. Get an A in science in high school. (S)
3. Design and describe a science experiment that I want to do. (S)
4. Classify animals that I observe. (S)
5.Predict weather on a weather map (S)
6. Construct and interpret a graph of rainfall amounts by state (S)
7. Develop a hypothesis about why kids watch a certain TV show (S).
8. If I do well in science, then I will do well in high school (S)
9. If I get good grades in science then my friends will approve of me (S).
10. I intend to take science classes in high school (S).
11. I am committed to study hard in my science classes (S).
12. I am determined to use my science knowledge in my future career (S).
13. I intend to enter a career that will use science (S).

Note: (S) indicates the item was on the science subscale.

Part II. Mathematics & Science (Self-Efficacy)

Indicate your ability to do each of the following statements below by writing the appropriate number to the right of each statement.

1 = Very High Ability
2 = High Ability
3 = Uncertain
4 = Low Ability
5 = Very Low Ability

1. Earn an A in math. (M)
2. Earn an A in science. (S)
3. Get an A in math in high school. (M)
4. Get an A in science in high school. (S)
5. Determine the amount of sales tax on clothes I want to buy. (M)
6. Collect dues and determine how much to spend for a school club. (M)
7. Figure out how long it will take to travel from Milwaukee to Madison, driving at 55 mph. (M)
8. Design and describe a science experiment that I want to do. (S)
9. Classify animals that I observe. (S)
10. Predict the weather from weather maps. (S)
11. Construct and interpret a graph of rainfall amounts by state. (M)
12. Develop a hypothesis about why kids watch a particular TV show. (S)

Mathematics & Science (Outcome Expectancy/Intentions and Goals)

Please indicate the degree to which you agree or disagree that you could do each statement below by writing the appropriate letter code to the right of each statement.

1. If I take a lot of math courses, then I will be better able to achieve my future goals. (M)
2. If I learn math well, then I will be able to do lots of different types of careers. (M)
3. If I take a math course, then I will increase my grade point average. (M)
4. If I do well in science classes in middle school, then I will do well in high school. (S)
5. If I get good grades in math, then my parents will be pleased. (M)
6. If I get good grades in math and science, my friends will approve of me.*
7. If I do well in science, then I will be better prepared to go to college. (S)
8. I plan to take math classes in high school. (M)
9. I intend to take science classes in high school. (S)
10. I am committed to study hard in my science classes. (S)
11. I intend to enter a career that will use math. (M)
12. I am determined to use my science knowledge in my future career. (S)
13. I intend to enter a career that will use science. (S)
14. The career my parents want for me is ____________________.
15. The career my teachers think I should enter is ________________.

*Due to poor psychometric characteristics, this item was dropped from the final scale. (M) indicates the item was on the Math subscale. (S) indicates the item was on the Science subscale.

Appendix F. Argument Driven Inquiry (ADI) Assessment Rubric: Investigation Report Peer Review Guide Middle School Version

This rubric is used by the teachers in the science department to collaboratively determine the level of mastery with ADI skills, including written argumentation skills.

Note: A copy of the actual rubric is provided on the following pages.

ADI Investigation Report Peer Review Guide – Middle School Version

Report By: ______________________
ID Number

Author: Did the reviewers do a good job? 1 2 3 4 5
Rate the overall quality of the peer review

Reviewed By: ______________ ID Number ______________ ID Number ______________ ID Number ______________ ID Number

Section 1: Introduction and Guiding Question	Reviewer Rating			Teacher Score
1. Did the author ***provide a context*** for the study?	No	Partially	Yes	0 1 2
2. Did the author provide enough ***background information*** about the phenomenon being studied?	No	Partially	Yes	0 1 2
3. Is the background information ***correct***?	No	Partially	Yes	0 1 2
4. Did the author make the ***guiding question*** clear?	No	Partially	Yes	0 1 2

Reviewers: If your group made any "No" or "Partially" marks in this section, please **explain how the author could improve** this part of his or her report.	**Author:** What revisions did you make in your report? Is there anything you decided to keep the same even though the reviewers suggested otherwise? Be sure to explain why.

Section 2: Method	Reviewer Rating			Teacher Score
1. Did the author provide a clear description of what he or she did during the investigation in order to ***collect data*** (the method)?	No	Partially	Yes	0 1 2
2. Did the author describe ***how*** he/she ***analyzed*** the data?	No	Partially	Yes	0 1 2
3. Did the author use the ***correct term*** to describe his/her investigation (e.g., experiment, observations, interpretation of a data set)?	No	Partially	Yes	0 1 2

Reviewers: If your group made any "No" or "Partially" marks in this section, please **explain how the author could improve** this part of his or her report.	**Author:** What revisions did you make in your report? Is there anything you decided to keep the same even though the reviewers suggested otherwise? Be sure to explain why.

ADI Argument-Driven Inquiry

Section 3: The Argument	Reviewer Rating			Teacher Score
1. Did the author provide a ***clear and complete claim*** that answers the guiding question?	No	Partially	Yes	0 1 2
2. Did the author use **evidence** to support his or her claim? Evidence is an analysis of data and an explanation of what the analysis means.	No	Partially	Yes	0 1 2
3. Did the author ***present the evidence*** in an appropriate manner by				
✂including a correctly formatted and labeled graph (or table);	No	Partially	Yes	0 1 2
✂using correct metric units (e.g., m/s, g, ml); and	No	Partially	Yes	0 1 2
✂referencing the graph or table in the body of the text?	No	Partially	Yes	0 1 2
4. Does the ***evidence support the author's claim***?	No	Partially	Yes	0 1 2
5. Did the author use a scientific concept to ***justify the evidence***? The justification of the evidence explains why the evidence matters.	No	Partially	Yes	0 1 2
6. Is the ***justification of the evidence*** acceptable?	No	Partially	Yes	0 1 2
7. Did the author **use scientific terms correctly** (e.g., *hypothesis* vs. *prediction, data* vs. *evidence*) and **reference the evidence in an appropriate manner** (e.g., *supports* or *suggests* vs. *proves*)?	No	Partially	Yes	0 1 2

Reviewers: If your group made any "No" or "Partially" marks in this section, please **explain how the author could improve** this part of his or her report.	**Author:** What revisions did you make in your report? Is there anything you decided to keep the same even though the reviewers suggested otherwise? Be sure to explain why.

Mechanics	Reviewer Rating			Teacher Score
1. ***Organization:*** Is each section easy to follow? Do paragraphs include multiple sentences? Do paragraphs begin with a topic sentence?	No	Partially	Yes	0 1 2
2. ***Grammar:*** Are the sentences complete? Is there proper subject-verb agreement in each sentence? No run-on sentences.	No	Partially	Yes	0 1 2
3. ***Conventions:*** Did the author use appropriate spelling, punctuation, and capitalization?	No	Partially	Yes	0 1 2
4. ***Word Choice:*** Did the author use the appropriate word (e.g., there vs. their, to vs. too, then vs. than)?	No	Partially	Yes	0 1 2
Teacher Comments:				

Argument-Driven Inquiry

Lederman, N., & Lederman, J. (2004). Revising instruction to teach Nature of Science: Modifying activities to enhance students' understanding of science. *The Science Teacher, 71(9)*, 36-39.

Appendix G: Ximena's Art Portfolio Illustration