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Why Ask Questions? How Phenomena-Based Inquiry Affects Student Engagement in a Middle School Science Classroom

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WHY ASK QUESTIONS? HOW PHENOMENA-BASED INQUIRY AFFECTS STUDENT ENGAGEMENT IN A MIDDLE SCHOOL SCIENCE CLASSROOM

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DEDICATION

This dissertation is dedicated to my family who have supported me through this process these last four years. First, I want to thank my mom, who has always believed in me even when I didn’t believe in myself. I also want to thank my sister and her family for their unyielding support and understanding. I love you guys all so much! In addition, I would like to thank my best friend Edmond, who has been so supportive by giving me the time I needed to get this thing done! And most of all, this dissertation is dedicated to my dad, who years ago probably thought I would never finish college. His never-ending encouragement was invaluable and, although I know he is looking down beaming with pride, I wish he was here. I love you Daddy!

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ABSTRACT

The purpose of this study was to examine the effects of phenomena-based inquiry on students' engagement levels in my science classroom. This action research study took place in the fall of 2021 with six student participants. Participants were enrolled in an eighth-grade honors science course in a middle school in South Carolina. The research was predominantly qualitative, and data was collected from participant pre- and post-study surveys and interviews, anticipation guides, exit tickets, online discussion forums, and teacher field notes. The data revealed that phenomena-based inquiry encouraged students to participate and engage in their own learning, as indicated by post interview questions, improved post-study survey scores, and teacher observations. By sparking students' curiosity, making content relevant to their own lives, and heightening their confidence, phenomena-based inquiry increased engagement in the classroom.

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CHAPTER 1

INTRODUCTION

As an eighth-grade science teacher, I have a responsibility to ensure my students both understand science knowledge and have the skills necessary to practice and refine this knowledge. Students learn pertinent vocabulary and concepts and then learn to apply and practice through labs, demonstrations, and other activities to promote active learning versus passive learning. However, *A Framework for K-12 Science Education* (2012) suggested enhancing this instruction by emphasizing inquiry and engineering practices in the teacher's daily lesson plans. The Next Generation Science Standards (NGSS) (2012) originate directly from the *Framework* and focus on making science relevant and innovative for students, while also preparing them for college and careers. Rigor, critical thinking, inquiry, and real-world applications prevailed as the major themes of the new standards and provide a foundation for a rich curriculum.

In the past, science teachers passively transferred information to the students, and students memorized and regurgitated the content on summative examinations (Sutton, 2021; Echeverri & Sadler, 2011; Krajcik et al., 2014). States adopted the NGSS (2012) to move away from the mundane *students know* and commence to reflect how science is practiced in the real world. Curriculum developers recognized that students must be able to *perform* a set of expectations rather than just *know* what they should be able to do.

While South Carolina has yet to officially adopt the NGSS, our 2014 science standards are based on the ideas of crosscutting concepts, disciplinary core ideas, and

scientific and engineering practices, focusing specifically on phenomena-based inquiry. Bendici (2019) asserted that a phenomenon "taps into students' natural desire to make sense of their world" and mirrors how scientists make sense of their world through reasoning and inquiry (p. 1). Students in phenomena-based classrooms start with a question, then they collaborate, discover connections, and design models to explore answers to explain phenomena (Bendici, 2019). These practices offer students some autonomy in their learning while also requiring them to actively engage with every part of a lesson. The teacher's role is more of a facilitator, observing and providing prompts when necessary, but letting the students figure things out for themselves. "The actual doing of science and engineering can pique students' curiosity, capture their interest, and motivate their continued study," while allowing them to explore real-world problems (National Research Council, 2012, p. 2). I believe this movement from *knowing* science to *doing* science will help my students stay engaged in my classes.

Student engagement can look quite different from one discipline to the next. In math class, students will be perhaps hunkered down solving problems on a worksheet; in English class, they may be diligently answering comprehension questions about a novel they are reading; in Social Studies, students could be watching a video about the Emancipation Proclamation; in science class, students may be furiously copying notes from a PowerPoint presentation. In each of these classes, administrators will see students who look engaged. The question is, are these students really engaged? Johnson et al. (2012) argued that true engagement only exists when students are tapping into their background knowledge to better understand real-world phenomena and events, asking questions, and gathering data to explain these events, and debating all alternative

explanations for phenomena. Relating current events to already acquired knowledge engages students in collaboration and allows them to see the value in what they are learning.

Many scholars believe that true engagement exists on the following three levels: emotional, behavioral, and cognitive (Fredricks et al., 2004; Milne & Otieno, 2007; Schmidt et al., 2017). Emotional engagement refers to the positive/negative feelings associated with other peers, the teachers, the instructional methods, and school in general (Schmidt et al., 2017). When students have a positive attitude towards these domains, they are more likely to participate fully and engage with the content. Behavioral engagement focuses on the value of the activities: are they relevant to the students' daily lives? Students will be more inclined to participate in instructional strategies that they perceive as "real world" activities. Finally, cognitive engagement deals with the individual's grit, participation, effort, and intensity in completing tasks (Schmidt et al., 2017). Grabau and Ma (2017) indicated cognitive engagement is the "student's investment in schooling and therefore a willingness to commit effort to master their work" (p. 1,046). Fredricks (2004) asserted all three strands are necessary to increase academic achievement, the primary motivation behind trying to increase students' engagement.

Statement of Problem of Practice

For me, engagement in my ideal classroom means bustling activity, with students working together to answer a question or to design a project. Unfortunately, my classroom rarely looks like this, as I am more comfortable with a direct teaching approach. That is, my students are usually copying down notes from a PowerPoint,

watching a video, performing a predetermined lab, or taking a quiz, none of which require students to be fully engaged. I think I may have been limiting my students of the entire nature of the science experience, particularly when I showed them the expected results and conclusions before they were able to discover them for themselves.

Complicating matters considerably was an international pandemic called COVID 19, which shut down virtually all schools in the Spring of 2020 and left many students learning from home on Zoom calls for over a year. When my eighth graders returned this 2021-2022 school year, some had not stepped into a classroom since about halfway through their sixth-grade year. Disciplinary referrals are a huge problem, with many of my students apparently having forgotten how to act in class as well as how to have social interactions with each other in person. Cell phone usage, fights and altercations, poor study habits, and general lack of effort permeate most of our students and the first quarter was a real struggle for us all.

I teach in a Title 1, below-average rated school in a larger city in South Carolina. Over 80% of our students are considered at or below poverty level, and 100% require free breakfast and lunch. Many of my students live in single parent homes, and older generations often live with them, making it difficult for these children to return to in-person learning. Absences have been astronomical so far this year, and, with Zoom no longer an option, students are falling behind. The demographics for my eighth-grade classes are 63% African American, 26% Hispanic, and 9% Caucasian. The percentage of students achieving proficiency in math is 19%, where the SC average is 45% and proficiency in ELA is 19%, where the SC average is 45% (Public School Review, 2018).

My typical lesson plan involved introducing content in a PowerPoint/lecture format with the students' copying notes as I talked. While my students "looked" engaged as they actively took notes, scores on their quizzes and tests indicated otherwise. The lecture was followed with some type of video which reinforced concepts before they left class. The next day was usually a lab, demonstration, or simulation dealing with the content from the day before. Students tended to get excited about these labs, etc. but often it was short-lived as they realized the labs were not as "fun" as they had anticipated. Often, I would give some type of short quiz after the lab to assess comprehension, and then we would move on to another topic or lesson.

Ultimately, I would like to lead my students in a student-centered learning environment where they are able to design and construct models, analyze and interpret data, and draw their own conclusions from the learning activities. This will involve invoking the students' curiosity to want to answer questions as presented and will require me to relinquish some of my control so they can discover their own capabilities. I want them to learn to think for themselves, rather than relying on me to provide answers. In applying this phenomena-based inquiry as suggested by NGSS to real world situations, I hope to motivate my students to participate in inquiry with fidelity and zeal. Science is meant to read like a story, each concept building upon the students' background knowledge learned in previous grades, so I want to ensure I build upon these skills as we tackle new content.

To effectively integrate these standards into my own practice, it was imperative I actively research effective strategies to both implement these standards and to tackle this tough environment. I was able to observe a seasoned NGSS teacher and modeled some

ideas in my own classroom, while also studying this idea of phenomena-based inquiry, thus making the procedures and process more conceivable to undertake. The National Research Council (2012) warned that "a narrow focus on content alone has the unfortunate consequence of leaving students with naive conceptions of the nature of science inquiry…and the impression that science is simply a body of isolated facts" (p. 41). By focusing on inquiry and students practicing science, I hope to improve engagement in my classroom.

In this high-stakes testing environment where I am held personally responsible for what my students learn and how they do on these tests, how can I let go of the reins and allow my students the time to problem-solve and create their own labs to integrate these performance-based standards? The SC science standards, primarily based on the Next Generation Science Standards (NGSS), incorporated a more student-centered learning environment, and emphasized analyzing and interpreting data, planning and conducting experiments, constructing explanations, developing and using models, and using mathematical and computational thinking to solve real-world problems. My problem started with how to "change from instruction that relies on sure-fire activities that reinforce concepts to activities that authentically engage students in scientific practices" (Colson & Colson, 2016, p. 52). Will their engagement in developing their own answers to questions and solutions to problems better prepare them for their future?

I wanted to motivate my students to enjoy science by integrating authentic and relevant labs and activities that spark creativity and engagement during class while also encouraging social interactions when trying to solve problems. Asowayan et al. (2017) attested, "The task of tutors is to assist pupils in acknowledging the role of social

presence through participating in scientific activities," and this participation "is an effective means to increase and enjoy one's social presence" (p. 67). Right now, engagement is lagging, and I wind up trying to entertain my students with stories and analogies to help them remember the required information.

My problem essentially existed on two levels: first, I wanted to satisfy my students' curiosity by using phenomena-based inquiry to improve engagement in my classroom; and second, during a pandemic where some students have not entered the building since March, 2020, I wanted to ensure all my students are actively engaging and participating in class lessons. I needed to ensure a safe classroom, so my students felt free to express their ideas and collaborate with each other, while also creating the desire for knowledge so my students have the motivation to participate.

In my classes, I see engagement as students actively collaborating to solve problems, designing a model to show how big the solar system really is, or designing their own lab to determine the speed of an object. Additionally, as I begin releasing the reins on my students, it will allow them to collaborate to solve real-world problems as I simply supervise activities. Facilitating the learning rather than directly supervising my students' learning will be difficult, but ultimately, I want to see if this shift will improve the engagement levels of my students.

Research Question

To what extent does student engagement in learning increase during a six-week unit on waves taught using phenomena-based inquiry from the Next Generation Science Standards based on the *Framework for K-12 Science Education?*

Research Purpose

The purpose of this study is to examine to what extent student engagement in learning increases during a six-week unit on waves taught using phenomena-based inquiry from the Next Generation Science Standards (NGSS) based on the *Framework for K-12 Science Education*.

Theoretical Framework

This action research study is framed around the Attention, Relevance, Confidence, and Satisfaction (ARCS) model, developed by John Keller in 1983 (Feng and Tuan, 2005). This model introduces four strategies designed to increase student motivation in the classroom: attention, relevance, confidence, and satisfaction (Keller, 2016). *Attention* focuses on arousing students' curiosity and generating a sense of wonder and can include asking pertinent questions, sharing personal anecdotes, or providing an opposing point of view. *Relevance* involves ensuring students know how the content can be used in their daily lives or at least how concepts connect to their background knowledge so they can draw connections from prior experiences. *Confidence* gives students the opportunity to control their own learning where teachers provide specific learning goals and timely feedback on students' success. Finally, *satisfaction* involves both extrinsic and intrinsic rewards for successful students. Keller (1987) asserted that the "real challenge is to help students sustain their learning so as to produce a satisfactory level of attention throughout a period of instruction" (as quoted by Feng and Tuan, 2005, p. 465).

Feng and Tuan (2005) developed a table (Figure 1, p. 468) that describes teachers' instructional methods and actions that may be least successful in motivating and

engaging students. These include teacher-led lectures and presentations, scarce or inconsistent feedback, and failure to highlight real-world examples. Because my study's goal is to increase student engagement, the ARCS model stands out as the most pertinent theory in which to frame this paper.

My literature review will provide a theoretical framework followed by the historical perspectives that shape my argument. In addition, I will review intrinsic vs. extrinsic motivation, ARCS model, parental involvement, use of technology, self-efficacy of my students, levels of engagement, NGSS, and social justice provided by the facilitation of NGSS to not only better understand what causes engagement, but also how to provide the classroom environment necessary for this engagement in my eighth grade science classroom.

Brief Overview of Methodology

My study uses action research in implementing NGSS, specifically phenomena-based inquiry, into my curriculum in my own eighth grade science classroom to improve student engagement and understanding. "Action research is a process of self-reflection in which [I] have the central role during all the phases of [my] action research project," and my plan will focus on improving my own practice for the benefit of my students (Efron & Ravid, 2013, p. 55). I planned a qualitative research study that will use student surveys, student interviews, teacher journaling, and student exit tickets and anticipation guides to document how the implementation of NGSS and inquiry teaching may heighten my students' understanding of eighth grade science concepts as well as improve the students' engagement in the classroom.

Journaling will be a way to assess and reflect on my own understanding of the NGSS process while student surveys, interviews, and exit tickets/anticipation guides will assess how my students are comprehending the material and how and if they are gaining motivation to participate in the newly revised lessons. I had the full support of my administrators and instructional coaches and the latter helped me with designing the anticipation guides, vital to the phenomena-based inquiry. Nathan Durdella suggested "building rapport with gatekeepers and working with site staff and key players in research settings to invite, recruit, and secure research participants" (2019, p. 60). I obtained permission from parents and my administration to conduct the necessary surveys and interviews so I could implement and properly document my integration of the intervention.

My participants were six chosen students from my honors classroom in a Title 1 middle school located in South Carolina. My students are predominantly African American and Hispanic with high poverty backgrounds. These students are typically very dependent on me to provide them with pre-designed labs and activities where they already know the desired outcomes. The inquiry-based lessons I designed are meant to engage students in real-world phenomena, and perhaps this will motivate them to collaborate with other students to design solutions and/or answers. Additionally, moving from this teacher-led environment to a classroom where students lead discussions and design their own investigations, I needed to gradually release these responsibilities to my students throughout the semester. By using the NGSS, specifically phenomena-based inquiry for lessons, I hope to have the students more engaged and involved in their own

learning, perhaps motivating them to solve problems and carry out their own investigations.

Significance of the Study

Although South Carolina has not yet officially adopted the NGSS, our standards are based on the general principles associated with them. Our standards stress the 3D model of crosscutting concepts (linking domains of science), implementing science and engineering practices, and promoting disciplinary core ideas. South Carolina standards also require teachers to implement best practices such as linking background knowledge of our students to new knowledge, addressing cultural differences, and relating concepts to our students' interests and life experiences. I hope to affirm how these standards and best practices are applicable to all science classrooms and can be used to generate curiosity and engagement in our students.

I am using action research to improve my own teaching while improving my students' learning. As stated, my problem of practice is engaging and motivating my students to actively participate in their own learning, while also addressing cultural diversity in my classroom. By definition, I am using action research to study my own classroom because I intend to make a positive difference in my own setting (Herr & Anderson, 2015). Kemmis (as cited in Herr & Anderson, 2015) described action research as a process where the practitioner will do the following:

1. Develop a *plan* of action to improve what is already happening;
2. *Act* to implement the plan;
3. *Observe* the effects of action in the context in which it occurs; and

4. *Reflect* on these effects as a basis for further planning, subsequent action and on, through a succession of cycles. (p. 5)

The proposed intervention, or plan of action, involved incorporating the NGSS's phenomena-based inquiry into my current curriculum to engage my students to ultimately stimulate their curiosity thus motivating them to improve in my eighth grade science class.

My intended audience were teachers who want to further engage their own students by using some of the methods described in the NGSS. I hoped to create a model of implementation that can be transferred to other teachers to improve their own classroom teaching. I also suspect that other teachers experience the same lack of motivation by their students and may be looking for support to engage their own learners. At the same time, I realize not all teachers have students who are exactly like mine, and that all classrooms are different. Some districts may have more or fewer resources than I do, or other teachers may not experience the same cultural diversity that I do in my classroom, so this study was not a general "fix it" for all classrooms. This study was intended to help me improve my own practice, and I hope it can at least allow other teachers to perhaps implement some of the suggestions as ways to improve their own teaching.

Summary of the Findings

Student engagement varies widely and can be influenced by the culture and climate of the school. The emerging themes of piquing students' curiosity, making content relevant, and increasing students' self-efficacy were critical to students' engagement levels. Capturing the attention of students through questioning phenomena

initiated initial engagement to the lessons while relevancy of the content allowed the students to directly compare the material to questions they had about their own lives. Likewise, students' confidence grew as they collaborated with their peers to discuss and design answers in the inquiry-driven classroom and delivering solutions to real-world problems led to self-efficacy in their work in my classroom. These themes resonate within phenomena-based learning and my students were more engaged in activities during this study.

Researcher Positionality

I was just entering my eighth year teaching middle school science and have taught sixth through eighth grades in North Carolina, Florida, and South Carolina. I graduated from college with a degree in English, so I spent much of the time reading science textbooks and the required standards, learning right alongside my students as we navigated our way through my first year. I also took science classes at night to obtain my clear science credential. With the support of the other science teachers and my college professors, I learned about the scientific method, implementing the method whenever I felt brave enough to do labs with the students. Using resources from the internet, I would have a clearly defined set of instructions for the students to follow and would usually perform demonstrations to show how the experiment should go. Through trial and error, labs and experiments did not always go as planned, but I do believe we all learned about the true nature of science in that it is always changing.

By being the teacher and trying to improve my own practice of teaching science, I am an insider trying to address a problem of practice in my own classroom. I am also attempting to improve my students' engagement and motivation levels, while improving

their test scores. However, being that I was relatively new to science concepts and principles, I was a bit of an outsider, trying desperately to keep abreast of our material to teach it with fidelity. I have actively sought outside opportunities for professional development while also continuing to look for lesson plans that fully embrace the NGSS, and have collaborated with other science teachers, both in my school and other schools in my district to model best practices in NGSS integration.

Perhaps another way I was a bit of an outsider is in the demographics of my classroom. I needed to ensure I provided culturally relevant material that would fully engage all learners, regardless of their social class, ethnicity, or race. NGSS specifically addressed equitable teaching and different ways of ensuring all students receive equal opportunities to excel.

Limitations of Study

The biggest challenge I foreshadowed was student misbehavior; as previously mentioned, I worried about what students would do when given the opportunity for more independence in their learning. I planned on utilizing a gradual release of responsibility during our first unit, hopefully ensuring students would learn how to perform and behave in an appropriate manner when given the opportunity. Another challenge I anticipated was lack of time for full implementation of phenomena-based inquiry for a unit of study. I knew I would have to teach and model how students would fill out anticipation guides and exit tickets, while also ensuring students knew how to appropriately hold discussions online. I teach five units per year and only have my students every other day, so I hoped this implementation for one unit of study would not infringe on me being able to cover all units appropriately.

Dissertation Overview

My action research study begins with a synopsis of NGSS and how these standards can improve student learning and retention of knowledge. Additionally, in Chapter 2, I provide a review of the literature referenced to complete my study. This includes a thorough review of prominent theories associated with the motivation and efficacy of students, pedagogical content knowledge of teachers, and the social cognitive theory associated with implementation of NGSS. Chapter 3 addressed the methodology I used in my qualitative study. I included the various types of data and how I intended to collect this data. Chapter 4 described how I organized and analyzed the data to convey the results of the study. Finally, in Chapter 5, I revisited the original action plan to correlate the findings with the initial problem of practice. I discussed what changes may have to be made for further research and an updated action plan was proposed for future practice.

Glossary of Terms

Next Generation Science Standards (NGSS): a set of standards adopted nationally in 2013 that focus on the 3D model of implementation: crosscutting concepts (CCC), science and engineering practices (SEP), and disciplinary core ideas (DCI).

- Crosscutting concepts (CCC): ways to link domains of science, e.g., patterns and organization, cause and effect, systems and system models, structure and function.
- Science and engineering practices (SEP): e.g., asking questions and defining problems, developing and using models, planning and carrying out

investigations, analyzing and interpreting data, constructing explanations and designing solutions.

- Disciplinary core ideas (DCI): Life Science, Earth and Space, Physical Science.

Action Research: "a form of self-reflective problem solving, which enables practitioners to better understand and solve pressing problems in social settings" (McKernan, as cited in Herr & Anderson, 2015, p. 4).

ARCS model: attention, relevance, confidence, and satisfaction. This is the theoretical framework supporting my research. I used this model as a guide for implementing the SEP aspect of NGSS.

Phenomena-Based Inquiry: questioning of natural phenomena, or observable events, that occur in nature (earthquakes, tornados, sending man to moon, etc.) allowing students to ponder, collaborate, and research the question.

SDT Self-Determination Theory: a theory developed by Edward Deci and Richard Ryan in 1985. The theory is based on how students (people in general) need autonomy, relatedness, and competence for them to be motivated to achieve goals or accomplish tasks.

CHAPTER 2

REVIEW OF LITERATURE

This chapter will be presented by addressing the various problems and hurdles I must address before I introduce and implement the instructional strategies suggested by NGSS. Understanding why my students feel disengaged to the content is paramount and I will discuss several factors that may inhibit their engagement: the absence of autonomy in their learning, the detachment my students may feel to the science curriculum, my students' lack of motivation, both intrinsic and extrinsic, my own developing content knowledge, and the absence of parents both at school and at home. I will show how the ARCS theory of motivation guided my lessons as it relates to phenomena-based inquiry aspect of NGSS, as well as this idea of both extrinsic and intrinsic motivation prompted by the desire for favorable outcomes. In addition, NGSS focuses heavily on students accessing prior knowledge which can directly positively impact their competence levels, thereby increasing their intrinsic motivation, prompting them to engage in content.

This chapter will also address how my own pedagogical and content knowledge can enhance my students' understanding of science concepts and structures. Different engagement levels will be discussed, indicating how students' participation, persistence, investment in learning, and relationships with teachers and other students can positively impact their proficiency in science. Parental involvement, or lack of, will be included, highlighting how parents can directly impact the engagement of their children.

Technology integration will also be discussed, to indicate how it can produce positive gains in engagement levels of students. Finally, I will discuss how NGSS adheres to the "All Standards, All Students" declaration of making content accessible and enjoyable for all students, regardless of race, ethnicity, or gender (Appendix D, 2013). Ensuring that all content is relevant and relatable for all students involves choosing culturally relevant instructional materials that highlight successful scientists who look like my students.

Purpose of Literature Review

Machi and McEvoy (2016) defined the literature review as a "written document that presents a logically argued case founded on a comprehensive understanding of the current state of knowledge about a topic of study…It establishes a convincing thesis to answer the study's question" (p. 5). My study involves action research, which "is different in that research participants themselves either are in control of the research or are participants in the design and methodology of the research" (Herr & Anderson, 2015, p. 1). I am studying my own students within my classroom and how an intervention, in this case implementing NGSS, can perhaps improve my students' engagement levels in class.

Reviewing the literature is imperative to understanding what exactly affects my students' engagement levels, and by continually revisiting the literature as my knowledge base grows, I can better understand the factors that lead to improved engagement. Herr and Anderson (2015) asserted, "this process is done in relation to a larger body of literature that helps illuminate the findings, deepen the understanding, and perhaps suggest directions for the next iteration" (p. 105). Developing a literature review will assist with making connections between what others have written about my intended

study and the direct applications for my own classroom. In other words, building my knowledge base by thoroughly reviewing the literature will help me to grasp what factors can both inhibit and enhance the engagement of my students, allowing me to comprehend the instructional strategies that may need to be implemented to increase these levels.

In essence, my argument involves how implementing NGSS can better engage my students than the current methods employed. The literature review seeks to present “a set of claims backed by sound reasons to support a conclusion,” and the evidence provided by the literature review can help me build my case (Machi & McEvoy, 2016, p. 40). While some critics encourage doing the literature review after the data collection stage as to avoid any bias, Efron and Ravid (2013) asserted, “being informed about current research, theoretical positions, and potential methods of data collection helps action researchers clarify and refine their own studies” (p. 18).

In reviewing the literature for my study, my focus was on what exactly constitutes engagement by students in the classroom. I wanted to find out how other researchers were able to measure engagement and what strategies they employed as they sought answers to their own research questions. Herr and Anderson (2015) suggested using the literature review to ascertain the relationship between “the researcher’s growing observations and data, and what others have written and understood about similar questions or contexts” (p. 105). In addition, the authors discussed how the literature review can create “a sense of unearthing the real issues or questions for study, and [how] this often leads researchers to read in directions that they had not previously anticipated,” sometimes leading researchers to embark in an entirely new direction (p. 105).

In my own review of the literature, I learned about different levels of engagement and how they can either contribute to or inhibit the understanding or application of content. While some of the literature discussed ideas on how to better engage students, most of the literature deals with how to measure engagement, how to keep students motivated and ways teachers can organize their instructional materials in a way that requires students to actively deal with content rather than passively memorize or regurgitate information. The review acts as a guide to both understand engagement and how to effectively engage students. Because my problem deals directly with how to ensure my students stay engaged, the materials and sources chosen will help me in my endeavor.

While researching for the literature review, I used electronic databases specific to education including ERIC and Education Source. I searched keywords such as middle school, science, NGSS, engagement, cognitive engagement, and classroom to gain access to materials directly related to my topic. While mostly peer-reviewed journals and NGSS websites were used, two books stand out as vital and pertinent in forming and citing my argument: *The Cambridge Handbook of the Learning Sciences*, specifically a chapter titled Motivation and Cognitive Engagement in Learning Environments and a book titled *Handbook of Research on Student Engagement,* specifically the chapter titled Developmental Dynamics of Student Engagement, Coping, and Everyday Resilience.

Theoretical Framework

ARCS Model

Blumenfeld et al. (2006) asserted, "Drawing connections to students' personal lives, embedding the introduction of new concepts and skills within meaningful tasks,

and emphasizing the instrumental value of mastering a skill or doing well in a subject matter enhances value," which can increase motivation thereby enhancing engagement by students in the classroom (p. 477). The ARCS model, developed by John Keller, succinctly adheres to these principles to keep students motivated and engaged. The model is based on expectancy-theory which "assumes that people are motivated to engage in an activity if it is perceived to be linked to the satisfaction of personal needs (the value aspect) and if there is a positive expectancy for success (the expectancy aspect)" (Keller, as quoted in Education Library, 2021, p. 1).

ARCS is an acronym that stands for *attention, relevance, confidence,* and *satisfaction* and the model offers different instructional strategies for each domain. *Attention* describes how to grab the learners' attention through funny anecdotes, videos, or by asking a thought-provoking question or debatable sentence. *Relevance* is how teachers relate the material directly to their students' lives. This can be as simple as providing real-world applications to the material or it could offer connections to prior learning. *Confidence* refers to teachers communicating expected learning outcomes and objectives, so learners' confidence increases with each goal which is reached. It is imperative teachers provide consistently quick and continuous feedback so students will feel comfortable moving on to the next goal.

In addition, teachers need to give students choices in their modes of showing what they have learned. Whether it be a poster, short YouTube video, debate, or a website design, when students can choose how they show mastery, it gives them more autonomy and control of their learning. *Satisfaction* is the last component of Keller's theory of motivation and references the pride students should feel after accomplishing their goal or

mastering an expected learning outcome. Verbal praise, a positive phone call home, or a small treat can all lead to elevated motivation levels in students.

NGSS, and more specifically phenomena-based inquiry, can directly or indirectly mimic these stages in the model of motivation. Asking questions and using models can grab the attention of students while planning and carrying out investigations that affect (or are at least relevant to) the lives of our students can enhance relevancy. Analyzing and interpreting data and using calculations assist with the confidence levels of students in that they are deriving their own conclusions from the data. Satisfaction is fulfilled when students begin to construct explanations and design solutions to problems and argue successfully for their prospective views.

Historical Perspectives

This action research study deals with how to incorporate NGSS into my classroom to improve the engagement levels of my eighth grade students. NGSS focuses on students actively engaging in classroom activities, constructing their own knowledge as they perform different tasks. This summary of the historical background includes constructivism, Progressive curriculum, and a Learner Centered Ideology, as well as the ultimate development of NGSS and the reasons for its creation. In addition, I have included issues unique to science, as women and minorities have notoriously been absent in various science fields. NGSS (2013) promises “All Standards, All Students” as a way to include these groups, and I will discuss what specifically teachers and schools can do to ensure their participation and engagement.

Constructivism

Constructivism is a learning theory where students build knowledge through their previous background knowledge on subjects. Students learn through first-hand experience versus second-hand information. By actively engaging in activities and experiments, students construct their own knowledge rather than passively absorbing material. “Information may be passively received, but understanding cannot be, for it must come from making meaningful connections between prior knowledge, new knowledge, and the processes involved in learning” (McLeod, 2019, p. 1). In addition, all knowledge is gained through social interactions, learning from others through collaboration (McLeod, 2019). “Learning is a social activity—it is something we do together, in interaction with each other, rather than an abstract concept” (Dewey, as cited in McLeod, 2019, p. 1).

Constructivism also contends that all learning is personal, where different races, ethnicities, and genders bring their own versions of background knowledge based on their own distinctive points of view. The teacher is responsible for creating a collaborative problem-solving environment where students actively engage with content and are full participants in their own learning (McLeod, 2019). The teacher acts solely as facilitator, guiding and providing feedback as the students work to design experiments or solve problems. Constructivist classrooms are learner centered, embedding learning with authentic tasks and providing ample time for student collaboration. Blumenfeld et al. (2006) asserted, “collaboration enhances motivation because it meets students’ needs for relatedness as they work with peers,” and as they work toward a common goal, they feel collectively responsible for their success, so self-efficacy is enhanced (p. 482).

Constructivism conforms well with SDT whereas it promotes autonomy in learning, relevance in students constructing their own meaning, and competence through reflection and feedback. Whereas traditional classrooms promote passive learning, teacher-centered direction, and fixed adherence to curriculum, the constructivist classroom enables learners to participate actively, collaborate regularly, and build upon their own knowledge to create their own meanings (McLeod, 2019).

Lev Vygotsky helped to develop the social constructivist theory in the early 1930s, which asserts that all knowledge develops as a social, or shared experience and is not simply observing, but interacting with others in the construction of knowledge. Active participation by learners, collaboration with other students, and the teacher as a facilitator of learning are all aspects of this theory (Lynch, 2016). "Through social interactions with peers and adults, and scaffolding supports, children are guided to discover or learn skills or concepts that they could not yet have learned alone" (Sharkins et al., 2017, p. 17). The scientific and engineering practices, a dimension of NGSS, incorporates these notions of collaboration, exploration, and socialization as paramount to the learning of science concepts.

Likewise, Jean Piaget believed children were born with certain innate knowledge which was exemplified by their physical and social environment (Maddux & Cummings, 1999). He believed that "children construct their own knowledge and should be supported in the development of moral and intellectual autonomy" (Sharkins et al., 2017, p. 12). Students are encouraged to find their own answers, in their own desired way, while also collaborating with others to find these solutions (Sharkins et al., 2017). In addressing diversity, Sharkins et al. (2017) expressed the need for "a cultural appreciation at the

familial level, leading to an acceptance that spreads throughout the school community, positively impacting the growth and development of children" (p. 12).

Learner Centered Ideology

Constructivism is the underlying theory in Learner Centered Ideology. "Learning takes place when people interact with learning environments…their cognitive structures consist of previously acquired meanings and an organizational structure that relates the meanings" (Schiro, 2013, p. 118). Students take their pre-existing knowledge and mold it to fit the current learning taking place. This is called assimilation and occurs when students construct new meanings by transforming their perceptions (Schiro, 2013). Students "reconstruct their existing cognitive structures by transforming themselves…[students] construct and reconstruct meaning by transforming both the new meanings they are acquiring and their preexisting cognitive structures—by transforming both their new understanding of their world and themselves" (Schiro, 2013, p. 118).

Teachers in learner centered classrooms are much less interested in content knowledge acquisition, but more in student growth and learning (Schiro, 2013). In addition, learner centered educators are not generally interested in knowledge objectives, but more in behavioral objectives: what will the learner be able to do? "Learner centered educators are not givers of knowledge, but rather givers of experiences out of which people will…create knowledge for themselves" (Schiro, 2013, p. 119). The learner entered classroom environment is, appropriately, learner centered versus teacher centered, where students contribute to classroom rules and procedures, and where students also decide "how they will grow and what they will learn" (Schiro, 2013, p.

122). Finally, teachers in learner centered classrooms carefully observe their students, both differentiating and scaffolding their instruction to meet each child's needs.

Progressive Curriculum

According to Ellis (2004), "The progressive curriculum emphasizes the quality of experience and processes of growth and development over content and skill mastery" (p. 33). As in Learner Centered Ideology, the teacher takes on the role of facilitator, guiding the learning rather than directing it. Students use their knowledge to solve real-world problems versus passively learning academic subjects; math, science, and English are used as tools to employ to solve these problems rather than a means to an end (Ellis, 2004). Jerome Bruner (1965) contended that students learn more by discovering ideas themselves rather than being told these ideas. Moreover, he asserted, "children should focus on the structure of disciplines, how things are related, rather than acquisition of mere information" (Bruner, 1965/2017, p. 69). Bruner's curriculum focuses on student's ability to not only make discoveries on their own, but to also reflect on the importance and relevance of these ideas, saying children need to "pause and review in order to recognize the connections within the structures they have learned—the kind of internal discovery that is probably of highest value" (Bruner, 1965/2017, p. 111). Formative assessments are used frequently, focusing on the growth and development of students' problem-solving skills, and these assessments are generally informal and often collaborative in nature (Ellis, 2004).

Next Generation Science Standards (NGSS)

Although controversial as it led us to No Child Left Behind, *A Nation at Risk,* published in April 1983, opened Americans' eyes to the growing discrepancy between

our nation's youth compared to the success of other country's children in education. Written as an open letter to the American people, *A Nation at Risk* warns that "the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people" (A Nation at Risk, 1983, p. 9). Specifically, science achievement measured by national assessments given to 17-year-olds indicated a steady decline in 1969, 1973, and 1977 (A Nation at Risk, 1983). Assessments showed students have significant deficiencies in essential skills, such as reading comprehension, data analysis, problem solving, and drawing their own conclusions, activities that are imperative for students to be college and career ready (Next Generation Science Standards, 2012). Moreover, too few students are entering Science, Technology, Engineering, and Mathematical (STEM) fields, so the creation of these new science standards are meant to entice young people, as well as improve their critical thinking skills. The NGSS were developed by the National Research Council, a division of the National Academy of Sciences and every standard has three different dimensions: disciplinary core ideas, scientific and engineering processes, and cross-cutting concepts (NGSS, 2012). The standards are meant to address how students learn best "in a hands-on, collaborative, and integrated environment rooted in inquiry and discovery" (NGSS Facts, 2012, para 1).

Social justice is also addressed with NGSS, ensuring every student learns and is given the opportunity to collaborate in a hands-on environment. Traditionally, underserved groups include minorities and girls, and the standards are meant to address this lack of equity by ensuring the standards are relatable and culturally relevant to all groups (NGSS Appendix D, 2013). Economically disadvantaged students do well with

project-based learning, connecting science to culturally relevant problems while looking for and applying solutions. These students also need ample school resources, including human and monetary capital, to effectively carry out these tasks in the classroom (NGSS, Appendix D, 2013). Asowayan et al. (2017) stated, “an unspoken but tangible idea that science is for the rich should be considered as a stumbling block that deteriorates academic performance…poor families may be deprived of the equal possibilities to use online learning and devices in schooling” (p. 67).

Likewise, racial and ethnic differences can be addressed by offering culturally relevant pedagogy, applying the standards in ways which address the cultural differences of students (NGSS, Appendix D, 2013). Community involvement and social activism can lead to increased engagement in the activities necessary in science, while also providing ample role models of similar demographics. Several approaches may be necessary to increase out-of-school community contexts, including the following: (a) encouraging parents as partners in the classroom and in science learning; (b) engage students in real-world problems in their communities and assist them as they work to define the problems and design solutions; and (c) focusing on science learning in non-traditional environments, such as museums or zoos (NGSS, Appendix D, 2013).

Technology also assists teachers in providing ample scientific schemata and models to ensure students understand the concepts necessary in culturally relevant terms (Asowayan et al., 2017). Unfortunately, students from poor neighborhoods may not have the technology necessary for these endeavors; in these situations, games, especially performed outside, are a highly effective way for students to learn and they can increase students’ motivation from an early age (Asowayan et al., 2017). Finally, “cultural

sensitivity should include well-developed communicative skills with the students of different cultural, social, economic, and religious backgrounds," and teachers' most important objective is finding different ways to teach science and engineering while adhering to students' values (Asowayan et al., 2017, p. 65).

Intrinsic vs. Extrinsic Motivation

Intrinsic and extrinsic motivation theory addresses that "challenge, curiosity, control, and fantasy are key factors to trigger up intrinsic motivation," and that intrinsic motivation proves more sustainable than extrinsic motivation, which relies on rewards and punishment (Gopalan et al., 2017, p. 2). If I can create an environment in my classroom that encourages exploration of scientific principles, perhaps my students will be more intrinsically motivated to work together in recognizing and solving problems. Students who are motivated in any sense are more likely to understand the material, face their challenges, and apply their knowledge in real-world situations (Gopalan et al., 2017).

Motivation is simply being moved to do something. Intrinsic motivation refers to being moved to do something out of general curiosity, or because it is interesting and enjoyable while extrinsic motivation is doing something for approval from a parent or teacher, or some type of extrinsic reward, like candy, a good grade, or money (Ryan & Deci, 2000). Researchers suggest intrinsic motivation as the catalyst for higher quality learning and engagement in activities (Gopalan et al., 2017; Ryan & Deci, 2000). Children are curious, playful and have a readiness to learn and explore and as teachers, our responsibility lies in developing value-laden tasks that invoke this behavior (Ryan & Deci, 2000). The learning tasks we choose to motivate our students need to have value so

children will want to engage in the activity. Likewise, any interventions enacted by teachers needs to increase the students' willingness to learn by including "personal and utility value, achievement goals, and individual interest" (Michaelis, 2017, p. 6). Often, students perceive learning science and engineering practices as unattainable or completely useless, especially for minorities and girls, so the tasks assigned need to have value and attainable, desirable outcomes for these specific groups (Michaelis, 2017). When the learning environment utilizes the principles of science, such as authenticity, inquiry, collaboration, and technology, learners from all groups are more likely to "think deeply about the content and construct an understanding that entails integration and application of the key ideas of the discipline," thereby increasing engagement (Blumenfeld et al., 2006, p. 475).

Extrinsic motivation, heightened by external rewards, is usually depicted as the wrong way to entice our children to do something (Ryan & Deci, 2000). However, there are two different types of extrinsic motivation, which are the following: there is the student A who only does the assignment to get a good grade so his parents will not reprimand him, and the student B who performs the tasks necessary to get into a good college so he can eventually become a doctor. Both students gain some type of extrinsic reward for completing the tasks, but "the latter case entails personal endorsement and a feeling of choice, whereas the former involves more compliance with an external control" (Ryan & Deci, 2000, p. 60).

Self-Determination Theory

Self-determination theory (SDT) addresses the autonomy, competence, and relatedness of my students, the learning environment, and the activities in a classroom.

Autonomy refers to the individual student's satisfaction with the subject or activity, usually brought on by offering choices in tasks to complete. Competence is related to the feelings of successful accomplishment in completing a task, while relatedness provides a sense of purpose and connectivity in the classroom (Gopalan et al., 2017). For students to remain motivated and engaged, they need to feel all three components of SDT. Teachers can develop strategies that specifically target each of these areas to increase engagement in their classrooms. Strategies for targeting students' autonomy include "providing choice and meaningful rationales for learning activities, acknowledging students' feelings about those topics, and minimizing pressure and control" (Neimiec & Ryan, 2009, p. 141). Strategies to enhance student's competence include providing relevant, real-world activities so students recognize the value in the tasks and, when able to complete them, are commended by those around them (Neimiec & Ryan, 2009). Establishing a warm and caring learning environment, where the teacher respects the students contributes to relatedness and allows students to feel safe when completing tasks (Gopalan et al., 2017).

SDT also applies to the teacher's own autonomy, competence, and relatedness. Often, with state standardized testing as the norm, teachers struggle with their own autonomy, usually feeling controlled by strict curriculums and unattainable timelines of progression of content (Niemiec & Ryan, 2009). When teachers feel their autonomy relinquishing, they often pass this on to their students, offering less choice in activities in a rush to cover all content. This pressure and perceived lack of time can often lead to less interesting and effective instructional strategies and a rushed feeling in the classroom (Niemiec & Ryan, 2009). Likewise, teachers' competence levels can diminish as the school year progresses, either because of this lack of progression through content or the

lack of engagement by their students. Finally, teachers' relatedness can be negatively affected by continued pressures from administrators who are looking for data-driven results and growth in students' outcomes, again causing teachers to rely on rote memorization of content by students, severely diminishing the engagement levels in classrooms (Niemiec & Ryan, 2009). Teachers also become less creative and energized by the material, negatively contributing to the motivation of their students.

Social Cognitive Theory

Likewise, Social Cognitive Theory (SCT) "refers to the acquisition of knowledge by direct observation, interaction, experiences, and outside media influence" (Gopalan et al., 2017, p. 4). Learning from others through a collaborative learning environment provides opportunities to gain insight into others' experiences while trying to make sense of scientific concepts. SCT asserts how students learn from others through modeling successful behaviors, hence becoming successful themselves. Self-efficacy is the most prominent predictor of students' science achievement, and once students can see how they can perform a task successfully, their self-efficacy improves, and confidence is gained to tackle another task (Ucar & Sungur, 2017). Again, this applies not only for my students, but also for my own confidence in facilitating the learning necessary to heighten engagement in my classroom. Perhaps if I can see other science teachers implementing the strategies of NGSS, I can become more confident and comfortable in leading my students in my own classroom.

Related Research

While studying and researching how best to engage my students in my eighth grade science class, I found other researchers addressing the problem by studying how

technology, parental involvement (or lack thereof), the self-efficacy of students, and the teacher’s content knowledge can affect students’ engagement in the classroom. Furthermore, I address the different levels of engagement and how to possibly improve engagement on all three levels.

Levels of Engagement

Fredricks et al. (2016) worked to understand engagement and disengagement in math and science and to determine what students are currently doing in classrooms versus what they should be doing. They also tried to determine what defines engagement and ways to measure engagement. The researchers clearly defined the following three distinct levels of engagement: (a) behavioral, (b) emotional/affective, and (c) cognitive engagement. Behavioral engagement is the students’ effort, participation in activities, attention, persistence, positive conduct, and behavior, while emotional engagement is the child’s positive/negative reactions to teachers, classmates, academics, or school. It is also the students' sense of belonging and identification with school or the subject. Cognitive engagement deals with the students’ level of investment in learning, and their willingness to exert the required effort to complete tasks (Fredricks et al., 2016).

Indicators of the different levels of engagement were derived from participants, including both students and teachers, who wrote down what it means for them to be engaged. Answering questions in class, effort, talking about math and science outside of class, looking forward to these classes, and thinking about multiple ways to solve problems were all examples from the teacher and student participants. These answers were compiled into data sheets which then were used as surveys to gage the engagement levels of students. These newly developed surveys offered insights into how teachers

think more about social aspects of engagement, like collaboration of peers and discussions. The analysis of the student and teacher responses supported the conceptualizations of engagement and were ultimately used as measures for academic engagement. Future studies could examine more indicators of engagement towards other subjects and different population characteristics should be considered as well as the differences between engagement criteria in middle school versus high school (Fredricks et al., 2016).

Grabau and Ma (2017) explored how science engagement, specifically from nine different aspects, affects science achievement. They defined the nine levels of engagement as the following: (a) science self-efficacy, (b) science self-concept, (c) enjoyment of science, (d) general interest in science, (e) instrumental motivation for science, (f) future-oriented science motivation, (g) general value of science, (8) personal value of science, and (h) science-related activities. The researchers found that hands-on activities had a direct positive relationship with both engagement and achievement, and this engagement in science correlates directly to achievement (Grabau & Ma, 2017). Focus on applications or models was also positively related to most aspects of science engagement. Finally, science teaching (pedagogy) was also directly related to the engagement of learners, also positively affecting student achievement.

The nine aspects of science engagement were used as dependent outcomes or variables and student questionnaires were developed to measure science achievement as independent outcomes. The data came from then 15-year-old students acquired from the 2006 PISA dataset and included 4,456 students in 132 different schools across the United States. Further studies could explore student characteristics more to include race and

ethnicity. Also, “instead of assuming science engagement as a ‘cause’ of science achievement, a more sophisticated model can be developed to treat this relationship as reciprocal (i.e., engagement improves achievement and achievement enhances engagement at the same time)” (Grabau & Ma, 2017, p. 1,060). Finally, the 2015 PISA datasets have been released and can be studied and replicated. My study will address how using the Scientific and Engineering Practices model of NGSS can better engage my learners by specifically using models and the collaboration of students as prescribed in these studies.

Technology

Online learning tools, platforms, and communication improve both students’ engagement with scientific principles while also providing valuable relationships between teacher and students (Asowayan et al., 2017; Bender & Bull, 2011; Scogin & Stuessey, 2014). Online material and tools, such as Prezi, Planting Science, and even Facebook, provide students a stimulating way to interact with other scientists, each other, and the teacher (Bender & Bull, 2011; Scogin & Stuessey, 2014). Bender and Bull (2011) researched how Prezi, specifically, worked to increase engagement levels in two different middle schools in North Carolina. Using Likert scales to assess student engagement levels while using Prezi, the researchers found that engagement levels did improve as students worked to produce Prezi presentations. In addition, “students indicated that Prezi helped with knowledge retention and learning, was an organized and effective tool to help understand new information and was an individualized and student-centered learning tool” (Bender & Bull, 2011, p. 17). Further research on the use of technology,

specifically multimedia presentation tools, can demonstrate both the value and effectiveness of this type of technology in students' engagement levels.

Scogin and Stuessey (2014) researched how an online platform called *Planting Science*, which is a computer curriculum specializing in integrating scientific inquiry, classroom instruction, and online mentoring from actual scientists. *Planting Science* has been around since 2005 and was designed to "improve scientific awareness, increase science classroom experience, and promote scientific proficiency" (Scogin & Stuessey, 2014, p. 317). The researchers used an extreme group comparison strategy and selected 10 student teams composed of four or five seventh graders each. The study followed the autonomy, relatedness, and competence model of the self-determination theory with student inquiry engagement as the outcome variable. Data was collected through the *Planting Science* website, and through dialogues and student work evidence such as journals, charts, and written reports. The study provided strong evidence supporting the existence of a relationship between online scientist-mentor support and student inquiry engagement. Limitations to the study included scientist-mentors providing different levels of support to the students, mainly because they were not educators; they were scientists volunteering their time to interact with students. In addition, the researchers were limited in studying student work because sometimes students would forget to post their findings or an assignment, leaving the researchers in the dark about some assignments. By using technology to address some of the facets of NGSS, I hope to engage students in the nature and inquiry of science content.

Parental Involvement

Grolnick et al. (1991) explored the relationship between parental involvement and children's motivation and performance in school using three variables: control understanding, perceived competence, and perceived autonomy. The researchers define parental involvement as "the degree to which parents are interested in, knowledgeable about, and spend time relating to their children concerning activities and experiences such as schoolwork" (Grolnick et al., 1991, p. 509). The subjects involved were 456 children in grades three through six from 20 classrooms, largely white in population, with parents who commuted to work in a city nearby. Children completed self-report scales and teachers were given competence ratings to rate their students. Parents completed a questionnaire about their parenting behavior and were interviewed and rated by the researchers for their parenting styles. This data was also used to evaluate the validity of the children's ratings of their parents. The study found that children's perception that their parents supported and cared about their education supplied them with more competence and autonomy in their learning, thereby increasing student achievement levels. Specifically, there was significant evidence of the relationship between a child's perceptions of their parents' autonomy support and the child's motivation, again leading to increased student achievement. Further studies would need to study the child's overall home environment, and how this environment affects the child's feelings of autonomy and competence.

Kurt and Tas (2018) also studied how middle school students' perceptions of parental involvement affected a child's engagement levels, focusing on performance in science class, specifically. How the parent supported the basic psychological needs,

including autonomy, competence, and relatedness, and how this related to students' engagement was specifically addressed, as well as their different levels of engagement behaviorally, cognitively, and emotionally. This correlational study used demographic questionnaires, student engagement scales, parental involvement scales, and basic psychological needs surveys to reveal the relationship between the variables of interest and to determine the engagement levels of students.

Data was collected through a 4-point Likert scale (1= Strongly Disagree, 4= Strongly Agree). The results found there is a positive relationship between parental involvement and students' motivation and engagement. Parental communication and autonomy support especially seemed to be useful in fulfilling these basic psychological needs. As parents want their children to succeed, students felt more competent, and as parents communicated with their children about school activities and participated themselves in school functions, students felt more related to the school. Additionally, as parents gave more responsibility to their child for their behaviors and allowed children to make their own decisions, children felt more autonomous. Limitations included relying strictly on students' perceptions of engagement, motivation, and parental involvement. Also, this study was limited to science, and relationships must be examined with other subjects as well.

Next Generation Science Standards (NGSS) and Engagement

Drew and Thomas (2017) studied how science teachers report implementing NGSS in their classrooms, specifically the Science and Engineering Practices (SEP). SEP includes "developing and using models, constructing science explanations, and engaging in argument from evidence," and these practices require higher order thinking skills and

careful planning and preparation (p. 274). The most frequent SEP used by teachers was to "analyze and interpret data," which was implemented very often or frequently by respondents (Drew & Thomas, 2017). The teacher participants were identified through the State Department of Education in a northeastern state and were sent emails to participate in the study. The surveys used a 7-point Likert scale (never to always), and the surveys were designed using the *Tailored Design Method* to make questions more appealing for maximum participation. Drew and Thomas recommended further research for middle school teachers, as this study strictly adhered to high school teachers. Also, this study did not explore how well the teachers implemented SEP, only whether they actually did employ the practices in their classrooms.

Phillips et al. (2018) researched how problematizing, the work of identifying, articulating, and motivating a problem or clear question, may be a better alternative to the NGSS practice of "Asking Questions." Ultimately, they wanted to study the dynamics of learners' engagement and persistence in science. The case studies showed the work students were doing to identify, articulate, and motivate a gap or inconsistency in their current understanding. "Their scientific work did not start with an agreed-upon question but with a student recognizing an inconsistency and then working to articulate and motivate it as a problem worth addressing" (p. 989). Students' confusion or misconceptions led them to construct their own questions and they worked towards answering these questions. The researchers selected only clear examples of students doing science, as captured on video and written work and they transcribed each instance, analyzing what contributed to the dynamics of scientific inquiry.

Problematizing consistently came up as a primary theme, so they reanalyzed each case looking for specific evidence within this realm. Problematizing is the "work of identifying, articulating, and motivating a problem or clear question" (Phillips et al., 2018, p. 983). Further research suggested includes studying how best to develop learning environments that support students in this type of inquiry and professional development for teachers to support students' formulating and articulating questions, gaps in knowledge, and problems. By definition, the Scientific and Engineering Practices adhere to this sense of inquiry, ensuring students are addressing their prior misconceptions and building upon their background knowledge.

Self-Efficacy

Ucar and Sungur (2017) examined the relationship between classroom goal structure perception variables (i.e., motivating tasks, autonomy support, and mastery evaluation), engagement (i.e., behavioral, emotional, cognitive), self-efficacy, and science achievement. The sample included 744 seventh grade students in nine different public schools in Turkey. Data was collected through the following four instruments: (a) survey of classroom goal structures, (b) engagement questionnaires, (c) motivated strategies for learning questionnaires, and (d) science achievement test. Students' perceptions of classroom goal structures, such as autonomy, motivating tasks, and mastery evaluation, were found to be significant predictors of their self-efficacy. Autonomy support was observed to be positively linked to all aspects of engagement, while motivating tasks were found to be related only to cognitive engagement. Also, mastery evaluation was shown to be positively linked to engagement variables, including cognitive engagement and self-efficacy. Behavioral, emotional, and cognitive

engagement were observed to be significant predictors of science achievement. Finally, results revealed relations among all engagement levels on student achievement. The study found that students who have high self-efficacy and who are behaviorally, emotionally, and cognitively engaged are more successful in science classes. The researchers recommend inquiry-based instruction and hands-on activities and that teachers "provide students with opportunities to make their own choices and decisions and to control their own action in science classes" (Ucar & Sungur, 2017, p. 149). Because only seventh grade students were studied, further research could include multiple grade levels. Also, the results were only derived from self-report questionnaires so further research could also utilize interviews and direct observations.

This literature review considers several factors that affect the engagement levels of students in classrooms. Specifically, students' self-efficacy, parental involvement, technology usage, motivation, and the NGSS are all direct factors in students' engagement levels. In my attempts to utilize NGSS, I hope to increase the engagement levels of my students, both online and in-person. "Only if students participate in academic activities with both 'hands-on' and 'heads-on' will the time they spend in classrooms result in the acquisition of knowledge and skills" (Skinner & Pitzer, 2012, p. 22).

CHAPTER 3

ACTION RESEARCH METHODOLOGY

This study focused on how implementing Next Generation Science Standards (NGSS) in my classroom affected the engagement and motivation of my students. Typically, it was extremely difficult to keep my students engaged in science. They seemed to rely on me to provide answers rather than thinking and exploring on their own. NGSS used a three-dimensional learning platform: (a) Science and Engineering Practices, (b) Disciplinary Core Ideas, and (c) Crosscutting Concepts (NGSS, 2019). Science and Engineering Practices required students to ask questions and define their own problems, engage in argumentative inquiry based on evidence, develop and use models to better understand phenomena, use math and computational thinking, and analyze and interpret data (NGSS, 2019). These practices asked that students independently or collaboratively explore the world around them while they plan and carry out their own investigations.

For my eighth grade classroom, the Disciplinary Core Ideas were evolution and adaptations in Life Science, Earth's resources and structure, Earth's history, and Astronomy in Earth Science, and force and motion and waves in Physical Science. Crosscutting Concepts are those that are used in all disciplines and involve cause and effect, deciphering patterns, systems and systems' models, structure and function, and stability and change. Students are required to understand these concepts as they relate to both science and other school subjects.

Research Question

To what extent does student engagement in learning increase during a 6-week unit on waves taught using phenomena-based inquiry from *The Framework for K-12 Science Education?*

Purpose of the Study

The purpose of this study is to examine to what extent student engagement in learning increases during a six-week unit on waves taught using phenomena-based inquiry from the Next Generation Science Standards (NGSS) based on the *Framework for K-12 Science Education*.

Action Research Design

The primary focus of this research was allowing students to use their skills independently as they explored the core ideas in class. By allowing students to explore concepts through phenomena-based inquiry before I fully explained the content, I hoped to spark the students' curiosity as they tried to figure out what was supposed to happen. After I lead a lesson, the students would have an opportunity to apply the information learned to improve on their skills with the knowledge they had now acquired. This research explored how students will remain engaged when they can explore and apply the information on their own, rather than just knowing and being able to recall content.

The research I consulted points to theories related to motivation, self-efficacy, and autonomy in learning tasks. Social-Cognitive Theory (SCT) explained how knowledge could be attained through observing and modeling the experiences of others. Once students could see *how* to effectively accomplish a task, they would become more confident in their own abilities, and perhaps gain the self-efficacy to continue dominating

learning tasks. I hoped the action research would indicate that this gained confidence would lead to higher engagement for students

My study was an action research study where I attempted to pique students' curiosity and enhance motivation of my students by utilizing NGSS, specifically phenomena-based inquiry, to improve engagement in my eighth-grade science classroom. Herr and Anderson (2015) asserted that action research is when practitioners "want to study their own contexts because they want the research to make a difference in their own setting" (p. 2). In addition, Durdella (2019) described qualitative research dissertations as those that "explore, describe, detail, and interpret facets of human social life—what people do, say, make, and believe" (p. 6). I would be learning directly from my students, the participants of my study, and would examine their experiences and feelings about my class, as well as my own reflections surrounding my teaching. Action research was a cyclical process, requiring I *plan* what I am going to do, then *act* to implement the plan. I then *observe* what happens because of the plan, and finally *reflect* on what I can do differently based on the data collected from the observations, therefore developing another plan and repeating the process (Herr & Anderson, 2015). My intervention, in this case, was the implementation of phenomena-based inquiry, a facet of NGSS and this was a case study by which I studied the effects of this implementation on my honors eighth grade class. My students were co-investigators, in that I was working with and learning from them to implement the new lesson plans. According to Merriam and Tisdell (2016), "one key to the success of an action research project is the extent to which there is participant buy-in and active participation" (p. 51). In that light, I hoped to create this climate by inviting my students to be both participants and co-investigators.

I was an insider to the research in that I was working within my own classroom to improve conditions. Because of my novelty in teaching science, my labs were usually pre-determined, and conclusions were already designed. With NGSS, I just set the parameters for my students, but they were charged with designing and implementing the experiment and drawing their own conclusions. Because of this type of lesson plan, they learned to think for themselves, leaving me as more of the facilitator while they actively worked out the problem.

The overarching question that guided this research is what impact implementing phenomena-based inquiry would have on the engagement level of eighth grade science students. It was hypothesized that the engagement of my students would be positively impacted by the implementation of phenomena-based inquiry. For the purposes of this study, engagement was measured by: (a) student pre- and post-surveys and interviews indicating their attitudes towards science class, (b) teacher observations via field notes of hopefully heightened participation and performance of students, and (c) student artifacts including anticipation guides with guided phenomena questions and weekly exit tickets asking open-ended questions about their individual engagement levels with the day's particular lesson.

Setting

The research was conducted in a Title 1 suburban middle school in North Charleston, SC. I teach six blocks of eighth grade science, three different blocks every other day. I work with a diverse student population, with about 82% African American, 13% Hispanic, and 4% Caucasian. I also have many students with IEP's and 504's in all my classes. Parental involvement is always a challenge, with only about 20%

participation in open houses and report card pick-up nights. Each of my blocks has between 25-30 students, with my honors class usually being right at 30 students. To protect the identities of both the participants and the school, pseudonyms were used throughout the study.

As previously stated, I recruited six students from my honors class because I believe they had the stamina and drive to complete and participate fully in the study. This study took place during the Fall 2021 semester, allowing time for me to get to know the students and for the students to adjust to my class expectations and their new environment. This was a maximum variation sample because engagement and motivation would widely differ from one student to the next. Some of these students were very goal-oriented and studious, while some liked to play and were seemingly uninterested in school.

The goal of this study was to maintain and further the motivation of those studious students while attempting to motivate and engage those who appeared not to be interested in my science class. I surveyed my students to make notes of those who were already engaged and those who would need encouragement. I wanted to note the growth of motivation and engagement throughout the process so I needed a baseline from which to start. Attrition can occur if students become frustrated and burned out by the rigor of the new standards, so I had to carefully select those who were up to the task. Ideally, I wanted to have several students who could help facilitate learning in collaborative situations as well as several on the other end of the spectrum, seemingly unmotivated to participate in regular activities. I wanted to note how their attitudes [hopefully] change as the study progressed.

Participants

The six student-participants are described below, using pseudonyms to protect their identities.

- Kelley is a 13-year-old White female who plays on both the volleyball and basketball teams. She is very outgoing, talks regularly in class, but generally gets her work done. She loves science.
- Missy is a 14-year-old Hispanic female who is extremely shy with anyone but her very small group of friends. She is bright and always completes her work, on time and done well.
- Manuel is a 14-year-old African American male who is bright but prefers to play and talk rather than working in class. He is very outgoing and is on the basketball team.
- Ryan is a 13-year-old White student who uses the pronouns they/them. They are very introverted and ask for a library pass every day during lunch/recess so they can read.
- Nathaniel is a 14-year-old African American who is a star athlete as well as a gifted student. He is fairly shy but seems to love science.
- Donna is a 13-year-old African American female student who has ADHD and is on a 504 plan. I allow her to walk around the room to relieve energy and yet it is a struggle working with her as she is very talkative. She tends to act immaturely and others in the room will call her out on it too.

Research Methods

Herr and Anderson (2015) suggested researchers "develop a *plan* of action to improve what is already happening," and then "*act* to implement the plan" (p. 5). The surveys, interviews, student artifacts, and my own field notes helped me "*observe* the effects of action in the context in which it occurs," and I could "*reflect* on these effects as basis for further planning, subsequent action and on, through a succession of cycles" (p. 5). "This cycle of activities forms an action research spiral in which each cycle increases the researcher's knowledge of the original question, puzzle, or problem, and, it is hoped, leads to its solution" (p. 5).

According to Durdella (2019), there were two types of observation: descriptive and reflective. In the descriptive observations, I detailed students' actions, the methods used, and how the activities were affecting students' engagement. In the reflective observations, I made notes about "new ideas, important insights, and emerging patterns from the fieldwork" (Durdella, 2019, p. 223). From these observations, I continually improved my implementation of NGSS based on both students' attitudes and student work. Durdella suggested using a field notebook to continually jot down ideas and observations because, again, this is a cyclical process where reflection plays an integral part in advancing and improving the plan. Merriam and Tisdell (2016) asserted, "observations are also conducted to triangulate emerging findings; that is, they are used in conjunction with interviewing and document analysis to substantiate the findings" (p. 139). Triangulation was critical to my study to ensure validity and reliability.

In addition to my own observations, my instructional coach also observed my class at least once per week, sharing her own conclusions about how students were engaging with the lessons. The first series of lessons done in the first quarter of Fall 2021

were my traditional ways of teaching, which means presenting a PowerPoint to introduce vocabulary, objectives, key concepts, and ideas, and then a predetermined type of lab in which the students were given explicit instructions to follow and already knew what was supposed to happen, then a quiz. Therefore, these observations needed to concentrate on the students, and how they reacted and engaged with the material. This provided the baseline for my lesson planning as well as students' attitudes and engagement towards the lessons.

The next series of lessons covered waves, our second unit of study, and I involved using NGSS, specifically phenomena-based inquiry, where my students worked collaboratively to develop their own plan of action in solving a problem or answering a question before any explicit instruction about concepts. Again, the observations focused on students and how they engage with each other. The last series of lessons occurred towards the end of my study, where I have hopefully refined and improved the implementation of phenomena-based inquiry and again focused on students' reactions to the lessons. In this way, I hoped to observe growth in my students' learning and engagement throughout the study. These observations also gave credence to my study as "one of the key issues encountered in insider action research is perceptions of possible coercion of participants, particularly when the researcher is also in a position of authority" (Herr & Anderson, 2015, p. 137).

Merriam and Tisdell (2016) discussed how important it is for me to reflect on these observations using margins in my notes. These included my "ideas, fears, mistakes, confusion, and reactions to the experience," and offered ways to improve for the next round of lessons (p. 152). Again, action research is a cyclical process allowing for

improvement during each round of lessons, so I hope to continually improve my teaching as well as enhance the experiences of my students.

Data Collection Instruments

During the implementation phase of this research, data was collected from the six student participants in the suburban middle school in South Carolina. The guiding research question for the collection of data was how utilizing NGSS impacted the engagement levels of six eighth-grade students in an honors science class at JZ Middle School. The specific data collection instruments are described in the following sections.

Pre/Post Surveys

Students took a Likert-scale 23 question survey (See Appendix A) that provided the baseline for the current engagement levels of my students. The survey addressed their interest, confidence, engagement, and perceived ability in science classes. The same survey was given at the end of the six-week period to gauge any changes during this time.

Pre/Post Informal Interviews

Students took home interview questions (See Appendix B) and answered on their own. They had two days to complete and turn in to me.

Exit Tickets

Exit tickets in the form of discussion questions were used as additional data reflecting students' engagement with the content (See Appendix C). Mondays and Fridays were engagement centered questions while Wednesday's exit tickets provided content related material and ensured students were learning from the activities. Students come to me every other day, so one week they had three exit tickets as described above,

but then the next week they only came to me on Tuesday and Thursday, so they completed only one engagement question and one content related question. For the six-week period, I had a total of 15 exit tickets per participant (See Table 3.1).

Anticipation Guides

The anticipation guides (See Appendix D) were the pinnacle of the phenomena-based inquiry. These guides challenged students to think about and discuss possible connections to everyday phenomena by investigating why they occur. By having the students fill in the guides each week, they were charged with determining outcomes and the teacher-researcher was able to expand on their initial knowledge, while also filling in gaps and clearing up any misconceptions. A total of six anticipation guides for each student was added to my data.

Observations/Field Notes

As I observed the students when they are working, I documented field notes in my journal (See Appendix E). Durdella (2019) identified three areas that can be investigated using field notes: time, space, and interactions. Each note includes the date, time, and setting of the observation. Interactions between students were noted and attributed directly to engagement of students. Merriam and Tisdell (2016) stressed the importance of detail and descriptions in the following: “enough detail should be given that readers feel as if they are there, seeing what the observer sees” (p. 151).

Field notes provided an imperative reflection piece to the research (Merriam & Tisdell, 2016). My commentary included my own feelings, reactions, and interpretations to what was going on in the classroom. “These comments are questions or notes about

what is being observed; with these comments one is actually moving from descriptions to beginning data analysis" (Merriam & Tisdell, 206, p. 152).

Ethical Considerations

In addition to using pseudonyms to protect the identities of my students and school, I was keenly aware of any potential biases I had in studying my own students and classroom. Lichtman (2013), as quoted in Merriam and Tisdell (2016), suggested "being explicit about the researcher's role and his or her relationship to those studied, making a case that the topic of the study is important, being clear about how the study was done, and making a convincing presentation of the findings of the study" (p. 240). I needed to ensure readers know I am an insider focusing on how to improve my own practice through the implementation of NGSS. My participant sample was my own students, and the implementations took place in my own classroom. I would more likely than not have my own biases, including knowing my students and their learning styles, personalities, and home lives. Hopefully, by being a reflective practitioner, I would "learn to learn" about my practice and become a better teacher in my own setting, but the transferability may get lost in others' classrooms if the conditions are vastly different than my own (Herr & Anderson, 2015). With this in mind, I made every effort to remain an unbiased practitioner by continually reflecting on my actions, procedures, and ethical interactions with my student participants.

Procedure

My student participants met every other day for 80 minutes in my fourth block, right before lunchtime. At the beginning of the six-week study, I sent home the formal interview questions to participants which were returned within two days. In addition,

engagement surveys were administered during class on the first day of the study. Results of these surveys gave me the baseline of their engagement in both my class currently as well as their engagement in past science classes and school in general.

I determined the data from student artifacts and my own field notes would be collected on Monday, Wednesday, and Friday of every other week and Tuesday and Thursday of the alternate weeks of the six weeks during the study. I obtained data from a total of fifteen school days. Data from student artifacts included anticipation charts, exit tickets, and online discussion questions where students conversed with their peers. These artifacts utilized the language of NGSS, because students were asked to analyze and draw conclusions from data, design and construct explanations for phenomena, and debate and analyze arguments from evidence.

The week before the study officially started, we discussed phenomena-based inquiry and I taught and modeled how these practices will be incorporated into our lessons. This was done as I was teaching content so as not to interfere with our schedule. The initial survey was also given, and students took home their pre-study interview questions. Students started doing anticipation guides on Monday by filling in the chart pertaining to our lesson that week. They were also asked to cite their prior knowledge leading to their conclusions. These guides helped students tap into their prior knowledge while also addressing common misconceptions about science concepts. The ‘why’ addressed the constructing explanations aspect of NGSS.

After our lesson, students were given an exit ticket question dealing directly with their engagement of the lesson. On Wednesday, I posted a discussion question on Google Classroom requiring students to communicate with me and their peers about a specific

aspect of the week's lesson. This exercise addressed the collaboration portion of NGSS. They were also given an exit ticket where they had to answer a question about the content covered on Monday and Wednesday. On Friday, students filled in the remaining section involving 'what they learned' of the anticipation guide indicating whether they were originally correct in their assertions and indicating what changed their minds about their answers. They also completed another exit ticket telling me about their engagement in the week's lessons. These activities were monitored by me, and I documented how these lessons went in my field notes.

During week two, I had the student-participants on Tuesday and Thursday; therefore, on Tuesday, students answered an exit ticket question about their engagement in the day's lesson. Thursdays included an exit ticket about the content as well as an online discussion question about engagement and how to improve lessons for the following week.

During weeks three through six, students continued with anticipation guides, exit tickets, and the online discussion questions as indicated in the table. Occasional informal interviews were held during these four weeks to assess how the students were feeling as they participated in the study. After the last week, student-participants took the original engagement survey again to reflect any changes in their engagement levels with the phenomena-based inquiry implementation; they also took home and completed the post-study interview questions.

Waves Unit Study Schedule

Table 3.1 Weekly Study/Activity Schedule

Week/Meeting Days	Topic	Study Activities
Week Before study		Administered Engagement Survey #1
1: M, W, F	Phenomena: What defines a wave?	**Monday**: Introduce anticipation guides "Are waves invisible?" followed by exit ticket after lesson..."If you were the teacher, what grade would you give your efforts today?" **Wednesday:** Group Discussion Question "Discuss the different waves you came in contact with today. Please reply to at least 2 of your classmates. Content exit ticket: "What does the amplitude of a wave tell us about the energy of the wave?" **Friday**: Engagement Exit Ticket: "As you look over your work today, what is one thing you would do differently next time?" Students fill in anticipation guides with what they have learned.
2: T, Th	Phenomena: How do sound waves work? How do they allow us to hear? Can we 'hear' in space?	**Tuesday**: Anticipation Guide: "How do sound waves allow us to hear?" followed by a Content exit ticket "What type of wave is a sound wave?"; **Thursday**: Engagement Exit Ticket: "Did you do your work the same way others' did theirs? What was similar and what did you do differently?" Students fill in the anticipation guide. Online Discussion Question: How can I improve lessons next week?
3: M, W, F	Phenomena: What is the relationship between wave properties (frequency and amplitude) and wave energy? Why are some sounds louder than other sounds?	**Monday**: Anticipation Guide: "Why are some sounds louder than other sounds?"; Exit Ticket: What did you find frustrating about today's work? What did you find satisfying?" **Wednesday**: Group Discussion Question How do you feel about our Waves Unit so far? Please reply to 2 other classmates as well. Content exit

		ticket: What is the property of a sound wave that determines the volume? **Friday**: students fill in anticipation guide. Engagement exit ticket: “Did today’s lesson keep you engaged? Why? Please provide specific examples”
4: T, Th	Phenomena: What makes objects appear as different colors? What happens when light waves interact with different types of matter?	**Tuesday:** Anticipation Guide “What makes objects appear as different colors?” Engagement Exit Ticket: “In what ways have you gotten better at working with other students? In what ways can you still improve?” **Thursday:** students fill in anticipation guide; Content exit ticket: “Give an example of opaque, transparent, and translucent matter” Online Discussion Question: How can I improve our lessons next week?
5: M, W, F	Phenomena: How are sounds and images sent through radio waves?	**Monday**: Anticipation Guide: “How are sounds and images sent through radio waves?” Engagement exit ticket: Did today’s lesson keep you engaged? Why? Please provide specific examples. **Wednesday**: Group Discussion Question: In your own words, describe how images are sent through radio waves. Reply to 2 other students with concrete examples. Content exit ticket: “When you are talking on the phone, how does your voice travel many blocks away or to a different town, city, or country?” **Friday**: Students fill in the rest of the anticipation chart and Engagement exit ticket: “What problems did you encounter while working today? How did you solve these problems (roadblocks)?”
6: T, Th	Phenomena: What are some design constraints in fiber-optic communications?	**Tuesday**: Anticipation guide: “What are some design constraints in fiber-optic communications?” Content exit ticket: What was different about the original analog waves and the digital version of those waves? **Thursday**: students finish anticipation guide; Engagement exit ticket: “In what ways have you gotten better at

		working with other students? In what ways can you still improve?" Online Discussion Question:
Week after Study		Administered Engagement Survey #2

Data Analysis

This study used a qualitative approach and began with a Likert survey (See Appendix A) given to the student-participants to establish a baseline engagement level for the onset of the study. Following the surveys, participants were given a series of semi-formal, open-ended interview questions (See Appendix C) which they took home and returned completed within two days. These interview questions were outlined by the ideas suggested by the ARCS model of motivation: attention, relevance, confidence, and satisfaction and answers were sorted initially using this predetermined coding system.

The most important aspect of data analysis is to continuously analyze the data in rounds as I collected the information. I did this by "capturing [my] reflections, tentative themes, hunches, ideas, and things to pursue that are derived" from each round of data collection (Merriam & Tisdell, 2016, p. 196). This also provided opportunities for me to learn from each round and "note things [I] want to ask, observe, or look for" in the next data round (p. 196).

As I sifted through the data, I coded every student statement, artifact, field note, and the surveys using different color post-it flags. Each color represented a different theme or pattern. This thematic data analysis will allow me to inventory and import these key concepts from every interview, student artifact, and observations noted on field notes I collect. I coded the data as the research progressed, linking these codes or categories

"that have common or shared characteristics and describe patterns," and "the outcome of all this activity is a theorized story, or set of stories that reveal patterns in the phenomenon under investigation" (Durdella, 2019, p. 273). Merriam and Tisdell (2016) defined coding as "nothing more than assigning some sort of short-hand designation to various aspects of your data so that [I] can easily retrieve specific pieces of the data" (p. 199).

In addition, the authors described how "each interview, set of field notes, and document needs identifying notations so that [I] can access them as needed in both the analysis and the write-up of [my] findings" (p. 199). Each week, I reviewed and organized the data into topics using post-it flags, which was paramount, rather than waiting until the end to process. Data analysis "involves consolidating, reducing, and interpreting what people have said and what the researcher has seen and read" and breaking this information down into categories or findings to discover relevancies in answering my research questions (p. 203). Making notations of pertinent insights on interviews and my own field notes and then categorizing this information into tabs helped me as I moved through the data analysis process. Selecting colors for each theme/topic and then organizing the data by color seemed to be the most sensible.

Ensuring validity and reliability in a research paper makes the conclusions usable and trustworthy to those who read and try to implement the strategies offered. Lichtman (2013), as quoted in Merriam and Tisdell (2016), suggested,

> Being explicit about the researcher's role and his or her relationship to those studied, making a case that the topic of the study is important, being clear about

how the study was done, and making a convincing presentation of the findings of the study. (p. 240)

I needed to ensure readers know I am an insider focusing on how to improve my own practice through the implementation of NGSS.

My participant sample was my own students, and the implementations took place in my own classroom. Hopefully, by being a reflective practitioner, I would "learn to learn" about my practice and become a better teacher in my own setting, but the transferability may get lost in others' classrooms if the conditions are vastly different than my own (Herr & Anderson, 2015). Maxwell (2013), as quoted in Merriam and Tisdell (2016), asserted, "validity is never something that can be proved or taken for granted. Validity is also relative: It has to be assessed in relationship to the purposes and circumstances of the research, rather than being a context-interdependent property of methods or conclusions" (p. 243). There will be "multiple constructions of how people have experienced a particular phenomenon," and they will need to be conformed to the setting of the reader's own circumstances (p. 243).

In my own setting, low motivation and engagement was a great challenge; therefore, this study was completely relevant and important to me as a practitioner. I tried to be explicit on how my study was conducted, offering insider tips that will help others transfer the practices to their own classrooms as warranted. Providing detailed lesson plans and references to find materials can help others with transferability. Finally, presenting my findings in a clear and concise manner would aid others in discovering the relevancy of the study.

Triangulation could also help me with establishing validity and reliability of my research. I used multiple sources of data (interviews, observations, and student and teacher artifacts) to solidify my results. By using multiple perspectives of data, I made sure to guard “against viewing events in a simplistic or self-serving way” (Herr & Anderson, 2015, p. 68). From these perspectives, I saw patterns in the data so I can draw accurate and descriptive conclusions. I also enlisted the help of some of my students, my assistant principal, and my instructional coach in verifying my interpretations of the interviews and observations to ensure my conclusions concurred with their thoughts. This is something that Merriam and Tisdell called respondent validation, soliciting feedback on my findings (2016). By doing this throughout the research process, I made sure my interpretations “ring true,” further adding validity to my research.

Plan for Reflecting with Participants

At the conclusion of the study, the student-participants and I had a debriefing session where we discussed any concerns about the study and any further recommendations on how to perhaps improve studies done in the future. Fichtanan Dana and Yendol-Hoppy (2014) asserted that these reflection discussions allow teachers and students to “intentionally ask questions about teaching and learning, organize and collect information, focus on a specific area of inquiry, and benefit from ongoing collaboration and support” (p. 15). Student-participants were free to offer any insights they may have had about the study, and they communicated any particular struggles or victories they had while participating.

Devising an Action Plan

Based on the results of this study, I developed an action plan that included ways in which NGSS, specifically phenomena-based inquiry, can best be utilized to invoke our students' curiosity, thus leading to more engagement in classroom activities. This plan was comprised of various helpful websites and the schedule of activities, including exit tickets and anticipation guides. Asking questions is one key component to arousing curiosity and can also get the attention of students if they are presented in an interesting way. I presented the schedule of activities along with the NGSS-aligned websites at our science professional development day.

CHAPTER 4

FINDINGS FROM THE DATA ANALYSIS

This study examined the impact of using phenomena-based inquiry, the overarching theme of NGSS, on the engagement levels of a middle school classroom. A sample of six eighth-grade students participated in the study over the course of six weeks with their teacher as researcher. The problem of practice for this study focused on improving the engagement of my middle school students in their science class through phenomena-based inquiry such as asking questions, collaborating with peers, and gathering evidence through their investigations.

The primary treatment method for this study was using both questioning and collaboration to engage students in the phenomena of science. By using the ARCS model as the theoretical framework, I used anticipation guides to capture the students' attention and real-world examples of how waves can directly affect my students' lives for relevancy. Students gained confidence in their collaborations with other students and satisfaction was attained through additional questioning in the form of exit tickets given at the end of class.

During the six-week period of data collection, student-participants responded to pre and post-Likert surveys, answered pre and post-interview questions, and participated in group discussions, completed anticipation guides, and answered exit tickets related to

both content and engagement in lessons. I also kept a journal of field notes and noted both successes and ways to improve lessons in the future.

All data was coded with post-it flags in different colors for each recurring theme seen. I used yellow flags for any statements concerning students' attention and/or curiosity. Red flags were used whenever I saw statements referencing previous knowledge or background knowledge. Pink flags were used for feelings about students' confidence in class, and I placed blue flags for any notes or statements concerning the teacher's attitude or energy. For final analysis, I consolidated all data into the following three major themes: (a) piquing students' curiosity, (b) relevancy of content, and (c) student self-efficacy.

The study population consisted of six eighth-grade student-participants who volunteered for the study. These students are in my honors class in a Title 1 middle school located in the Charleston area. This chapter provides a summary of the findings.

Research Question

To what extent does student engagement in learning increase during a six-week unit on waves taught using phenomena-based inquiry from the Next Generation Science Standards (NGSS) based on the *Framework for K-12 Science Education*?

Research Purpose

The purpose of this study is to examine to what extent student engagement in learning increases during a six-week unit on waves taught using phenomena-based inquiry from the Next Generation Science Standards (NGSS) based on the *Framework for K-12 Science Education*.

Findings of the Study

During the six-week unit on waves, this teacher-researcher collected data using various instruments as follows: pre- and post-Likert surveys, pre- and post-interviews, teacher-researcher field notes and observations, and student artifacts, which include anticipation guides and both content-related and student engagement-related exit tickets. After carefully coding and reviewing the data, three prevalent themes emerged. The first theme can be characterized as sparking the curiosity of students. The second theme indicated students' need to relate the content to their own lives. The third theme revealed how students need to feel confident in their endeavors as they learn and discuss material.

Theme One: Sparking the Students' Curiosity

Prior to this study, I would ask questions often to my class, but the same few students always raised their hand to answer, leaving the rest of the class disengaged in the lesson. SEP's first direction is asking questions of the class, so this teacher-researcher decided to use anticipation guides to both ensure participation by all students and to pique their curiosity.

The week before the study, participants completed a student engagement survey (See Appendix A). After the survey data was collected and coded, the following four survey items indicated fairly low levels of interest in science: (1) I enjoy learning science; (2) I put a lot of effort into learning science, (3) I like science because it challenges me, and (4) I find learning science is interesting. All four of these statements had relatively low numbers, indicating "never," "rarely," or "sometimes," indicating a disconnection by the students to my class. I coded these statements with yellow post-it flags, indicating students' lack of interest and my failure to spark their natural curiosity. Nathaniel and

Donna were particularly disengaged as both put “never” for science as challenging and “rarely” for finding science interesting. Phenomena-based inquiry is meant to challenge and engage students with phenomena-based questions that motivate learners to want to know more (Bendici, 2019). Before this study, I did not allow students to figure things out either on their own or collaboratively but was rather telling them the answers before we even asked a question.

After the six-week treatment, students’ responses to the four items rose significantly, with both Nathaniel and Donna indicating “sometimes” and “usually” to the four items. In fact, five of the six participants indicated “usually” for science being challenging, rising dramatically from the pre-study survey.

Table 4.1 Piquing Students’ Curiosity

Survey Question	Pre-Study Mean	Post-Study Mean
I enjoy learning science.	3.83	4.33
I put a lot of effort into learning science.	4.17	4.33
I like science because it challenges me.	2.67	3.33
I find learning science is interesting.	3.5	3.83

In the initial interviews, several student-participants’ statements also supported this theme of sparking their curiosity. Donna expressed how she feels like she pays attention more when the subject is something she is generally interested in and when she is given the opportunity to talk about the subject. Manuel wrote, “I like learning the different things that I wouldn’t know before,” and Kelly said, “I’ve always liked science, but it gets boring just doing paperwork; I’d prefer having more labs and interactive work.” These statements attest to how students were bored, uninterested, and

unstimulated by the methods used in my classroom. Missy and Ryan expressed how taking notes left them feeling bored and sometimes even overwhelmed. Nathaniel's response to participating in class was as follows: "I don't like to participate, not because I don't know the answers, but because I feel it's a waste of my energy."

In the post-interviews, student-participants expressed how the phenomena-based inquiry sparked their curiosity and interest in class: Kelly wrote, "I pay attention more in class when the course is more interactive; I liked the class discussions and being in groups." Missy's attitude towards my class really improved as she said, "her class is one of my favorites now; it's a time to learn new things the easy way." Nathaniel's interest in class changed too. He said, "I saw and listened to others talk about what we were learning, and it made me want to talk too." Ryan expressed how thinking about the phenomena introduced every week made him want to learn more. He wrote, "I was genuinely interested in why waves in the ocean start in the first place." Donna expounded on this interest and said, "I liked talking about why things happen before actually learning why." Students are generally curious about the world around them and if teachers can capitalize on this curiosity, it will engage students and make them want to participate.

Additionally, as Ryan indicated in the post-interview, my energy directly impacts my students' willingness and excitement about the content. Ryan noted, "something that makes me pay attention is the teacher's energy, talking energetically about the subject makes me want to learn more about what she's excited about." When teachers are genuinely excited about the material, and when they add some suspense to the content, students will be excited and want to learn more.

Student engagement was also determined by exit tickets, most of which were engagement-centered, but once a week (for a total of six), exit tickets were content related. The student-participants answered every content-based exit ticket correctly, indicating they were paying attention to the lesson, understanding the material, and engaged with the lessons.

Interpretation of the Results of Theme One: Piquing the Students' Curiosity

Based on the interviews turned in before the study, it was evident students were both not engaged and appeared not interested in science class. Part of this disengagement stemmed from my instructional methods, whereas I was presenting science as a culmination of, through their eyes, useless facts. For students to be engaged in science, it is necessary for them to actually participate and *do* science (Asowaya et al., 2017; Bendici, 2019; Grabau & Ma, 2017; McLeod, 2019; Schmidt et al., 2017). Sparking curiosity in students is necessary for them to want to participate and learn the information. By using anticipation guides as inquiry focused on various phenomena, students could brainstorm what they already knew and think about questions they still had regarding the question. Students were taught to generate their own ideas instead of relying on me to tell them what they needed to know.

Keller (2016) emphasized inquiry as a technique to grab the students' attention. Students must desire learning the information and I tried to focus on phenomena that they would truly want to know more about. I had to model how this inquiry worked: my students were used to the hand-holding aspects of my usual lessons. NGSS and phenomena-based inquiry requires a shift from teacher-led to student-led classrooms (Bendici, 2019). Teachers facilitate learning while students generate their own knowledge

through collaborations, investigations, and discovery (Bendici, 2019). The NGSS asserted that the "goal of building knowledge in science is to develop general ideas, based on evidence, that can explain and predict phenomena" (Next Generation Science Standards, 2016, p. 1).

Typically considered one of the duller units by my students in years past, by using phenomena-based learning in learning waves, students had the opportunity to explore why some sounds are louder than others, how sound waves travel through cell phones, and how waves have generally improved our lives (e.g., cell phones, computers, televisions, microwaves). Natural phenomena like ocean waves, sunsets, and the Doppler Effect were also explored. "By centering science education on phenomena that students are motivated to explain, the focus of learning shifts from learning about a topic to figuring out why or how something happens" (NGSS, 2016, p. 1). This curiosity in learning about why things happen leads students to engage and participate more, which explains the higher survey numbers in the post-study survey.

Students answering all the content-related exit tickets correctly also lends itself to this theme of curiosity; when students are curious, they want to learn more and figure out the answers to the questions presented. According to Fredricks et al. (2004), when students can correctly answer questions that check for their understanding, this indicates a higher level of engagement by the students.

Theme Two: Relevancy of the Content to Students' Everyday Lives

Prior to this treatment, the six student-participants thought science had very little to do with their everyday lives. I noted the following statements with red flags indicating relevancy to students' everyday lives: (1) I like how science relates to everyday things I

think about, (2) the science I learn has practical uses for me, (3) I think about how learning science can help me get a good job, and (4) I think about how I will use the science concepts I learn. According to the pre-study survey, Missy saw the smallest link to her real-life experiences, putting “rarely” for all but one statement. Donna and Nathaniel ranged in responses from “rarely” to “sometimes,” and Kelly, Ryan, and Manuel were fairly consistent between “sometimes” and “usually.” The two latter statements about how science could improve the types of jobs and how students will use science concepts in the future saw averages of 3 each, indicating students “sometimes” agreed with these statements.

In the pre-study interview questions, Kelly expressed her interest in doing “more labs and interactive work” and “talking about things I know.” Missy, Ryan, and Donna all referenced making science more relatable in their interviews, most notably with Ryan writing “I want to be able use what we’ve learned.” Nathaniel and Manuel gave higher marks for relatedness, referencing how we worked and talked about cars all during the Force and Motion unit. Donna said, “I think it is good to know about science and understand it, but honestly, I think that the majority of the stuff taught in school is useless to survive on in the real world when we have to be on our own.”

However, after the treatment, the scores for the relatedness statements mentioned above all improved. When asked about how science relates to everyday things on the post-study survey, Missy and Donna jumped from “rarely” to “usually,” while Ryan went from “sometimes” to “usually.” The other two statements saw similar results: Kelly went from ‘sometimes’ feeling learning of science as useful for getting a job to usually,” and while both Kelly and Missy indicated “rarely” regarding actually using science concepts

in the future pre-study, they “usually” thought about how they could use science concepts post-study.

Table 4.2 Relevancy of the Content to Students’ Everyday Lives

Survey Question	**Pre-Study Mean**	**Post-Study Mean**
I like how science relates to everyday things I think about	3.33	4.00
The science I learn has practical uses for me	3.17	3.67
I think about how learning science can help me get a good job	3.00	3.5
I think about how I will use the science concepts I learn	3.00	3.67

For the post-interview questions, Kelly explained how the relevancy of the subject matter helped her comprehend the content as follows: the teacher “allowed us to discuss how we use waves and how they affect our lives every day.” Missy agreed, saying that the teacher “uses real-world examples that tend to relate to students’ daily lives, using those and connecting them to the topic being learned.” Donna equated relevancy to being able to visualize the content, saying, “real-world examples make it easier to visualize the things and relate it to certain other things.” When students can relate what they are learning to either their own background knowledge or to something they deal with every day, they are more apt to pay attention, engage with the material, and want to learn more.

When looking back at the field notes taken during our lessons, this theme of relevancy stands out the most (I used red post-it flags for relevancy). At least once on every field note, I made notes of the student-participants making exclamations of familiarity with concepts we were learning. For example, when discussing why some sounds are louder than others, Missy was able to connect the concept to her own voice

and how her parents and teachers talk about how loud she is. Nathaniel, in another discussion, asked about his colorblindness and one of his classmates said, "the cones in your eyes don't work." When students are conversing about concepts they know a little about, it becomes familiar and relatable, and therefore, doable. Relevancy takes away the question "Why do we have to know this?" and replaces it with "I've always wondered about…?"

Interpretation of Results of Theme Two: Relevancy of Content

Phenomena-based inquiry will not work if the students are not interested in the phenomena. Luukkonen (2003) asserted, "relevancy is not something that is easily grasped; it is something we must work hard to achieve" (p. 53). My student-participants come from many different backgrounds. Some speak English as their second language, some live in poorer areas of town, and one identifies as a gender other than the one given when born. Designing lessons that are relevant to every single child can be challenging, but this is necessary to engage them.

The questions asked in our classrooms need to pertain to some aspect of our students' lives, and teachers are tasked with finding out what questions will truly interest them. For example, our textbook suggests using ocean waves as a phenomena-based question and, after performing a quick student survey, students indicated only a small interest in the ocean as over three fourths of the class had never been to the beach. However, students were very curious about how cell phones and computers work as these are devices they use daily and are a perfect vehicle for describing how different waves work. Especially pertinent during the pandemic where our students were locked down at home for a year and a half, we discussed how valuable these devices were, not only for

schoolwork, but also for their socialization. Students were dismayed when I told them how life was before these inventions. Imagine life during a pandemic without TikTok, Facebook, Instagram, and no computer to get and turn in assignments while also collaborating with classmates. I wrote a note on my field notes about how I literally saw jaws drop during this exchange. Students became keenly aware of the importance of science to their daily lives.

Keller (2000) explained how relevance of content is derived from directly relating the content to the goals of students, their interests, and their learning styles. Teachers can do this through case studies, analogies, and "examples related to the students' immediate and current interests and experiences" (Keller, 2000, p. 2). During this treatment, I continually asked myself how I could best tie my students' experiences into the content being taught. When students see the value of the material based on their personal experiences, they have a vested interest in what is being taught and will engage in the classroom.

Theme Three: Growth in Self-Efficacy

According to the pre-study survey, the student-participants held a fairly low confidence level in science in all six statements I coded with blue flags for confidence in science class. Of these six survey items I coded blue, the following four were positive: (1) I am confident I will do well on science tests, (2) I feel confident doing science experiments and labs, (3) understanding science makes me feel like I accomplished something, and (4) I believe I can master the knowledge and skills in all science classes. The following two survey items were negative, indicating a lower mean would mean

higher self-efficacy: (5) I am concerned other students are better in science than me, and (6) I worry about failing science tests.

Missy, Nathaniel, and Donna had the lowest scores for doing well on tests as they all indicated they only “sometimes” felt confident taking science tests. The other three students “usually” felt confident. These already high scores increased post-study as Missy indicated she “always” feels confident taking tests, and Nathaniel and Donna moved to “usually” feeling confident. For confidence in performing labs and experiments, Kelly had the lowest score pre-study, indicating she “rarely” feels confident, whereas the others expressed they “sometimes” and “usually” felt confident. Post-study, these scores increased, with Kelly jumping to “usually” feeling confident and most others moving to “always” being confident. Only Ryan showed no growth in this area, still indicating only “sometimes” feeling confident. For the last positive statement pre-study, Kelly again indicated “rarely” feeling able to master the skills and knowledge necessary to be successful in science classes. Post-study, she jumped to “usually” feeling able to master the skills necessary in science classes. Others indicated pre-study “sometimes” and “usually” with only Nathaniel feeling he “always” felt confident to master these skills. Post-study, Nathaniel maintained “always” feeling confident to master the skills necessary to be successful, while Missy, Ryan, Manuel, and Donna moved to “usually” and “always” believing they could master the skills and knowledge in science.

Table 4.3 Growth in Self-Efficacy: Positive Statements

Survey Question	Pre-Study Mean	Post-Study Mean
I am confident I will do well on science tests	3.50	3.83
I feel confident doing science experiments and labs	3.83	4.33
Understanding science makes me feel like I accomplished something	3.50	3.83
I believe I can master the knowledge and skills in all science classes	3.33	4.33

In addition to the positive statement results, I noticed how the negative statement survey items decreased in means. Pre-study, Kelly indicated "always" being concerned how others in class were better in science than she was, while Nathaniel and Manuel indicated "never" being concerned about others performing better. Missy, Ryan, and Donna were just "rarely" or "sometimes" concerned. Post-study, Kelly moved down to "rarely" feeling anxious about others' performance in science while Nathaniel and Manuel stayed the same with "never" being concerned. Missy and Donna remained stagnant at rarely caring about others' performance, but Ryan went from "sometimes" to "rarely" caring about others' knowledge in science.

Table 4.4 Growth in Self-Efficacy: Negative Statements

Survey Question	Pre-Study Mean	Post-Study Mean
I am concerned other students are better in science than me.	2.33	1.67
I worry about failing science tests.	3.83	3.00

In the pre-study interviews, my student-participants seemed to understand the importance of how feeling confident might make them perform better in their science classes. For example, Kelly shared how she "wants to feel confident about all my classes because I think I would make higher grades. I second-guess myself on tests and don't talk much in groups because I'm scared." Ryan also shared these sentiments, saying "I feel like I understand what's going on, but then I listen to my friends, and they sound so much smarter than me." Missy said she felt like she understood science "really well," which made her feel confident, but she added that "speaking in front of others makes me feel really anxious." Donna also expressed her reluctance in working in groups, saying "I don't like to talk in discussions because I feel like others are smarter than me."

I took notes about the students' hesitancy to speak in front of others, hoping that the online discussion groups would allow them to express their thoughts more freely. Because of the ongoing pandemic, we are still discouraged from allowing students to congregate in in-person groups. I think requiring students to respond to online questions and to their peers allowed those who were otherwise shy about sharing their ideas feel more comfortable. I noted how the student-participants were excited about others' responding to their ideas, which seemed to boost their confidence to express themselves without the impending doubts.

Perhaps because of this boost, students in the post-study interviews described how their attitudes towards discussions had shifted a bit. Kelly relayed how her confidence was lifted by the online discussions and said, "I felt like I contributed well to them." Likewise, Ryan noted how he enjoyed other students commenting on his posts by saying, "It made me feel like I had said something worthy" and "I liked reading other peoples'

posts because I was usually thinking the same thing." Only Nathaniel expressed his disinterest in the online discussions. He commented on how the discussions made him feel like he had to participate when he really "did not want to comment on some posts." My own comments providing feedback also seemed to contribute to higher self-efficacy. Missy expressed, "I felt good when [the teacher] agreed with what I had said."

Finally, the engagement-related exit tickets also contributed to this theme of self-efficacy of the students. When asked to answer, "What was particularly satisfying about your work today?" the student-participants all agreed on how receiving feedback from both their teacher and classmates made them feel like they had contributed valuable information to the discussions. Additionally, when asked how they have gotten better at working with other students, most of the student participants expressed an improved attitude towards group work.

Interpretations of Theme Three: Growth in Self-Efficacy

Students desire feeling confident in their efforts in the classroom. Many studies have shown how improved self-efficacy leads to enhanced engagement and motivation to improve even more (Blumenfeld et al., 2006; Fredricks et al., 2016; Grolnick et al., 1991; Michaelis, 2017). Niemiec and Ryan (2009) asserted, "students are competent when they feel able to meet the challenges of their schoolwork," thus allowing them to work without self-doubts and insecurities (p. 135). Frustration and feelings of incompetence can lead students to give up completely, so it is imperative teachers provide encouraging feedback to keep the energy alive.

In this study, students noted how positive feedback from classmates also contributed to their own self-efficacy. They were more confident when responding to

both initial posts and to those of their classmates. This allowed them to express their thoughts without hesitation and to feel like they were contributing to the overall classroom discussions, thereby increasing their engagement with the material.

Keller (1987) stressed the importance of teachers fostering the development of confidence "despite the competitiveness and external control that often exist in schools" (p. 5). My honor students can be extremely competitive in terms of grades, games, and the feedback they receive. They can also give up easily when they feel like they are losing or not understanding the content, so initiating and instilling their confidence is paramount to them persevering. Keller (1987) offered a few strategies to ensure students feel confident, made up of the following: (a) attributing students' successes to effort versus luck, (b) gradually giving students autonomy in their learning, and (c) having students learn new skills under low risk conditions. Armed with these strategies, I was able to continually offer positive feedback about efforts exerted while also gently providing tips for more success. Students also were given more autonomy in their learning throughout this study; I was simply facilitating their discussions about the phenomena-based inquiries and offering suggestions as appropriate. Finally, by allowing students to initiate discussions and replies via an online platform, students could respond in a fairly low risk way.

Conclusion

Acquiring and maintaining students' engagement with lessons is imperative to improving student achievement (Borup et al., 2014; Fredricks et al., 2004; Grabau & Ma, 2017). However, using phenomena-based inquiry in our science classes to increase engagement of learners appears to be limited in my review of the literature. Because our

state is officially adopting the NGSS this upcoming 2022-2023 year, I thought it appropriate to study how this phenomena-based inquiry might engage my students. The data collected through pre- and post-surveys, pre- and post-interviews, exit tickets, anticipation guides, online discussions, and my own field notes showed how this type of inquiry can increase learner engagement. The student-participants positively indicated how phenomena-based inquiry piqued their curiosity, provided relevancy to their own daily lives, and gave them a sense of self-efficacy to persevere through lessons.

These three themes that emerged through data collection and analysis are indicative of how teachers can help students engage in lessons. By asking questions, I created some suspense in learning, allowing students time to think about why phenomena happen, while also allowing them to ask more questions in their investigations. Providing all the answers before students even get to address the questions eradicates any curiosity from students. Making content relevant to my students' lives made them feel invested in their learning as they could make comparisons and draw their own conclusions from their experiences. Finally, allowing students to feel confident in their abilities and ideas gives students a sense of empowerment and ownership of their learning. Students were more engaged and invested in their learning because of these methods used in my classroom.

This type of teaching requires preparation, in that teachers should model best practices in asking questions of peers, filling out anticipation guides, and participating in online discussion forums. Teachers also need to become accustomed to facilitating, rather than leading discussions and they should prepare students to continually ask questions and research as they piece together information to solve the phenomena-based inquiry.

CHAPTER 5

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

Traditional teaching techniques, such as lectures, worksheets, and watching videos all require little to no action by our students. Students are treated like passive knowledge-seekers waiting for teachers to fill their brains with the information they need to survive in the real world. In today's world, instructional strategies need to revolve around active participation by students asking questions, citing evidence, identifying problems, and designing solutions to these problems (*Framework*, 2012). This is especially true in science, where students have so many questions about everyday phenomena but are usually reluctant to ask.

By using Keller's ARCS model of motivation as the theoretical framework, I sought to discover if this phenomena-based inquiry would better engage my students in my science classroom. Everyday phenomena encourage students to ask questions, cite evidence when trying to answer those questions, and finally put all the pieces together after lessons are complete. The phenomena need to spark curiosity in the students so they are eager to learn more. Relevancy to our students' everyday lives is critical in invoking this curiosity. In addition, ensuring students feel confident in their abilities is paramount to sustaining their attention throughout lessons. Students need to feel they can tackle a problem or question without risk of others mocking or chiding them.

This study involved six student-participants over a six-week period during our unit on waves. The problem of practice focused on increasing student engagement in my science classes through utilizing phenomena-based inquiry, the guiding principle of NGSS. I really noticed the last few years how disengaged my students were in class. I thought maybe it was cell phones, family matters, or some other distraction, but really started to get concerned when grades began plummeting. Students' disinterest in school typically begins in middle school, with engagement rates falling drastically as students move up from grade to grade (Fredricks et al., 2004). I wanted to explore how to halt this decline and make students become excited about school, especially science, again. Phenomena-based inquiry asks students to explore the world around them, making content both relevant and equitable to all students.

Research Question

To what extent does student engagement in learning increase during a six-week unit on waves taught using phenomena-based inquiry from the Next Generation Science Standards based on the *Framework for K-12 Science Education?*

Research Purpose

The purpose of this study is to examine to what extent student engagement in learning increases during a six-week unit on waves taught using phenomena-based inquiry from the Next Generation Standards (NGSS) based on the *Framework for K-12 Science Education.*

Overview of the Study

As mentioned in previous chapters, the pandemic has made the last several years very difficult, with this current year almost intolerable. Students are academically behind,

socially unprepared, and emotionally traumatized. They are apathetic to school, teachers, parents, and their friends. Social media has become the norm and students spend much of their time using their phones. Where science used to be their favorite subject, I have seen a sharp decline in enthusiasm and interest, as well as complete disengagement by most children. Masks and social distancing are still required, so we still are asked not to group students except virtually. I originally designed this study to address engagement of online learners, but quickly refocused on the classroom engagement when students returned to school this year and I realized just how disinterested students were.

Participation in the study was completely voluntary and both students and parents signed consent forms. Six students were randomly chosen, specifically by pulling names out of a jar to ensure fairness. Of the six student participants, three were girls and three were boys. Three students are African American, two are White, and there is one Hispanic. This is indicative of the demographics of my science honors class and the middle school as a whole.

Data for this study was mostly qualitative, drawing on the students' experiences, while some aspects involved quantitative data. Pre- and post-treatment surveys used Likert scale questionnaires on which students indicated their preferences from "1 = Rarely" to "5 = Always" for different student engagement statements. These responses were used to generate engagement exit ticket questions as well as initiate interview question probes for more discussion. Additional data included anticipation guides and the teacher-researcher field notes. The data collected was used to evaluate how the students' engagement in class changed from pre- to post-treatment.

The participants began each week with an anticipation guide with a phenomena-based question. They would reword the question then ask additional questions. They also indicated what they already knew about the subject (background knowledge) and anything else the phenomena may have made them think about. Students would then spend some time discussing their ideas in an online class discussion forum through Google Classroom. Towards the end of class, students filled out a single question exit ticket indicating their engagement in the lesson or, once a week, a content-related question assessing their mastery of the content (See Appendix B).

Summary of the Study

The data analysis uncovered the following three themes pertinent to engage students: (a) piquing students' curiosity, (b) relevancy of content, and (c) growth in self-efficacy (See Figure 5.1). When comparing both pre- and post-Likert scores and pre- and post-interviews, students showed growth in all three domains, indicating better engagement throughout the unit. Anticipation guides, exit tickets, and my own field notes also contributed data to support increased engagement in the classroom. Prior to the treatment, the surveys and interviews indicated that students were relatively disengaged in science class. Student engagement can be critical to higher student achievement, improved classroom behavior, and lower dropout rates (Fredricks et al., 2004; Grabau & Ma, 2017; Kiran et al., 2018; Schmidt et al., 2017; Ucar & Sungur, 2017).

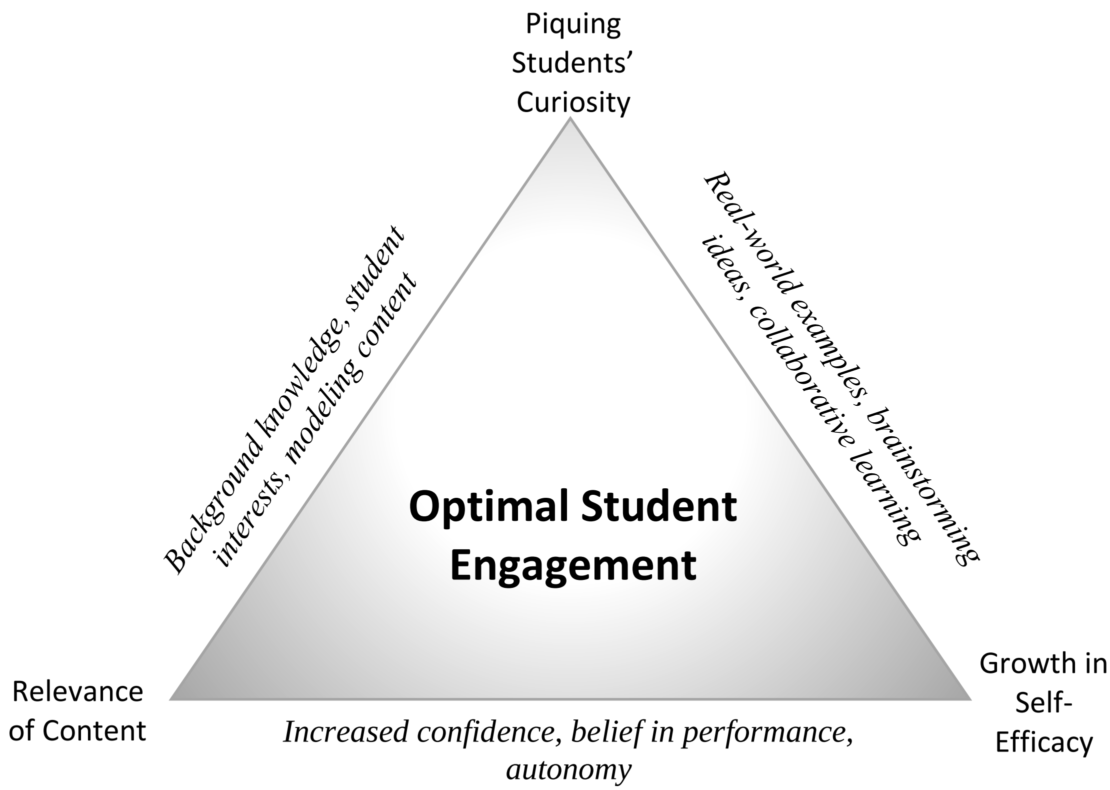

Figure 5.1 Optimal Student Engagement

Again, because of the pandemic, students had very few opportunities to converse with each other, work through problems, or ask questions. Based on my experience during this time of online learning, students were hesitant to reach out to others. I thought students would return to school this 21-22 school year ready to socialize and engage in their classes, but this pandemic has made most of them apathetic to school, teachers, and their friends. Perhaps the isolation students felt when confined in their homes the last year and a half has made them a bit hesitant to converse with others, reach out to teachers, and return to "normal" life.

When designing this study, I knew the importance of discovering students' interests and making the science content relevant to their lives. I also studied how allowing students to make observations and ask questions about confusing phenomena

could lead to quality discussions and generate even more questions to be worked out. It seems the online discussions gave the students a sense of anonymity and eased some of the anxiety they felt when conversing with their peers. Pre-study surveys indicated participants were reluctant to work in groups and again, I trace this back to the pandemic. Post-study surveys showed increased willingness to work with others, which is so valuable to scientific practices (*Framework*, 2012).

Students also exhibited positive growth in enjoying learning science and finding science interesting according to the pre- and post-surveys. The phenomena introduced every week during the study invoked students' curiosity to find out more. Whereas I would explain all concepts at the beginning of units in the past, allowing students to collaborate and ask questions to figure out phenomena on their own increased their engagement with the material and students' participation grew exponentially compared to the prior unit taught. I noted many instances of students conversing with others when they had not previously participated at all. This type of inquiry also gave students some autonomy in their learning as I was not dictating their discourse, but rather facilitating discussions when necessary. Allowing students to generate their own questions and talk through phenomena motivates them to continue and persevere as they search for answers (Niemiec & Ryan, 2009).

Students' confidence in their abilities in science also increased according to post-study surveys and interviews. Whereas before the study, students indicated low levels of confidence in science classes, scores improved significantly on these survey items post-study. By allowing students to ask questions and converse freely about phenomena, I noticed how students began to believe in themselves and the ideas they had. On several

occasions, I made notes of previously reluctant student-participants who slowly began expressing their thoughts in the online forums.

This increase in confidence also was supported by the engagement exit tickets. When students were asked in what ways they have gotten better at working with other students, most student-participants expressed how it was easier for them to express themselves. Students wrote about how their communication skills had improved and how they no longer felt scared to participate. This newly found confidence allowed them to fully engage in discussions without the fears they felt before the study.

Action Plan: Implications of the Findings

Three themes related to student engagement emerged from my analysis of the data: invoking students' curiosity, making content relevant to the learners, and instilling confidence in learners' abilities. These three themes were not isolated, in that the data indicated that all three were imperative for students to engage with the material. The most significant concept I learned through this study was how I need to relinquish control and allow students to learn through their own inquiry. I developed the following action plan for teachers so they can increase student engagement in their own science classrooms:

1. Allow students to observe and inquire about content before revealing explanations.
2. Get to know students' interests and hobbies.
3. Give positive and constructive feedback.
4. Document positive lessons and reflect for future improvement.
5. Share ideas and collaborate with teachers through professional development.

Action Step One: Allow Students to Observe and Inquire About Content

In previous years, I divulged information immediately, usually in a lecture-style format, telling my students exactly what they needed to learn, the vocabulary they needed to understand, and providing specific instructions on how to perform labs for desired results. This style of teaching resulted in students' eventual disinterest and boredom.

By allowing students to observe phenomena, ask questions, and discuss potential answers, students were engaged in the scientific practices of deriving their own explanations. Nurturing students' curiosity is what potentially makes science so fascinating for the students. Often, there is no clearly defined answer to a question and many times, there can be multiple "correct" answers. This allows for stimulating discussions where students can argue points, present evidence to back up their assertions, while also listening and pondering others' points of view.

Action Step Two: Get to Know Students' Interests and Hobbies

As a teacher, I often tune out personal conversations my students are partaking in while in my classroom. However, I have learned I can gather some valuable information about their lives, specifically what they do in their free time, what sports they play, or any hobbies they may enjoy. Armed with this information, I can derive questions that specifically pertain to the different aspects of my students' lives. For example, I knew Kelley, Manuel, and Nathaniel were avid athletes, so when discussing reflection of waves, we made comparisons of these waves to a basketball hitting a backboard and bouncing back.

For the anticipation guide dealing with what causes loud sounds, Missy was able to draw connections based on her playing the trumpet. She knew she had to blow harder

to get a louder sound, hence she connected her energy level to the volume of the sound her trumpet made. Later, while discussing possibilities, Donna noticed how it required more energy for her to talk loudly while Ryan made connections to vibrations 'they' felt while listening to loud music. Students pondering their own lived experiences and how they relate to the science principles taught is what can make science so engaging for our students.

Action Step Three: Give Positive and Constructive Feedback

While it is difficult to avoid correcting students when they get off track, I tried to simply offer guidance when students' discussions veered in the wrong direction. I would simply ask another question to try and get them back on track. For example, in our discussion of sound waves interacting with matter, several students assumed sound waves traveled faster in air than in water and that sound waves could not travel at all through solids. Instead of squashing their ideas, I carefully asked them about the number of molecules in gas, liquids, and solids (background knowledge as this is taught in seventh grade science). Students slowly began to comprehend how the number of molecules determines the speed of sound as more molecules equal more vibrations, hence faster speed.

My students tend to give up quickly when they are struggling to understand material. Through this study, I have learned to allow them to express how they derived their answers and compliment their thinking rather than immediately correct their thinking. When students begin to get frustrated, their immediate response seems to be giving up completely. Allowing them time to process other students' responses and perhaps offering a guided question from me, we avoid students thinking they are 'wrong'

and embrace their thoughts and move on. The student feels like their comment contributed to the discussion and will likely respond again to another prompt, which is exactly what I want. Participation equals engagement in the discussion.

Action Step Four: Document Both Positive Lessons and Reflect for Future Improvements

This component of the action plan includes documenting lesson plans that went well while also reflecting on what I can improve for future lessons. As previously mentioned, South Carolina is formally adopting NGSS for the school year 2022-2023. I had the opportunity to assist the state in making the necessary revisions pertinent to our students' needs during the summer of 2020. Because of this opportunity, I will be leading the professional development this summer (2022) necessary for all our district's middle school science teachers. I want to ensure I am prepared with lessons where phenomena-based inquiry works well at grabbing our students' attention, while also describing problems that can arise and how to deal with them.

Because student-led lessons are fairly new to me, I also commented on how I felt when facilitating lessons. I want to ensure that teachers who are unaccustomed to this type of teaching know it is alright to feel somewhat lost in the beginning. If they are similar to me, relinquishing control of my classroom was daunting, and it took some time to adjust. Teachers need to know they are not alone in their feelings because other teachers feel similarly.

Action Step Five: Share Ideas and Collaborate with Teachers Through Professional Development

This final component of the action plan will allow me to share my study with other teachers. By offering professional development in phenomena-based inquiry, other teachers across my district can learn how to better engage students in their own classrooms. Instructional strategies, lesson ideas, and learning how to reflect on lessons will be discussed and units can be designed that adhere to this type of inquiry. It is important to note that while this study focused on my own science classroom, these strategies will also benefit other subjects too.

A Matter of Equity

Equity, simply defined, is equal treatment of all (*Framework*, 2012). This means allowing equal opportunity for all groups of students to succeed in school. When designing instructional materials, it is imperative to consider the backgrounds of all groups, their communities, and personal interests (Asowayan et al., 2017; Kurt & Tas, 2018; Schmidt et al., 2017). As discussed throughout this paper, providing content relevant to our students' lives is paramount to engagement, and because I teach a wide variety of demographics, the instructional materials, and examples I use must address this cultural and racial variety.

Teachers who use phenomena-based inquiry in their lessons can address this issue by allowing all students the opportunity to discuss their various viewpoints as they pertain to the content. Students can draw on their own lived experiences to make connections and draw conclusions to the content being learned. Through these discussions, students can personalize science to their own lives and science becomes relevant and attainable.

In addition, rigor is vital to equity across classrooms. Culturally relevant pedagogy insists teachers know their content, their students, and how to teach this content to each learner (Escudero, 2019). Holding high and transparent academic expectations for every student is paramount in equitable classrooms. Escudero (2019) maintained that this pedagogy "requires that teachers understand culture and its role in education, that they take responsibility for learning about their students' culture and community, and that they interrogate their own identity, culture, biases, and privilege to critically assess and strengthen their instructional practice" (p. 2). The *Framework* (2012) discussed how low learning expectations and stereotypical views about the abilities of students or demographic groups hurts their educational opportunities and leads to inequitable treatment. Holding high academic expectations for all students, regardless of their skin color, gender, or cultural background. My school's motto is "Every Student, Every Day, No Exceptions, No Excuses," to which I try to adhere when designing my lesson plans.

Suggestions for Future Research

In adhering to an action research study, my student-participant sample was small, making it difficult to make any large-scale generalizations. One suggestion for future research is to apply this treatment of phenomena-based learning to entire grade-level or even an entire middle school's science classes. Increasing the number of participants would make it more feasible to assess the success of this study.

In addition, my student-participants were selected from my honors class. Generally, they tend to have a strong work ethic, are involved in school activities, and are motivated to achieve. Future research could focus on the effects of phenomena-based inquiry on a sample of the general population of students. For a study like this,

modifications could include detailed modeling of the discussions, clear expectations for the anticipation guides and exit tickets, and scaffolding instruction for English language learners and those students who have an individualized education plan.

Also, I planned my study around an eighth-grade unit on waves, which took approximately six weeks to complete. Future studies could include another unit or a longer amount of time to see long-term results. As previously mentioned, historically, the waves unit is not one of my students' favorite areas to study. This research could easily be transferred to other units in the eight-grade science curriculum.

Finally, as addressed earlier, we are still under restrictions caused by the pandemic, meaning group work was confined to online discussions only. I think when restrictions are lifted, this study may prove even more invaluable as students could participate in actual in-person groups. This would enhance discussions as students could speak directly to their classmates, listen to the responses, and observe facial expressions and gestures.

Conclusion

As teachers, we have a responsibility to prepare our students for their future, ensuring they are ready for college and/or their career. During this time of a global pandemic, I realized my students were not only apathetic in class, but also were somewhat disengaged in their life in general. Students were isolated for almost two years, stuck behind a computer at home, with little to no social interactions. Even though the pandemic is not officially over yet, at least my students are back in the classroom and trying to motivate them has been a constant struggle.

I chose Keller's ARCS model of motivation (1987) as my theoretical framework because a multitude of research shows us that highly motivated students tend to be more engaged in our classrooms (Bender & Bull, 2011; Blumenfeld et al., 2006; Feng & Tuan, 2005, Fredricks et al., 2004, Kiran et al., 2018, Schmidt et al., 2017). As the purpose of my study is to increase engagement in my science class, I used this model of motivation as somewhat of a template for my instruction. By implementing phenomena-based inquiry, students were able to collaborate and discuss ideas, while questioning the world around them. We moved from teacher-led instruction to a student-led classroom, allowing students greater autonomy in their learning. Grabbing my students' attention, making content relevant to their lives, and giving them the confidence to continue and persevere through difficult content were the three themes that emerged from the data analysis.

This study reveals how these three themes can indeed increase the engagement levels of our students. But perhaps more importantly, students began to break out of their shells they had been in since the pandemic started. I noticed greater enthusiasm, confidence, and those "a-ha" moments that can evade teachers. My classroom transformed into students discussing ideas, backing up their assertions with evidence, and truly *doing* science, rather than passively absorbing what I taught them.

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APPENDIX A

SURVEY QUESTIONS

In order to better understand how to best teach science, I have designed the following survey. Please answer honestly so I can use your answers to improve my own teaching as we move through this study. Please enter the appropriate number on your Google Form.

Scale: 1- Never; 2- Rarely; 3- Sometimes; 4- Usually; 5- Always

1. I enjoy learning science
2. Earning a good grade in science is important to me
3. I put a lot of effort into learning science
4. I am confident I will do well on science tests
5. I like science because it challenges me
6. I like how science relates to everyday things I think about
7. The science I learn has practical uses for me
8. I find learning science is interesting
9. I am concerned other students are better in science than me
10. I worry about failing science tests
11. I feel confident doing science experiments and labs
12. I think about how learning science can help me get a good job
13. It is my fault if I don’t understand science
14. Understanding science makes me feel like I accomplished something
15. I think about how I will use the science concepts I learn
16. The science I learn is more important to me than the grade I receive
17. I believe I can master the knowledge and skills in all science classes
18. I use strategies to make sure I understand science concepts
19. I like working with a group
20. I draw my own conclusion and solutions

21. I like to be outdoors when I learn about science
22. I like to work independently
23. I feel confident to design my own experiment in an attempt to answer a question or solve a problem

APPENDIX B

EXIT TICKETS

Example (only 3 or less questions per Monday/Friday; Content Question Exit Tickets on Wednesdays) Student Exit Tickets (Reflections)

1. As you look over your work today, what is one thing you would do differently next time?
2. If you were the teacher, what grade would you give your efforts today?
3. What was particularly satisfying about your work today?
4. What did you find frustrating about today’s work?
5. Did you do your work the same way others did theirs? What was similar and what did you do differently?
6. What problems did you encounter while working today? How did you solve these problems? (roadblocks?)
7. In what ways have you gotten better at working with other students? In what ways can you still improve?
8. Did today’s lesson keep you engaged? Why? Please provide specific examples.

APPENDIX C

INTERVIEW SEMI-STRUCTURED QUESTIONS AND PROMPTS

Thank you so much for your participation in this study. This interview should take only 15-20 minutes to complete, and it is the first of two interviews required for the study. Everything you write is confidential, meaning I cannot tell anyone about your answers. Please return your interview answers to me in two days.

How would you describe your overall feeling about this class? Prompts: Do you like to learn? Are you bored? If so, why? Are you happy to be in class?

Attention:

1. Tell me about your attention in class. Prompts: What makes you want to pay attention in class? What has been your favorite activity so far in the class?
2. Describe how you participate and how often. Prompts: Do you pay attention so you can answer questions and/or participate in discussions? Does the teacher hold you accountable (give you a grade) for participation?

Relevance:

1. Describe how real-world examples and applications make you feel about the material? Prompt: Do these real-world examples make you think the content is useful? How do you show you understand the material presented?
2. Tell me about the things you do to help you understand the material. Prompts: Do you think about the times you have heard the information before (background knowledge)? Do you try to apply it to real-world situations you have been in before?

Confidence:

1. Tell me about the feedback you receive in this class. Prompts: Does the teacher grade and return assignments in a timely manner? Does the teacher provide feedback that is helpful and helps you to do better on other assignments?
2. Describe how confident you feel in class? Prompts: Do you feel comfortable participating in discussions? Do you feel like you contribute to group projects/labs?
3. Tell me about a time when you felt completely confident when beginning an assignment or lab. Prompt: What makes you feel confident about completing an assignment or lab?
   What can the teacher do to make you feel more confident?

Satisfaction:

1. Tell me about a time where you felt confident about an assignment or project you turned in. Prompt: Why did you feel confident? Was it something the teacher did to make you feel more confident?
2. Tell me about a time you learned about something in class and then saw something about it on the news. Prompt: Do you and your parents ever talk about what we do in class? Have you ever tried something we've done in class at home?

APPENDIX D

ANTICIPATION GUIDE TEMPLATE

Anticipation Guide: Week of ___________________

Please fill out the first four rows before our lessons, then we will check and discuss your answers at the end of the week and fill in the fifth row.

Phenomena #_: ____

What I'm trying to figure out	
Some questions I have…	
What I already know about this	
This makes me think of…	
What I learned this week	

Additional questions or clarifications?

APPENDIX E

FIELD NOTES: OCTOBER 18-DECEMBER 16, 2021

Date:

Lesson: (phenomena addressed, activities, and background knowledge required)

Description of Activity:

Reflections: