Spring 2019

The Impact of the Biological Sciences Curriculum Study (BSCS) 5E Model on Middle-Level Students' Content Knowledge

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THE IMPACT OF THE BIOLOGICAL SCIENCES CURRICULUM STUDY (BSCS) 5E MODEL ON MIDDLE-LEVEL STUDENTS' CONTENT KNOWLEDGE

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Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Education in

Curriculum and Instruction

College of Education

University of South Carolina

2019

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DEDICATION

This Dissertation in Practice is dedicated to my husband Dave and my children Xander and Maddie. I know you went through this journey with me and I know it was not easy for you. Xander and Maddie, thank you, for helping me when I needed it and supporting me when you were not even sure what I was doing most of the time. I will always be here to support you, when you go after your dreams.

Dave, you are my everything. Thank you for supporting me through this, taking on so much extra work so I could have time to study, focus and work. Thank you for helping me, supporting me, and loving me every step of the way. I would be lost without you. I love you.

To my Dr. Kitty. Thank you for keeping me company through this journey. I wish you were still here with me.

ACKNOWLEDGEMENTS

I would like to acknowledge all of my friends and family who supported me through this journey. No one ever said this was going to be easy, and one ever said it could not be done. The support of my friends and family made this challenge possible. “Thank You”. I would like to thank my advisor Dr. Susan Schramm-Pate for her guidance and support through this process. I appreciate the time you took to help me be my best.

Everyone is where we are today because of the hard work of a teacher. I would like to acknowledge the amazing teachers I have had in my life to encourage my life-long love of learning and discovery.

ABSTRACT

The purpose of this qualitative action research study was to describe a middle-level science teacher's transition to an inquiry-based, progressivist, student-centered model from a traditional, teacher-centered model as well to document the student-participants' perceptions of the new model. The study population consisted of one-hundred student-participants, three teacher participants, and one administrator participant. Data was collected at Lakeview Middle School (LMS) (pseudonym) in the low country of South Carolina. The Research Question driving the study: *How do middle-level students, accustomed to a traditional teacher-centered curriculum, perceive an inquiry-based, student-centered science classroom based on the Biological Science Curriculum Studies (BSCS) 5E Instructional Model?*

1. Regardless of how they perceive the student-centered curriculum, how do the students negotiate the class?
2. What are some of the problems involved in facilitating teacher planning of the 5E Model science curriculum?

In order to answer the research question, an inquiry-based unit titled "The Organization of Life" was developed using the BSCS 5E Inquiry Model in a seventh-grade science class over the course of six weeks in the fall of 2018. Finding include the ways in which students engage with the BSCS 5E Instructional Model enable students to Engage, Explore, Elaborate, Explain, and Evaluate science instruction and information. An

Action Plan based on the findings includes a professional development for inquiry-based STEM at the middle-level in spring of 2019 for science teachers at LMS.

Key Words: Action Research, BSCS 5E Instructional Model, Constructivist Pedagogy, Inquiry-Based Learning, Middle-level STEM

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LIST OF ABBREVIATIONS

ATSSA..Attitude toward Science in School Assessment

BSCS.. Biological Science Curriculum Studies

LMS .... Lakeview Middle School

PLC .... Professional Learning Community

SC DOE ....South Carolina Department of Education

WSD..Winter Haven School District

CHAPTER ONE

INTRODUCTION

In 1957, the former Union of Soviet Socialist Republic (USSR) launched Sputnik I, the first artificial Earth satellite. This act triggered the "space race' between the Soviet Union and the United States of America (USA) and was a contributing factor to the Cold War between the two superpowers. In response to this astronomical Cold War competition, the United States government expanded and reformed science education by doubling the funding to the National Science Foundation (NSF) and placing precedence on science education with the driving goal to put the first human in space (Hechinger Report, 2011).

Science Education reform continued steadily until the momentum decreased in response to the 2002 "No Child Left Behind Act" (NCLB) (NSTA, 2012), which shifted educational focus to improving Mathematics and English achievement scores and pushed science education, social students, physical education, and the arts to the side (NSTA, 2012). The NCLB Act required schools to test students in grades three through eight and once in high school in Math and Reading. Schools were required to show "adequate yearly progress" of student scores in these topics or face state interventions (Klein, 2015). The pressure placed on performing well on these exams resulted in schools spending less time teaching non-tested subjects (2015).

In recent years, the focus of science education in US public schools has shifted once again (NRC, 2012). The National Academy's (2007) report "Rising Above the Gathering Storm" argued that science education was critical for the Unite States to remain a dominant force in a word being shaped by science and technology. The development of national science standards call the "Next Generation Science Standards" and "Project 2061: Science for all Americans" have increased pressure on public schools to raise science achievement scores and reform the delivery of science education (Duran & Duran, 2004; NRC, 2012).

However, Scott, Schroeder, Tolson, Tse-Yang Huang, and Williams (2014) demonstrated that students were not learning the science inquiry skills necessary to succeed in a rapidly growing global economy and excel in the fields of engineering, medicine, and technology. The need for the development of these skills in the twenty-first-century prompted lawmakers at the national level to encourage the incorporation of Science, Technology, Engineering, and Mathematics (STEM) education into the US public education system. In response to the ongoing prioritization of STEM education, the "Next Generation Science Standards" (NGSS, 2013) were developed by the National Research Council (NRC), National Science Teachers Association (NSTA), American Association for the Advancement of Science, and Achieve (managing lead participating states) to provide a national framework of science education (2013). The Next Generation Science Standards (NGSS) were published in 2013.

The STEM education and NGSS initiatives were designed to develop literacy and inquiry in STEM and to identify and build twenty-first century skills such as adaptability, complex communication, social skills, non-route problem solving, self-management, and

technology integration (Bybee, 2011). These initiatives support a student-centered classroom environment by incorporating inquiry-based learning.

Despite these efforts, US students continue to "fall behind" in science achievement and science-based professions when compared to their peers in similar industrialized countries such as Japan, China, and France (Kim, 2016). According to the National Research Council (2012), although students in the US demonstrate science interest and achievement at the elementary level, their enthusiasm and performance diminish in middle school. The authors argued that attempts to reform science education, such as the development of new standards, have resulted in student scores that are stagnant or have only slightly increased towards national benchmarks. Kim (2016) maintained that there is a relationship between science achievement on standardized tests, socio-economic status (SES) and racial background. Middle school, in particular, is a critical time for STEM education for historically marginalized students, specifically students who have been classified as low SES and for students of color.

Through action research, collecting, and interpreting data, a teacher-researcher can develop a plan of action to address an area of need in his or her classroom (Mertler, 2017). The problem of practice addressed in the present study developed from the need to implement more inquiry-based instruction in my science classroom. I needed to implement this curriculum to meet the South Carolina requirements for science education reform, including the 2014 South Carolina Science Standards and the *Interactive Science* (Buckley, Thornton, Miller, Wysession, & Padilla 2017) curriculum purchased by my school district. To implement inquiry-based instructions, there needs to be a pedagogical shift from a teacher-centered to a student-centered learning environment. Therefore, I

examined the impact this pedagogical shift had on my student-participants in my science classroom at Lakeview Middle School in the fall of 2018.

I designed a student-centered, inquiry-based unit called “Organization of Living Things” for my seventh-grade science students at Lakeview so they could increase their scientific inquiry skills as well as change their attitudes toward sciences. I implemented the “Organization of Living Things” unit in the fall of 2018 with 100 student participants. What follows are the identified problem of practice (PoP), research question (RQ), and the purpose for the student, culminating in an overview of the contents in this dissertation-in-practice (DiP) using action research methods.

Problem of Practice

Background

Famed educator John Dewey (1938) was a supporter of science education. He summarized the difficulty in changing educational pedagogical practices by noting that, “the conduct of schools is so much more difficult than the management of schools, which walk in beaten paths” (p. 5). Educators are typically so ingrained in teacher-centered, day-to-day instructional practices that their assumptions often blind them to the problems in their classrooms, such as equity and access to upper-level science courses for historically marginalized groups of students. The current state of education reform for middle-level science in the US supports an increase of inquiry-based instruction (NRC, 2012).

The shift from a teacher-centered to a student-centered educational pedagogy and towards an inquiry-based science curriculum is a challenge for both teachers and schools.

Dewey (1938) and Mintrop (2016) both indicated that the traditional teacher-centered model is based on pedagogical practices that are deeply entrenched in American public schooling and are perpetuated through the hidden curriculum in where teaching practices are often underpinned by the new “three Rs” of Rules, Routine, and Regulations (Bates, 2016). In *Pedagogy of the Oppressed. 30th Anniversary Edition* (Freire & Ramos, 2014), adult educator Paulo Freire described the traditional educational model as a banking model in which students are passive depositories of information where instructors deposit knowledge. In Freire’s model, students passively receive, memorize, and repeat back information to demonstrate learning. The narration and action come from the teacher. There is no involvement on the part of the passive students, whose prior knowledge, experiences, personal insights, and emotions are ignored (Freire & Ramos, 2014).

Following Freire (2014) and Dewey (1938), I confronted my pedagogical norms and the hidden curriculum in Lakeview’s current science curriculum to identify a problem of practice for the present action research study. This study involved an inquiry-based model that I designed using the Biological Science Curriculum Study (BSCS) 5E instructional model of science. The BSCS 5E model as an instructional model based on the constructivist approach to learning, which builds on the students’ previous knowledge and experiences (Robinson, 2016). I taught this to 100 seventh-grade students in the fall of 2018 at Lakeview. This study seeks to determine the impact this model had on the students.

Inquiry-based activities increase middle-level students’ achievement and interest in science (Kim, 2016). Accordingly, I implemented this inquiry-based, 5E model into my science classes and shifted my traditional, teacher-centered attitude to a student-

centered pedagogy. I accomplished this by designing and implementing lessons based on the BSCS 5E model that devoted a majority of class time to student-centered instruction, allowing the students to learn through periods of engagement, explanation, elaboration, and evaluation.

Problem of Practice

The problem of practice addressed in the present study is based on designing and implementing inquiry-based, middle level (seventh-grade) science curriculum that aligns with the 2014 South Carolina State Science Standards (SCSS)(SC DOE, 2014) and engages student-participants with science content in ways that are constructivist and progressivist. In other words, pedagogy that is “active” rather than “passive” lessons such as traditional, lecture format classrooms. In 2017, curriculum materials were purchased by the Winter Haven School District (a pseudonym) to enable science teachers to develop curriculum and pedagogy that was relational to students’ cognitive, affective, and psychosocial domains. The curricular materials are designed to support the BSCS 5E learning model (Bybee, 2011). This is an inquiry-based model consisting of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation. When the textbooks were adopted, the BSCS 5E model was not being tested or implemented at Lakeview Middle School (LMS) (a pseudonym).

In order to implement BSCS 5E, there needs to be a paradigm shift from a teacher-centered to a student-centered learning environment at LMS. The present action research study examined 100 student-participants’ perceptions of a BSCS 5E model.

Study Rationale

The BSCS 5E learning model “engages students’ thinking, and then allows for explorative discovery and factual learning to deepen student understanding of content matter” (Chitman-Booker & Kopp, 2013, p. 9). By focusing this action research project on the use of the BSCS 5E learning model, a pedagogical, student-centered shift is supported through inquiry-based lessons and the five phases of the instructional model.

Purpose Statement

The primary purpose of the present study is to describe the implementation of a unit based on the BSC 5E model with a seventh-grade science class at LMS. The secondary purpose is to describe my transition, as a middle-level science teacher-researcher in South Carolina, to an inquiry-based, progressivist, student-centered pedagogical model.

The tertiary purpose is to develop an Action Plan for professional development to share the findings of the present study with other teachers at Lakeview Middle School (LMS). The school district uses *Interactive Science* (Buckley et al, 2017) science textbooks and the corresponding curricular materials that accompany the textbooks. The materials are designed to incorporate the BSCS 5E Instruction Model. Due to the reciprocal nature of action research through professional development, I will be able to work with other middle school science teachers to develop units that are constructivist, using the *Interactive Science* (2017) materials and the 5E Model. By sharing the student perceptions of the unit, I am giving the students an opportunity to have a voice in curriculum development.

Background of the Study

In the mid-1980s, the "Biological Science Curriculum Study" received a grant from IBM to research to produce a curriculum designed for elementary-level science and health programs (Bybee, 2015). By the end of the study, a team led by researcher Rodger Bybee (2015) developed the 5E Instructional Model, consisting of five distinct phases of inquiry-based learning. Over the years, the model has been successfully applied to middle-level and high school curriculums (Bybee, 2015), but has only been recently introduced to my district through the new textbooks.

According to Chitman-Booker and Kopp in their book *The 5Es of Inquiry-Based Science* (2013), a constructivist viewpoint, based on the works of Piaget (1968) and Vygotsky (1978), formed the foundation of the BSCS 5E model. The intent of the 5E Instructional Model was conceptual development in which students refine, reorganize, and redevelop initial concepts through investigation, collaboration, and reflection. The 5E Instructional Model consists of five phases of predominantly student-centered activities with the teacher serving as the guide (Bybee, 2015).

During Phase One, the Engagement Phase, the teacher hooks the students' interest and stimulates their curiosity (Bybee, 2015). This could be an opening demonstration or question, but not a formal pre-assessment. The purpose of this phase is for the teacher to assess the students' prior knowledge and identify content misconceptions. Buoncristiani and Buoncristiani (2012) indicated that student comes to school with preconceptions about how the world works. If their initial understandings are not engaged, they will not grasp new information. Through the Engagement Phase, the teacher can identify these preconceptions and address them through discussions and direction of the lesson.

According to Buoncristiani and Buoncristiani (2012), for students to develop competence in an area of inquiry, they must develop factual knowledge in the context of a conceptual framework and reorganize the information in a way that they can apply and retrieve. The next three phases of the BSCS 5E model (Exploration, Explanation, and Elaboration) support these findings. The phases are designed in a way for students to explore knowledge, build on it, and apply it to other complex situations. When following the 5E Model, students use a metacognitive approach to learning through their reflections and progress monitoring through the phases.

"Exploration" is the second phase of the model (Bybee, 2015). The purpose of the Exploration Phase is to recognize the students' understanding of the content and examine their current abilities. This phase is characterized by a concrete experience in which the students will explore situations, events, and materials.

The third phase, "Explanation," is more teacher-centered (2015). The teacher provides direct attention to concepts and vocabulary that the students need to learn. Rather than merely depositing this information with the students, the teacher draws on the students' experiences from the previous two stages and encourages the development of meaningful connections.

During the fourth phase of the model, "Elaboration," (2015) students apply their knowledge and experience from the previous phase to new contexts. The teacher provides activities that are challenging to the students, but are achievable because of the connections they have created.

"Evaluation" is the fifth phase. It was developed to allow teachers to evaluate educational outcomes (2015). Although formative assessments are inserted throughout

the 5E model, the summative assessments are found in this final phase, where the knowledge gained is measured and examined. In the evaluation phase, students also evaluate their learning and relate their knowledge to their experiences. As supported by the constructivist method, the students are constructing new knowledge from learning experiences (Bybee, 2015).

Research Questions

This study was guided by the following research question and sub-questions: *How do middle-level students, accustomed to a traditional, teacher-centered curriculum, perceive an inquiry-based, student-centered science classroom based on the Biological Science Curriculum (BSCS) 5E Instructional Model?*

The study also addresses the following sub-questions:

1. Regardless of how they perceive the student-centered curriculum, how do they negotiate the class?
2. What are some of the problems involved in facilitating teacher planning of the 5E Model science curriculum?

During the implementation of an instructional until based on the BSCS 5E Model, the teacher-researcher was able to obtain data through student attitude surveys, and teacher made examinations, student reflection exit tickets, and field notes. The data collected guided the progression of the study.

Theoretical Framework

Student-centered, inquiry-based science instruction has been identified as a successful method of teaching science in terms of content knowledge and student

attitudes toward the subject (NRC, 2012). Llewellyn describes inquiry as "an approach to learning that involves a process of exploring the natural or material world, and that leads to asking questions, making discoveries, and testing those discoveries in the search for new understanding (2014, p. 5). Scientific inquiry is developed as scientists investigate the world around them and propose explanations of the phenomena they observe based on their observations and collected evidence of their explorations (NRC, 1996). The process of scientific inquiry is supported in the pedagogical theories of Progressivism and Constructivism.

Progressivism

John Dewey (1938) founded the progressive education movement over one hundred years ago under the belief that schools are agents of democracy and social change. Dewey's progressive pedagogy was one of the first educational movements to stress the importance of learning through discovery and inquiry. The phases of the BSCS 5E model support learning through discovery and inquiry. During the "Organization of Living Things" unit, the students will practice learning through discovery as part of the Engagement and Exploration phases when they are introduced to new information, and participate in labs to explore the new information. During the Explanation and Elaboration phases, students will use inquiry-based learning to investigate information and expand on the information as they apply learned concepts to new situations.

Progressivism is a student-centered curriculum focused on democratic social issues being solved in a cooperative environment. Progressivism's strengths lie in students learning together through inquiry and investigation of real experiences, while the teacher serves as the facilitator of the investigation. Students are taught to formulate

meaningful questions and answer them with critical thinking based on real-world experience (Dewey, 1938).

Progressivism supports problem-solving and critical thinking skill development for students through student-centered learning and discovery. “Rather than sacrificing the present for some hypothetical future, progressive educators seek to live fully in the present precisely so as to prepare for the future” (Hogan & Bruce, 2013, p. 1). Dewey’s progressive education philosophy encourages students to explore the world around them, use inquiry to solve problems, and collaborate with others to learn from their environment (Dewey, 1938). The progressive education philosophy is reflected in inquiry-based science classrooms where the learning environment supports preparation for students to develop critical thinking, communication, creativity, and collaboration skills to be successful in a global society (Llewellyn, 2014).

According to Bybee (2016), the educational works of Dewey are one of the precursors to the development of the BSCS 5E Model used in the present study. Bybee (2016) postulates that Dewey’s instructional approach, based on student experiences, engaging in reflective thinking, and interacting with others developed into an instructional model influential to the BSCS 5E Model. When participating in the “Organization of Living Things” unit, the student-participants question scientific phenomena in the Engagement phase, learning through inquiry and investigation during the Exploration phase, apply information to their natural environment in the Elaboration phase, and use reflection and critical thinking during the Evaluation phase (Chitman-Booker & Kopp, 2013)

Constructivism

The constructivist learning model for classroom inquiry originated with the research of foundational educational scholars such as Dewey, Jean Piaget, Howard Gardner, and Lev Vygotsky (Cetin-Dindar, 2016) In general terms, Constructivist pedagogy involves student learning as an "active" process in which knowledge is constructed by students based on prior knowledge, new experiences, and information (Cetin-Dindar, 2016; Qarareh, 2016). In the BSCS 5E model, the teacher-researcher involves student-participants' prior knowledge during the Engagement phase. The student-participants gain new experiences through the Exploration and Explanation phases, building on their previous knowledge. The student-participants construct connections and new knowledge during the Elaboration phase and reflect on their learning in the Evaluation phase. For example, as student-participants engaged in a hands-on, inquiry-based activity using microscopes, they were able to explore the microscopic world of cells, strengthen relevant connections through the process of elaborating on the information by connecting this new experience with previous knowledge and explain what they witnessed to the teacher-researcher and other student-participants.

Constructivism has developed into three separate pedagogical models: Exogenous Constructivism, Endogenous (Cognitive) Constructivism, and Dialectical (Social) Constructivism (Applefield, Huber, & Moallem, 2000). The overarching premise of the three models is that learning is constructed by the assimilation and accommodation of new knowledge and there are epistemological differences in how the knowledge is acquired.

According to Applefield et al. (2000), Exogenous Constructivism is characterized by building learning through the reconstruction of knowledge based on external reality. Learning is developed on the perception of the world around us. By incorporating relevant, timely information into the unit, the teacher-researcher was able to encourage student-participants to examine relatable situations scientifically, such as infection and treatment of strep through in a lesson on bacteria.

Cognitive Constructivism is influenced by the work of Piaget, in which learning is a dynamic process consisting of the reorganization and reconstructions of cognitive structures resulting from intrinsically motivated interactions with our environment (Berkeley Graduate Division, n.d.). In this model, students learn through the process of active discovery and the assimilation of knowledge dependent on their mental state of development. The inquiry-based model supports this through the process of scientific investigation.

Social Constructivism is influenced by the work of Vygotsky (1978) in which learning is constructed through social interactions that Vygotsky referred to as the Zone of Proximal Development. In short, we learn from others in our learning community. In social constructivism, learning is extrinsically motivated and supported in a collaborative environment (Berkeley Graduate Division, n.d.). In a student-centered learning environment, the students collaborate to construct knowledge and make scientific predictions through the development of knowledge.

The constructivist model supports inquiry and scientific thinking. During the scientific inquiry process, learners formulate new ideas and bridge them with prior knowledge. As in a progressive classroom, learning in a constructivist classroom is

student-centered, and the teacher is seen as a facilitator rather than a producer of rote facts and information (Cetin-Dindar, 2016; Chitman-Booker, & Kopp, 2013).

Constructivism encourages learners to inquire and explore the world around them through collaborative activities and investigations (Chitman-Booker & Kopp, 2013, ;Qarareh, 2016). “Inquiry-based learning grounded in constructivism means a transition from traditional teaching styles to a more active mode of learning and teaching” (Isiksal-Bostan, Sahin, & Ertepinar, 2015, p. 604). For example, when student-participants learned about the processes of osmosis and diffusion, they explored the concepts in a student-centered lab, predicting, observing, and drawing conclusions on what would happen to potatoes placed in hypertonic, hypotonic, and isotonic solutions.

The cognitive and social constructivism models form the foundation of the BSCS 5E Inquiry Model (Chitman-Booker & Kopp, 2013). Bybee (2015) indicated that the development of the BSCS 5E Instructional Model was heavily influenced by the belief that learning is an active process consisting of the development of cognitive structures resulting from interactions between the learning and the environment.

Scholarly Literature

Through the utilization of inquiry and encouraging student to think critically about the nature of science, we can teach students to distinguish between topics that can be answered through scientific questioning and those that cannot (Llewellyn, 2014).

> By giving students the capacity to understand why those topics are not taught, we simultaneously show respect for students’ belief while we help them understand why the concepts are not considered part of science (Bilica, 2012, p. 28).

The review of the literature in Chapter Two of this dissertation in practice describes the theoretical framework that I used to create my pedagogical shift to a student-centered curriculum through the incorporation of inquiry-based lessons and technology to improve both my teaching practices and the science education experience of my students. The present action research study supports the use of the BSCS 5E Model as well as inquiry-based learning in improving middle-level science achievement scores and students' attitudes toward science education (Bybee, 2011; Bybee, 2014; Kim, 2016).

"Quality science teaching and learning will need to incorporate diverse modes of instructions in order to achieve the greatest benefits" (Grooms, Enderle, & Simpson, 2015, p. 50). This literature review will examine the following topics:

- Inquiry-Based Science and Technology
- Inquiry-Based Instruction
- The BSCS 5E Instructional Model

Inquiry-Based Science and Technology

The incorporation of inquiry-based activities in the science curriculum was demonstrated to increase student achievement and their continued interest in the varied fields of science (Kim, 2016; Scogin, 2016). Although this connection was established, students in the United States continue to fall behind other industrialized nations in the science-related professional fields (NRC, 2001). Science education reform programs were developed in schools nationwide (Kim, 2016; Marshall & Alston 2014). According to Kim (2016), the incorporation of technology and inquiry-based, hands-on activities in science has resulted in positive gains in science achievement.

Pringle, Dawson, and Ritzhupt's (2015) research indicated when educational technology is successfully integrated into teaching; students become engaged with tools that afford them opportunities to analyze and manipulate systems and processes in the construction of scientific knowledge and problem-solving. Through the incorporation of technology with inquiry-based teaching, students can be provided new opportunities to access, organize, and share information on a global scale (Isiksal-Bostan, Sahin, & Ertepinar, 2015).

Inquiry-Based Instruction

In order to teach students the critical thinking, inquiry, and collaboration skills, as well as the content standards of science achievement determined by the state of South Carolina in the 2014 State Science Standards, there is a need for a shift in scientific teaching practices. "Science proficiency will likely require that teachers implement new instructional strategies which privilege the essential practices of science (Grooms, Enderle, & Sampson, 2015, p. 46). Bybee (2010) indicated science teachers who utilize student-centered, inquiry-based lessons have higher science achievement scores and an achievement gap between students in different socioeconomic classes. Bybee's (2010) finding supports my pedagogical shift to a student-centered classroom to improve science achievement and decrease the achievement gap between my students of different socioeconomic classes.

Action Research Methodology

The guiding framework for this research study is Action Research, which is education research at a grassroots level. Essentially, action research is the study of the

practice by the practitioners themselves. The process beings with defining an inquiry-based question from my teaching practice, collecting data, analyzing the data, and taking action by implementing findings from the data (Mertler, 2017). The Action Research framework enabled me to become an active participant in my professional development and growth by examining areas of improvement in my teaching practice. Educators worldwide have embraced the notion that engaging in action research can empower teachers as classroom researchers who improve their teaching practices and increase their students learning outcomes (Lebak & Tinsley, 2010, p. 954). This action research study examined the impact of a pedagogical shift in my teaching, and the incorporation of the BSCS 5E Model, would have on my students as I implemented new curricular materials. Throughout the study, student-learning outcomes were measured by the use of student attitude surveys, informal observations, teacher-researcher field notes, and formative assessments conducted throughout the study.

My students were personally involved in the Action Research process, becoming student-participants. The student-participants indicated that they had little to no experience in a student-centered science classroom. Through the action research process, the student-participants were shifting to a new way of learning with my shift in teaching.

Significance of the Study

National science education reform and the 2014 South Carolina Curriculum Science Standards (SC DOE, 2014) indicate a need for an increase of inquiry in the science classroom. Several published research studies indicated stagnation in scores for science achievement and twenty-first-century skills for students in the middle-school

levels (Kim, 2016; Marshall & Alston, 2014). This study specifically addresses the problem of a lack of inquiry-based lessons being developed and implemented in my seventh-grade science class. LMS adopted a curriculum based on the BSCS 5E Instruction Model but, at the time, I had not yet adopted the student-centered, constructivist approach needed to incorporate the model into my classroom.

This action research study examines the impact of the BSCS 5E Instructional Model on my students as I shift my pedagogical focus and implement the BSCS 5E Instructional Model-based “Organization of Life” unit in the fall of 2018. Although this research takes place at the local level in one school, the results can be applied to other middle schools facing the same concerns.

Conclusion

The present action research study describes the implementation of a BSCS 5E Instructional Model unit in a middle school in South Carolina with students who are accustomed to a traditional, teacher-centered instructional model. As stated by Alston and Marshall (2014), “despite us knowing that inquiry-based instructions helps to challenge and encourage critical thinking, it is evident that effective inquiry-based instruction is far from the norm in most classrooms” (p. 810). This statement supported my past teacher-centered instructional practice and my need to shift to a student-centered practice to incorporate inquiry-based science instruction into my classroom.

Through the incorporation of technology and the 5E model, I am changing science instruction at the local level. “Scientific study leads to and enlarges experience, but this experience is educative only to the degree that it rests upon a continuity of

significant knowledge" (Dewey, 1938, p. 10). Through this action research project, I examine the impact this pedagogical shift has on my seventh-grade science students. The information gained from this study will be shared with the staff and administration at LMS.

Dissertation Overview

Chapter One of this dissertation in practice introduces the problem of practice leading to the development of the action research study, explains the significance of the study, and the reasoning for a pedagogical shift. The first chapter introduces the BSCS 5E Instructional Model and the plan for implementation.

Chapter Two is an extensive review of scholarly literature, which frames this action research study. The literature review covers the areas of science education reform, motivation, and learning of middle-school students, inquiry-based science instruction, constructivism, and the BSCS 5E Model.

Chapter Three discusses the methodology of action research, including research design, the student participant population, the role of the researcher, and the data collection and analysis process.

Chapter Four presents the data collection process and details the findings, data analysis, and interpretations. Chapter Four also explains the coding and dissemination of data collected through the action research process.

Chapter Five provides an overall summary of the action research study. Interpretations of the data are expanded upon, and the chapter includes future implicates

of the study. The possible areas of future research and professional development are also addressed in Chapter Five.

Glossary of Key Terms

The following terms are incorporated into the research and design of the study and operational definitions are provided for how the terms pertain to the study.

Action Research. The study of the practice by the practitioners themselves. A research method that enables teachers to become active participants in their professional development and growth (Mertler, 2017).

Biological Science Curriculum Study 5E Learning Model. An instructional model based on the constructivist approach to learning which builds on students' previous knowledge and experiences (Robinson, 2016, p. 60). The model is comprised of five phases of learning: Engage, Explore, Explain, Elaborate, and Evaluate.

Inquiry. The practice of exploration, questioning, developing explanations, and engaging in reflecting on understanding the world around us (NRC, 2012).

Inquiry-Based Learning. A variety of student-centered teaching models in which the teacher triggers student curiosity, students question and explore the world around them. "Students will themselves engage in the practices and not merely learn about them secondhand" (NRC, 2012, p. 30).

Professional Learning Community. In this study, the professional learning community (or PLC) is comprised of seventh-grade science teachers. These teachers meet weekly to reflect on student learning, plan lessons, develop assessments, and share best practices.

STEM. An interdisciplinary curriculum designed to engage students in the disciplines of Science, Technology, Engineering, and Mathematics. “A true STEM education should increase students’ understanding of how things work and improve their use of technologies” (Bybee, 2010, p. 996).

Student-Centered Curriculum. A methodology of instructions in which students initiate the learning process and the teacher serves as a facilitator.

21st Century Skills. “The skills, dispositions, responsibilities, and self-assessment strategies that are necessary for the 21st-century learner” (Dweck, 2009, p. 8). Examples of these skills are critical thinking, productivity, social skills, and technology literacy.

CHAPTER TWO

LITERATURE REVIEW

The literature review supports the conceptual framework of this action research study and frames the positive impact a pedagogical shift to a student-centered, inquiry-based model as on middle-level science education, including the success of designing lessons using the BSCS 5E Instructional Model.

The first section explores the current state of science education in the United States and the science education reforms developed to address educational concerns. Many argue that the United States has fallen behind other industrialized nations regarding public school student achievement in science and mathematics standardized test scores, interest in science professions, and election to take advanced-level science courses (NRC, 2012). This debate led to a science education reform movement focusing on inquiry-based science. The influences of this reform movement are seen at the local level in the adoption of new curricular materials in 2017 and the revision of the 2014 Science Education Standards (SC DOE, 2014).

The review discusses the theoretical influences of educational scholars, such as Piaget, Dewy, and Vygotsky, on the development of the BSCS 5E Instructional Model and the pedagogical shift to a student-centered instructional pedagogy. The educational theories of these researchers contributed to the development of the constructivist and progressivist education theories that support inquiry-based, student-centered instruction.

The review of the literature examines several studies, both qualitative and quantitative, on the impact of inquiry-based science and the BSCS 5E Model of science education.

Purpose of the Literature Review

The purpose of a literature review is to develop a case supporting a research position, examine current knowledge and information on the position, and explore the potential for further study (Machi & McEvoy, 2016). In an action research study, the researcher needs to identify the theoretical perspectives, prior studies, and methodologies to frame the action research process and focus the research question (Mertler, 2017).

The reforms in science education in South Carolina resulted in the adoption of new curricular materials and an emphasis on inquiry-based science instruction. The *Interactive Science* (2017) curriculum materials adopted in 2017 at LMS were developed with the BSCS 5E curriculum model, but the staff had little training or experience with this pedagogical framework.

In order to develop an understanding of the BSCS 5E Instructional Model (5E Model) and the pedagogical shift required to transition to a 5E, inquiry-based model, this literature review was conducted. This review of the literature sought to examine the influence of student-centered, inquiry-based instruction on middle-level science students, including the effectiveness of the BSCS 5E inquiry model, the pedagogical shift needed to incorporate inquiry-based instruction, and the theoretical models supporting the model and the instructional shift. A secondary focus of the literature review was to review research findings on middle-level science instructional strategies and adolescent motivation.

The chosen articles for this literature review have been peer-reviewed and published in academic journals. They provide supported research and theoretical perspectives on middle-level science education, inquiry-based science, and the 5E model. The related research was surveyed and critiqued by the teacher-researcher. The information was determined to provide supportive data and a theoretical framework on the topics under investigation.

Professional books focused on educational theories and perspectives served as secondary sources of information on science education reform, inquiry-based science, and the educational learning theories of constructivism and progressivism. The books were peer-reviewed and published in conjunction with professional organizations.

Process of the Literature Review

The reviewed literature addressed science reforms and methodologies tested to improve science education for middle-level students. The review also examined the role of inquiry-based science interventions in the development of science achievement and engagement for secondary school students and the programs that yielded positive results in student achievement and engagement.

The review was conducted using online resources through the Thomas Cooper Library at the University of South Carolina (USC). Due to the nature of the graduate program, all research was conducted online. The articles were identified through the ERIC, EBSCO JSTOR, and SAGE databases. The USC online databases provided a comprehensive collection of research articles that extend far beyond what a brick-and-mortar library can provide (Machi & McEvoy, 2016). Books utilized in the literature

review were acquired through the National Science Teacher Association, the National Research Council, and through graduate level courses supporting this degree.

Science Education Reform

The impetus of this action research study was the district, and local school changes brought about by science education reform. The teacher-researcher questioned the impact these reforms would have on her students at Lakeview Middle School (LMS), and the instructional supported needed for these changes to take place. In this section, the recent history of science education reform and inquiry-based teaching strategies are examined. Historically, the incorporation of inquiry-based science education was suggested as a strategy to improve achievement and interest for several years, but there continues to be debate regarding the most beneficial method of implementation and the type of inquiry-based methods to use (Marshall et al., 2017; NRC, 2012).

Science was not considered a high priority in education in the 20th century until the 1950s and the start of the space race (Scruggs, Mastorpieri, Bakken, & Brigham, 1993). In response to the Soviet Union's launch of Sputnik, the United States began a national reform of science education to become the best in the world in regards to science and technology (Scruggs et al., 1993). Since that time, there were numerous science education reform movements with the primary goal of making the United States a leader in the global field in science and technology (Scruggs et al., 1993; Doerschuk, Bahrim, Daniel, Kruger, Mann, & Martin, 2016). According to Doerschuk et al. (2016), despite years of education reform, the USA is still not recognized as a leader in science education. The number of students getting degrees in the math and science fields remains

unchanged in the past decade, despite a growing need for professionals in these fields (Doerschuk et al., 2016).

These unchanging numbers sparked a new wave of science education reform at the national level with the development of the Next Generation Science Standards (NGSS) and the Science, Technology, Engineering, and Mathematics (STEM) Initiative (NGSS, 2013; Marshall, Horton, Igo, & Switzer, 2009). These reforms trickled down to the state level with the development of the 2014 South Carolina Science Standards (SC DOE, 2014) and local school districts development of school STEM programs and initiatives.

The Next Generation Science Standards (NGSS) and STEM Initiative caused a resurgence in the call for more inquiry-based, hands-on instructional strategies in the classroom. "Inquiry-based instruction provides a vehicle by which teachers can engage their students in experiences that go beyond lower-level thinking" (Marshall & Alston, 2014, p. 809).

The NGSS raised performance expectations for students, encouraged higher order thinking skills, and supported the development of 21st century skills (Haag & Megowan, 2015). The reformed performance expectations called for the focus of science education to no longer focus on the memorization of facts and information, but the mastery and demonstration of scientific practices and processing skills (Marshall & Alston, 2014). Science teachers were encouraged to implement more inquiry-based strategies through a problem-solving context and spend less time on direct content instruction (Kerlin, 2012). The challenges of local science education reform now asked the question "What are the

best methods to achieve these performance expectations and how are the students affected by these changes?"

Imig and Imig (2006) suggested that one of the largest focal points of education reform in the United States is an attempt to measure and define student learning and effective teaching practices. This struggle to quantify what is considered "good teaching" and what is evidence of student learning can impede teachers' desires to implement inquiry-based instruction in their classrooms. There is a fear of altering established, teacher-centered instructional practices to shift to a student-centered model needed to support inquiry-based instruction. This action research study addressed the insights and struggles that the teacher-researcher faced when shifting to a student-centered instructional model to implement inquiry-based science into the classroom.

Despite the overwhelming amount of research and theoretical models supporting an inquiry-based, student-centered teaching pedagogy, the teacher-research had not made a committed change to this model. Kazempour and Amirshokoohi (2014) reported that many teachers do not incorporate inquiry-based science because of the complexity of planning and the methodological changes needed to implement it in the traditional classroom setting. The student-centered, reflective process of inquiry-based teaching is much different from the traditional, standards-driven, teacher-centered classroom of public schools in the United States of America (Atar, 2011). The success of an educational reform effort depends on the teachers' competency in incorporating the necessary changes into the classroom. If the teachers are unable, or unwilling, to institute reform in their classrooms, then there is a gap between the concept of reform and the practice of teaching (Atar, 2011; Kerlin, 2012). This action research study addressed the

pedagogical shift of the teacher-researcher to reform her classroom and the achievement and attitudinal implications the changes had on the students.

Theoretical Framework

The theoretical framework supporting this action research study was based on the educational approaches of Progressivism and Constructivism. Although these are two different approaches, they have similar foundations and complement each other in an inquiry-based science classroom. These education approaches provided the epistemological support for incorporating inquiry-based instruction to improve student achievement and engagement.

Constructivism

Science education reform created a push in reforming not only what students are learning, but how they are learning (Qarareh, 2016). The Constructivist approach to learning supports the instructional methods emphasized in this literature review by providing a theoretical foundation for inquiry-based, student-centered instruction.

Constructivism developed from the 20th century works of education scholars and psychologists Dewey (1938), Vygotsky (1978), and Piaget (1968). In Constructivism, learning is an active process, influenced intrinsically and extrinsically and constructed on experiences and previous knowledge (Bybee, 2015; Cetin-Dindar, 2015). Based on formulating new ideas by building on prior knowledge with new information, it essentially allows the learner to construct their knowledge. Cetin-Dindar (2015) hypothesized that a constructivist learning environment would enhance student motivation and engagement due to the student-centered approach to learning.

Teaching with this approach required the teacher-researcher to shift the classroom dynamic from teacher-centered to student-centered for the students to build on their prior knowledge and experiences. The student-participants in this action research study indicated that they were not accustomed to constructivist classroom pedagogy.

For learning to take place in constructivism, challenges to students' current conceptions are required as well as time and activities to encourage the students to reconstruct their ideas. The student-participants are offered ways to interpret events and experiences without accepting things at face value. The students redefine, reorganize, and reconstruct the information they are learning (Bybee, 2015; Yager, 2000). For the change in pedagogy to be successful, the shift in control was gradual and was scaffolded for the students to become comfortable with the new classroom methodology (Brooks & Brooks, 1999).

The scaffolding process of constructivism developed from Vygotsky's educational research. Vygotsky (1978) believed knowledge developed through social interaction with others, in what he referred to as the Zone of Proximal Development (ZPD). When student-participants were in the ZPD, the teacher-researcher divided the content into small, manageable tasks for the students to work on collaboratively while the teacher-researcher served as a guide and facilitator of discussions and inquiry, rather than as the sole provider of information.

A strength of the constructivist approach is providing students with opportunities to develop their cognitive problem-solving skills and attitudes toward science (Cetin-Dindar, 2015; Qarareh, 2016). Inquiry-based science instructional strategies, specifically the BSCS 5E Instructional Model, are closely tied to the learning theory of

constructivism and the development and process of implementation. The cognitive and social constructivist models form the foundation of the BSCS 5E Inquiry Model (Chitman-Booker & Kopp, 2013). Bybee (2015) indicated that the development of the BSES 5E Instructional Model was heavily influenced by the belief that learning is an active process consisting of the development of cognitive structures resulting from interactions between the learning and the environment.

As the student-participants moved through the phases of the 5E Model, they constructed new content knowledge through the experiences and information they encountered in each phase of the model. Their content misconceptions and prior knowledge were introduced during the Engagement phase, at the beginning of the 5E Model (Bybee, 2015). While this information hooked the students to the topic, they were able to refer back to it as they moved through the other phases. The emphasis in a constructivist classroom is on what students can do, and the assessment of the measurement of learning is based on performance and the process of learning, rather than on a standardized achievement (Dev, 2016).

The Elaboration phase of the model supports Dev's (2016) description of measurement of learning. During this phase, the student-participants could not elaborate or expand on their previous knowledge if they had not successfully built knowledge in the prior phases.

Throughout this action research study, the student-participants took part in student-centered activities that encouraged the development of critical thinking skills and self-evaluations to examine their learning critically. Qarareh's (2016) research indicated that the constructivist model is effective in the development of higher-order thinking and

processing skills. Dev's (2016) research on the constructivist approach in teaching English to primary school students found that students who were taught using constructivist methods had a deeper comprehension of the learning process and thought more critically about learning than those who were taught in a traditional method.

Progressivism

Inquiry-based science instruction, reflective thinking, and the ideology of the student-centered classroom originated in the work of educational philosopher John Dewey almost a century ago. Dewey (1938) was the founder of the progressive education movement that supported the belief that schools are agents of democracy and social change (Van Patten & Davidson, 2010). Van Patten and Davidson (2010) described Progressivism as a response to the teacher-centered, structured, and rigid educational system of the time that is still overwhelmingly found in the contemporary classroom.

The progressive education philosophy encouraged students to explore the world around them, use inquiry to solve problems, and collaborate to learn from their environment (Dewey, 1938). As a student-centered curriculum, Progressivism focused on democratic social issues solved in a cooperative environment. As with Constructivism, students are taught to formulate meaningful questions and answer them through critical thinking and real-world experiences. The students can apply these critical thinking skills to their society and other educational disciplines. This is reflected in inquiry-based, student-centered teaching and the BSCS 5E Instructional Model (Bybee, 2015).

Dewey (1938) believed a child's education developed through the demands of the social situations he or she was placed in. The child's actions and responses to the situation developed the ideas and knowledge the child holds. The student's instincts and insight provide the starting point for learning, and the teacher helps guide the process and provides the student with the experiences need to grow (Dewey, 1938). Progressivism's focus is student-centered learning in which the child uses the skills of inquiry and exploration to learn about the world around him. The teacher is a facilitator of this learning and helps to guide the process, but it is the child's innate wonder that leads the process of learning. John Dewey's (1938) progressive education philosophy encouraged students to explore the world around them, use inquiry to solve problems, and collaborate to learn from their environment.

Inquiry-based learning is identified as an effective strategy for teaching science, but it has not been a constant fixture in science education since the development of the progressive reform. The educational system of the United States predominantly follows an Essentialist curriculum philosophy (Van Patten & Davidson, 2010). Developed by William Bagley in the early 20th century as an alternative to Dewey's progressivism movement, students in an essentialist classroom are taught educational standards in a structured, teacher-centered environment (Imig & Imig, 2006). The continued conflict between progressivism and essentialism influenced the development of educational policy in the United States for almost a century (Van Patten & Davidson, 2010).

Middle School Students and Motivation

In this section, the constructs of the problem of practice for the action research study are addressed. The trends of stagnant achievement in middle school science, gaps between student groups, disinterest, and decreased motivation in science class were identified as concerns reflecting in classrooms across the United States and in the teacher-researcher's classroom (Brookhart, Walsh, & Zientarski, 2006; Johnson, 2009; Kim, 2016).

Middle school students

Adolescence, between the ages of ten and fifteen, is a unique developmental period characterized by fluctuations in social, physical, emotional, moral, and intellectual development that are not seen as dramatically in any other developmental age group (NMSA & AMLE, 2010). The singularity of this age group creates an educational environment that is unlike the elementary or high school environments. According to the American Middle Level Education Association (AMLE, 2010) and the National Middle School Association (2010), during the 1980s, the term "middle-level" was added to the educational vernacular to describe the level of education that serves students in this young, adolescent population. The term encompasses more than just the organization of a school or a specific grade plan. The term "middle grades" is a more modern term used when the teachers or the practices in the middle level are the focus of the discussion. This need for specific terminology reinforces the particularity of early adolescent education.

For over forty years, the educational needs of a middle-level student have grown and developed in accordance with advances in technology, medicine, psychology, and

educational philosophy. “The curriculum, pedagogy, and programs of middle grades school must be based upon the developmental readiness, needs, and interests of young adolescents. This concept is at the heart of middle-level education” (NMSA & AMLE, 2010, p. 3).

Adolescent development

During early adolescence, a human undergoes profound changes in the physical development of their mind and bodies. Often, for an adolescent, their cognitive, physical, emotional, and social development are not balanced with each other, resulting in a complex instructional challenge for teachers. According to Armstrong (2016), it is essential for middle-level educators to understand and appreciate this variability in growth and development to teach this student population effectively. Despite the unique needs of middle-level students, the teacher-researcher recognized that she was not meeting these needs and identified this as a problem of her teaching practices.

During adolescence, the brain will grow and mature, but the different areas will develop at different rates. Specifically, the prefrontal cortex responsible for decision making, impulse control, planning, and other executive functions develops at a slower rate than the limbic system, which controls emotions and biological drives (Armstrong, 2016). Due to these developmental inconsistencies, adolescents can be more emotionally reactive, with less rational thought than people outside of their age groups. The neuroplasticity, the brain’s ability to form new neural pathways, of the early adolescent’s brain is influential on the shaping of the adult brain of the students. The brain will wire itself in response to experiences and environmental influences, resulting in an increased vulnerability to internal and external stress (Armstrong, 2016). It is during this time that

adolescents reach out to peers for structure and support. Ironically, the development period when adolescents need scaffolding information and peer interactions is when the traditional classroom becomes teacher-centered instruction with less cooperative learning (NMSA & ALME, 2010; Armstrong, 2016). Through student-centered, inquiry-based instruction, the teacher-researcher aimed to provide the student-participants with social and collaborative experiences. The adolescent brain is biologically wired to learn through socially mediated activities and meaning learning that is not found in a teacher-centered classroom. This supported the need for a pedagogical shift to a student-centered classroom.

The social and emotional development of adolescents in the ten to fifteen age-range is a significant factor in their engagement and motivation to learn. Adolescents are searching for continuity and sameness with their peers in conflict with the development of their own identity. According to Erikson (1994), adolescents tend to lose their identity in the formation of cliques and by stereotyping themselves into a societal model, which can include the exclusion of others who are different through intolerance and bullying. NMSA and AMLE (2010) describe the middle adolescent as being highly sensitive to criticism, easily discouraged, with variable levels of self-confidence and self-esteem. Traditionally, learning content is fixed and fragmented to cover large amounts of standardized material. As previously discussed by my colleagues, there are too many standards to teach and not enough time to reach them all.

When students are not learning as required, they face negative sanctions, and they are cut off from the positive opportunities that are harmful to their sensitivities. Students withdraw when they are faced with an environment of fear and lack of emotional support

(Halpert, Heckman, & Lanson, 2013). The various biological and sociological influences on the middle-level student populations influence their motivation in school. These students develop new capacities for thinking and learning. At this age, they can consider multiple ideas, reflect on their learning, and question the world around them (2013). However, they are often not given the opportunity in a traditional teacher-centered school setting. The adopted *Interactive Science* (Buckley et al., 2017) curriculum materials support student reflection and real-world examination, but they are not being utilized as designed.

When students are not engaged and actively participating in their learning, there is a decline in motivation, interest, and a willingness to take on challenges (Bathgate & Schunn, 2017; Halpert, Heckman, & Lanson, 2013). "Motivation can be fragile, especially in adolescence. It is easily disrupted by all the other urgencies in young people's lives" (Halpert, Heckman, & Lanson, 2013, p. 12). Bathgate and Schunn (2017) identified that adolescent motivation to learn science content is influenced by the scientific learning activities taking place in the classroom. These findings suggest effective engagement and perceived success of the material positively affected student motivation to learn science content more than behavioral-cognitive engagement supporting the influence of peers and a cooperative environment for instruction.

Interest and engagement

One of the significant factors in the development of achievement gaps in science is a lack of sustained interest in science for students (Basu & Barton, 2007). As students move through elementary school into middle school, their interest and motivation in science education drop more every year (Kim, 2016). Students will develop additional

negative attitudes toward learning science and science teachers the longer the students study the subject (Akcay, Yager, Iskander, & Turgut, 2010). In examining these results, it would be beneficial for the teacher and students to develop a positive attitude regarding science (Brookhart et al., 2006; Akcay et al., 2010).

Akcay et al. (2010) described two categories of attitude regarding science. The first is the attitude toward science or the interest in science, or the beliefs and values one holds toward science. The second category is the scientific attitude or the desire to know and understand science and wanting to learn more (Akcay et al., 2010). These attitudes influence students' science and achievement and interest in future careers in the STEM fields (Akcay et al., 2010)

Many middle-level students, specifically in low-income areas, think of science as boring, confusing, and un-relatable (Basu & Barton, 2007). Often, students are unmotivated in science because they are unable to connect the subject to their experiences and interests (Basu & Barton, 2007; Kim, 2016). Researchers argued that there is a disconnect between school and life outside of school regarding the practicality and place which science has in the lives of students (Basu & Barton, 2007). This disconnect was identified predominantly in students who are members of traditionally marginalized groups. These students do not identify the connections of science to their own lives, and they picture scientists as older, white men wearing lab coats (Basu & Barton, 2007, Johnson, 2009: Kim, 2016). Teachers who engaged students in activities, utilized performance-based assessments, inquiry-based instructional technologies, and increased student participation in the educational process were all successful in

improving science achievement and interest in students across socioeconomic and racial groups (Johnson, 2009).

Inquiry-Based Science Instruction

In science education, the definition of *inquiry* developed and changed over the years. Inquiry can be described as scientific investigation, science process skills, and exploration. Scientific inquiry refers to how scientists study the natural world and propose explanations based on the evidence (NRC, 1996). In classroom instruction, inquiry refers to the activities of the students in which they develop and construct scientific information rather than having the teacher reveal the information to them (Duran & Duran, 2004; Olson & Loucks-Horsley, 2008).

The NGSS (2013) and the NRC (1996) support learning science through inquiry and the mastery of higher order scientific practices. In *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas* (NRC, 2012) the National Research Council supports the implementation of inquiry-based instructional methods as the best way to achieve student mastery of the NGSS. Inquiry-based instruction is supported as being an effective method of teaching for the development of cognitive and procedural skills and influential in the development of positive attitudes toward science (Zion & Mendelovici, 2012; Yager & Akcay, 2010). The development of the South Carolina State Science Standards (2014) was influenced by the NGSS (2013), leading to the assumption that inquiry-based instruction is the ideal method to achieve state-level standards.

Inquiry-based instruction is a deviation from the traditional classroom setting. Utilizing inquiry in the classroom requires a change in approach to learning by the students and the teachers (Citation). The teacher becomes the facilitator of student-centered learning and now emphasizes guiding students through an active learning process rather than directing education. In turn, the students become more responsible for the path of their learning (Zion & Mendelovici, 2012). As students learn science best through personal experiences, learning science is something students do, not something that is done to them. Learning is an active process that includes investigation and inquiry (NRC, 1996; 2012).

Teachers' lack of inquiry-based instruction

Although several years of research has indicated inquiry-based strategies are the best method for science instruction, there is a deficit of teachers using these methods in the classroom (Lebak & Tinsley, 2010). This lack of pedagogical practice supporting inquiry was identified as an area of concern during the development of the problem of practice. This section will explore the obstacles teachers face in incorporating inquiry-based methods into their classrooms. There are conflicting beliefs concerning the use of inquiry regarding student success, what inquiry-based science is, and how to implement it (Atar, 2011; Lebak & Tinsley, 2010; Imig & Imig, 2006; Zion & Mendelovici, 2012).

Reasons for lack of inquiry

As evidenced in this action research study, many teachers support the incorporation of inquiry into science classrooms, but they think there are factors beyond their control obstructing the implementation of this student-centered pedagogy. Teachers believe that time constraints, lack of materials, lack of administrative support,

standardized and criterion-based testing, parental expectations of graded assignments, and the amount of content needed to be covered are obstacles they are unable to overcome in order to incorporate inquiry (Kazempur & Amirshokoohi, 2014; Atar, 2011; Walan, McEwen, & Gericke, 2016).

Through action research, Lebak and Tinsley (2010) identified several reasons why teachers struggle to break the mold of teacher-centered, textbook instruction. Often, teachers do not know how to incorporate different methods of inquiry and fear learning will not take place without whole group instruction (Lebak & Tinsley, 2010). They are also missing opportunities to self-examine and reflect on their teaching processes, collaborate with peers, and reflect upon the reactions of the students to teaching practices. All of these factors were identified as instrumental tools in advancing teaching practices, which improve student achievement (Lebak & Tinsley, 2010).

A classroom teacher's attitudes and beliefs about inquiry-based teacher determine whether that teacher utilizes these strategies (Lebak & Tinsley, 2010; Isiksal-Bostan, Sahin, & Ertepinar, 2015). Walan, McEwen, and Gericke (2016) identified one of the strongest predictors in students' attitudes toward science and inquiry as the attitude and behavior of their teachers. For students to be involved in inquiry-based classrooms, the teachers need to believe that inquiry-based science is an effective teaching strategy. They must also have high efficacy in their abilities to teach effectively in this method (Lebak & Tinsley, 2010).

In order to teach inquiry effectively, the teacher must allow students to take control of the learning environment. This puts the teacher into a position of shared control. Many teachers find this method intimidating or threatening and they fear losing

control of their class (Osisioma & Onyia, 2008; Atar, 2011). A teacher who was little experience in inquiry, or keeps a structured management style, may lack the strategies to implement inquiry and the unexpected results of student-centered learning (Odom & Bell, 2015; Walan et al., 2016).

Teachers' knowledge of inquiry

Despite our new, inquiry-based textbooks and curricular materials, science teachers at LMS are not using the methods framed in the text. In order to successfully adopt an inquiry-based approach to teaching and learning in a classroom, teachers need to be familiar with both the nature of scientific inquiry and inquiry-based and learning and how to implement such practices in their classrooms (Kazempour & Amirshokoohi, 2014).

Marshall et al. (2007) indicated, for teachers to implement inquiry-based science effectively, "Strong science content knowledge enhances teachers' ability to guide, mediate, and facilitate student learning" (p. 545). One of the reasons for the shortage of inquiry-based assignments in science could be due to the teachers' lack of familiarity with what constitutes inquiry-based science (Kazempour & Amirshokoohi, 2014; Lebak & Tinsley, 2010; Osisioma & Onyia, 2008). Teachers coming into the field may not have an understanding of how scientists work and little knowledge of how to replicate it in the classroom (Kazempour & Amirshokoohi, 2014; Osisioma & Onyia, 2008).

This misunderstanding of what inquiry is could prevent its incorporation into the classroom. As exemplified in this study, there are instructional challenges to teachers who enter the profession with training on the content of science but without training on inquiry-based instructional strategies. This challenge is pertinent to the teacher-

researcher's professional background. She did not go to college to become a science teacher and fell into the position several years ago because there was a job opening. At the time, the teacher-researcher was not familiar with inquiry-based instructional strategies and equated a lab to following the steps of the scientific method. To many teachers in this situation, science is about the facts-and-figures of the content and not about the inquiry process (Lebak & Tinsley, 2010). In these cases, the teacher may view inquiry-based instruction as too lenient or not rigorous enough to meet the required content standards.

The BSCS 5E Model of Inquiry-Based Instruction

This section discusses the development of the BSCS 5E Instructional Model, the five phases of the method, adaptations and advancements of the model, and successful programs utilizing this inquiry-based approach in science.

The BSCS 5E Model of inquiry-based instruction

The Biological Sciences Curriculum Study led by Rodger Bybee developed the BSCS 5E Instructional Model or method of inquiry-based instruction (BSCS 5E model) in 1987 to develop a science and health education curriculum model (Bybee, 2015). Over the years, the model was developed and adjusted to support the NGSS, STEM initiatives, and the development of 21st Century Skills (Bybee, 2015, 2016). The BSCS 5E Model of instruction purports to produce scientifically literate students through the process of a five-step inquiry-based scaffolding, or cycle (Bybee, 2011, 2014; Duran & Duran, 2004). The 5E Model can be utilized in addressing the knowledge of science concepts, but also to the application of science to new situations. "It engages students' thinking, then

allows for explorative discovery and factual learning to deepen students' understanding of content matter" (Chitman-Booker & Kopp, 2013, p. 9).

Structure of the model

According to Bybee (2015), the BSCS 5E Model's development was influenced by the previously developed instructional models of John Herbart, John Dewey, and Robert Karplus and by the educational philosophies of Jean Piaget and Lev Vygotsky. The BSCS 5E Model is grounded in the psychology of learning, explicitly in the constructivist perspective (2015). As a student-centered model, the BSCS 5E Model allows students to bring their current knowledge of a topic and, through interactions with the teacher and each other, to reorganize and redevelop initial concepts through investigation, collaboration, and reflection (Bybee, 2015).

As with inquiry-based, student-centered teaching, the instructional strategy of scaffolding information is a key component of the BSCS 5E Model, with the instructor acting as a guide and facilitator of the information (Chitman-Booker & Kopp, 2013). Bybee (2011; 2014; 2015) indicated that the BSCS 5E Model has five distinct phases that build on each other in order to develop science content knowledge. As described by Bybee (2015), "each phase has a specific purpose and contributes to the teacher's coherent instruction and the students' constructing a better understanding of content, attitudes, and skills" (p. 29). The five steps are:

1. Engage
2. Explore
3. Explain
4. Elaborate (or Extend)

5. Evaluate

The intention of the first phase of the model, Engagement, is to generate the interest of the students and stimulate the learning process. The Engagement phase is successful if the students are posing questions and are actively motivated to learn the information (Bybee, 2011, 2015). This phase helps students build interest in the topic and increase student motivation to learn.

The second phase, Exploration, is indicative of the inquiry-based learning strategies. During this phase, students explore objects, events, or scientific phenomena in order to establish relationships, develop patterns, and question the process (Bybee, 2015).

There can be a shift from student-centered instruction to teacher-centered instruction during the third phase, Explanation. At the mid-point of the model, the teacher can introduce concepts and, with the students, interpret the observations made in the Exploration phase (Bybee, 2015). The inclusion of this phase addresses the inquiry implementation challenge many teachers have regarding a lack of control or missing key content standards (Lebak & Tinsley, 2010).

As previously discussed in this review of the literature, one of the most influential factors in student motivation is the relevancy of the instructional topic (Jones et al. 2015; Bathgate & Schunn, 2017). This motivational factor is addressed in the Elaboration phase. The application and transfer of related topics in the content and environment takes place at this time (Bybee, 2014, 2015). During this phase, the students meet new challenges that are achievable through the previously learned knowledge and construct new information and connections. The process of the Elaboration phase supports the attributes of effectively learning as described by Halpern, Heckman, and Lanson (2013).

“Good learning provides time and opportunity for in-depth work on specific problems and sets of learning tasks, and gradually deeper immersion in a particular discipline” (p. 9).

Evaluation, the final phase, is a necessary component of an instructional model. Teachers are often required to administer assessments to determine if the required content has been learned or instructional standards have been met (Bybee, 2014, 2015). During the Evaluation phase, the knowledge and skills developed in the prior phases are represented, and students are involved in feedback and reflections of their learning, encouraging the student-driven learning process (Bybee, 2014, 2015).

Bybee (2014) suggested not omitting any of the phases of the model because each is integral to the learning process and, when phases are omitted, the integrity of the model is corrupted.

The success of the 5E Model of Instruction

Numerous studies from around the world have been conducted on the effectiveness of the BSCS 5E Model (Scott, Schroeder, Tolson, Huang, and Williams, 2014; Kim, 2011, 2016; Dasdemir, 2016). Studies exist on a variety of content subject matter and different educational age groups. Programs developed around the BSCS 5E Model show promising results in science achievement and the decrease in the achievement gap between underrepresented groups of students (Duran & Duran, 2004). The incorporation of the BSCS 5E Model results not only in increases in student achievement and motivation, but also in the students’ ability to apply concepts and skills to new situations (Dasdemir, 2016; Liu, Peng, Wu, & Lin, 2009).

In a four-year longitudinal study, Scott et al. (2014) examined the changes in achievement gaps and science content knowledge of fifth-grade students due to the sustained training and utilization of a text developed on the BSCS 5E Model. The results indicated that, although there were still achievement gaps in underrepresented populations, the gaps decreased and content knowledge increased. The scale scores for the group rose higher for students in the district using the text when compared to their counterparts in the rest of the state (Scott et al., 2014).

The incorporation of technology with the BSCS 5E Model increased student achievement in science and development of 21st century skills (Kim, 2016; Matuk, Linn, and Eylon, 2015; Pringle, Dawon, & Ritzhaupt, 2015). With the advancements in personal technology and the growth of 1:1 computer initiatives, technology has an established presence in many schools (Chitman-Booker & Kopp, 2013). Technology integration is a beneficial learning tool for student motivation and achievement when incorporated into a learning model (Liu et al., 2009). Students can use technology to fulfill inquiry-based activities and engage in self-directed learning (Kim, 2011; 2016). "Educators agree that when educational technology is successfully integrated into teaching, students become engaged with tools that afford them opportunities to analyze and manipulate systems and processes in the construction of science knowledge and problem solving" (Pringle et al., 2015, p. 657).

Through the incorporation of technology into the BSCS 5E Model, the interactive tools enable students to visualize explanations and design solutions. The Inquiry-Based Science and Technology Enrichment Program (In STEP) is an intensive, weeklong program designed to increase female students' interest in science, content knowledge,

and science-related careers (Kim, 2016). The lessons in the program utilize the BSCS 5E Instructional Model with the incorporation of technology. The participants in the program are middle school girls who apply to attend the program at a local university. The results of the program indicate an increase in content knowledge and interest in science for the participants. Inquiry-based learning positively influenced the girls' attitudes and long-term outlook on science (Kim, 2016).

Lack of time is often a deterrent for incorporating inquiry-based instruction (Kazempour & Amirshokoohi, 2014). Through the addition of technology, time can be removed as a pressing concern against inquiry. The use of technology can take scientific learning outside of the classroom and individualize the learning experience for each student (Liu, 2009).

Arguments against inquiry-based instruction

Despite the amount of research supporting student-centered, inquiry-based instruction, there are educational professionals who do not believe that inquiry-based science is an effective method of teaching, implying that students get lost in the lack of classroom guidance (Kirschner, Sweller, and Clark, 2006).

Kirscher, Sweller, and Clark (2006) described two main assumptions underlying programs that use minimal guidance, such as inquiry-based learning. The first assumption being "having learners construct their own solutions leads to the most effective experience. Second, they appear to assume that knowledge can best be acquired through experience based on the procedures of the discipline" (Kirschner et al., 2006, p. 76). Minimally guided instruction gives the appearance of proceeding without reference to long-term and working memory. The continuous searching for solutions to a problem

does not allow the brain to formulate knowledge and commit it to long-term memory (Kirschner et al., 2006).

Kubiatko (2016) questioned if the inquiry-based study is the best approach for learning science because students are often not learning new knowledge, but they are grasping a body of established knowledge put forth by the teacher. The inquiry-based science method has been widely advocated for student success in science, but there has been little growth in science achievement over several years of education reform (Dev, 2016; Kirschner et al., 2016).

Dev (2016) posited, in utilizing inquiry-based models, concepts and standards essential to the class could be forgotten or left out because of the constructivist approach. This supports the reasons given in this action research study by the teacher-researcher's colleagues. The BSCS 5E Model supports the balance between minimal and direct instruction in the classroom, alleviating the purported reasons against the student-centered, inquiry-based instruction.

Conclusion

Students across the United States, and at LMS, are not achieving in science education. Middle-level students find science boring and un-relatable (Esparza, Shumow, &Schmidt, 2014; Kim, 2016). This national trend prompted science education reform at the national level and in my classroom. The incorporation of STEM initiatives and new state standards indicate there will be a shift in how science education is currently being taught (Marshall, Smart, & Alston, 2017).

Educational research trends indicate science classroom teachers are not incorporating inquiry into their instructional practices and are maintaining a teacher-centered classroom pedagogy (Kirschner et al., 2006; Odom & Bell, 2015). The shift to a student-centered pedagogy is needed to incorporate inquiry-based instruction in the classroom. The utilization of the BSCS 5E Model can enable teachers to make this shift.

CHAPTER THREE

METHODOLOGY

Chapter Three describes the qualitative action research methods used in the collection of data at LMS during the fall of 2018 to determine the implications of a BSCS 5E Model instructional unit on students in a seventh grade classroom. This qualitative action research study describes the teacher-researcher's shift from a traditional teacher-centered to a student-centered instructional model. Mertler (2017) described action research as a "systematic inquiry conducted by teachers, administrators, counselors, or others with a vested interested in the teaching and learning process" (p. 4). Action research is a cyclical process of planning, acting, developing, and reflecting throughout the process (Mertler, 2017).

Through this cyclical process, the teacher-researcher was able to reflect on the problem, the plan, and the data collected continuously. By using a constant comparative method to analyze and interpret data as it was collected, the teacher-researcher was able to adjust the direction of the study as needed (Merriam & Tisdell, 2016). Action research is reciprocal in nature. Through the teacher-researcher examining and improving a problem of practice, the students and colleagues of the researcher benefited from the implementation of the plan and provided feedback to the researcher during the process. This chapter will review the research design process including a summary of the problem of practice, research question, and purpose of the action research study.

Purpose Statement

The primary purpose of the present study was to describe the implementation of a unit based on the BSCS 5E Model with four seventh-grade science classes at LMS. The secondary purpose was to describe my transition, as a middle-level science teacher-researcher in South Carolina, to an inquiry-based, progressivist, student-centered pedagogical model.

The tertiary purpose was to develop an Action Plan for professional development to share the findings of the present study with other teachers at LMS. The school district uses *Interactive Science* (Buckley et al., 2017) textbooks and the corresponding curricular materials. The materials are designed to incorporate the BSCS 5E Instructional Model. Due to the reciprocal nature of action research through professional development, I was able to design a professional development plan to work with other middle-school science teachers in developing units that are progressivist and constructivist using the *Interactive Science* (Buckley et al., 2017) materials and the BSCS 5E model (Bybee, 2015).

Problem Statement

The problem of practice addressed in the present study was based on designing and implementing an inquiry-based, middle-level (seventh-grade) science curriculum that aligned with the 2014 South Carolina State Science Standards (SCSS) (SC DOE, 2014) and engaged student-participants with science course content in ways that are constructivist and progressivist. That is to say, pedagogy that was "active" rather than "passive," as in traditional lecture format classrooms. In 2017, curricular materials were

purchased by the Winter Haven School District to enable its science teachers to develop curriculum and pedagogy that was relational to the students' cognitive, affective, and psychosocial domains. The curricular materials are designed to support the BSCS 5E Learning Model (Bybee, 2015), an inquiry-based model consisting of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation.

When the textbooks were adopted, the BSCS 5E Model was not being tested or implemented at Lakeview Middle School. In order to implement the BSCS 5E Model, which is an inquiry-based model, there needed to be a paradigm shift from a teacher-centered to a student-centered learning environment at LMS. Therefore, the present action research study examined 100 student-participants' perceptions of a BSCS 5E Model and described the teacher-researcher's transition to a student-centered learning model.

Problem of Practice

In order to conduct an action research study, a problem of practice (PoP) must be identified and developed from an area of interest. Mintrop (2016) described a problem of practice as "a problem for which a remedy is urgently sought that can be locally implemented" (p. 23). This definition supports the first step in designing an action research plan. According to Mertler (2017), the first step is deciding what to study and limiting the topic. During action research, the research is personally involved in the situation and the topic identified is a local problem of practice (Mertler, 2017).

The identified problem of practice for the present study involved a pedagogical shift in my teaching for my seventh-grade science class. The problem of practice addressed in the present study was based on designing and implementing an inquiry-

based, middle-level (seventh-grade) science curriculum that aligned with the South Carolina State Standards (SC DOE, 2014) and engaged students with course content in ways that are constructivist and progressivist.

The following research question guided the conceptual and methodological decisions for the study within a qualitative action research design.

Research Question

This study was guided by the question *How do middle-level students accustomed to a traditional, teacher-centered curriculum, perceive an inquiry-based, student-centered science classroom based on the Biological Science Curriculum Studies (BSCS) 5E Instructional Model?*

The study also addressed the following sub-questions:

1. Regardless of how they perceive the student-centered curriculum, how do they negotiate the class?
2. What are some of the problems involved in facilitating teacher planning of the 5E Model science curriculum?

During the implementation of an instructional unit based on the BSCS 5E Model, the teacher-researcher was able to obtain data through student attitude surveys, teacher-made examinations, lesson exit tickets, semi-structured and informal interviews, and field notes. The data collected guided the progression of the study.

Research Objectives

Mintrop (2016) indicated researches must be realistic in the focus of their investigation and incorporated remedies. “The actual formulation of aims or goals for the

design comes at a later stage when designers have enough information about the beliefs, attitudes, practices, and capacities of people who will participate in the project" (p. 28).

The research objectives for this qualitative action research study were:

1. Through action-based research, I determined the impact of the inquiry-based BSCS 5E Instructional Model on middle-level seventh-grade science students.
2. Through action research, I determined the impact of a pedagogical shift from teacher-centered instructions to student-centered instruction in a middle-level seventh-grade classroom.

Action Research

Traditional educational research can be conducted through a variety of methods. The focus in all methods is the same; the researchers seek to answer questions about education (Mertler, 2017). Due to the teacher-centered problem of practice, Action Research was the appropriate form of education research for this study as the teacher-researcher examined her instructional practices and her lack of experience with the BSCS 5E model used in the district-mandated curricular materials. "Teachers must be able and willing to critically examine their own practices as well as how students (both collectively and individually learn best" (Mertler, 2017, p. 12).

The inductive nature of action research focuses on a bottom-up approach. The researcher begins with observations and looks for patterns and commonalities to develop theories (Mertler, 2017; Trochim, 2006). The research being conducted is non-experimental, qualitative, action-based research.

The action research model I used to conduct the study was Mertler's 4 Stage Action Research Process. These stages occur in a cyclical process, in which there may not be a specific end to the study or steps may change and adjust over time due to the nature of the research. The steps of action research are characteristically not set in stone due to the personal nature of the research and the reflections of the practitioner (Mertler, 2017).

Planning Stage

The planning stage is characterized by identifying the topic, gathering information, reviewing the related literature, and developing the action plan (Mertler, 2017). As a seventh-grade science teacher, I chose to focus on instructional practices for the action research study. Educators are typically so ingrained in teacher-centered, day-to-day instructional practices that their taken-for-granted assumptions often blind them to the problems in their classrooms, such as student engagement and reflection. The current state of education reform for middle-level science in the United States supports an increase in inquiry-based instruction (NRC, 2012). The Winter Haven School District (WDS), a pseudonym, has adopted the *Interactive Science* (Buckley et al., 2017) curriculum for all middle schools in the district. The textbook and curricular materials are designed with the framework of the BSCS 5E Instructional Model. The adoption of a new curriculum prompted the planning stage of this action research study, to learn more about the model and the pedagogical practices for implementation.

Gathering Information

Information was gathered through reflections of my teaching practices, discussions with science colleagues, and data collected on inquiry-based science, the

BSCS 5E model, and student-centered learning. Mertler (2017) stated, “More formally, doing reconnaissance involves taking time to reflect on your own beliefs and to gain a better understanding of the nature and context of your research problem” (p. 39). This action research study developed out of a desire to improve my own instructional practices to comply with the science education reform movement of the incorporation of inquiry-based science and the adoption of a new district curriculum.

Reviewing the Related Literature

As discussed in Chapters One and Two, the literature supports the incorporation of instructional strategies using the BSCS Instructional Model and the pedagogical shift to a student-centered learning environment. The National Academies report “Rising Above the Gathering Storm” (2007) emphasized the importance of science education to remain a dominant force in a world being shaped by science and technology. The development of national science standards, called the “Next Generation Science Standards” (NGSS, 2013), and the “South Carolina Academic Standards and Performance Indicators for Science” (SC DOE, 2014) added pressure on South Carolina public schools to raise science achievement test scores and reform the delivery of science education (Duran & Duran, 2004; NRC, 2012; Quinn et al., 2012; SC DOE, 2014).

Development of the Research Plan

The development of the research plan is the fourth step in the planning stage of Mertler’s process (2017). This action research study is a qualitative, constant comparative study design. During a constant comparative action research study, data is collected from multiple sources and analyzed during the collection process, helping to guide the direction of the study (Merriam & Tisdell, 2016; Mertler, 2017).

Acting Stage

Mertler (2017) describes the acting stage as "where the action researcher implements the plan and then collects and analyzes the data" (p. 36). The Action Research plan in Chapter Three details the acting stage of the study.

Developing Stage

Once the data have been analyzed and the results interpreted, the next step in the action research process is the development of an action plan (Mertler, 2017). The development of the action plan is described in Chapter Five of this Action Research study.

Reflecting Stage

The premise of Action Research is examining one's own practice. Reflecting on the process is a vital step (Lebak & Tinsley, 2010; Mertler, 2016). In Chapter Four, I review the process, implementation and reflect on the data collected during the study. Lebak and Tinsley (2010) stated that "transformative learning requires multiple levels of reflection and the use of peer collaboration" (p. 955).

Merriam and Tisdell (2016) reinforce the importance of developing and maintaining social interactions during action research that enhance the lives and learning of the participants. The reflection stage gave me the opportunity to share the results of my study with my colleagues at my school in content level meetings. The reflection of best practices and classroom challenges with another seventh-grade science teacher provided direction and suggestions for lesson delivery and classroom management strategies.

Design of the Present Study

This action research study is a qualitative, constant comparative design. Since the goals of the study were to determine the student perceptions of the BSCS 5E Model and the student-centered instructional pedagogy, a qualitative approach supported the process of collecting data from multiple sources for description and explanation rather than predictions of cause and effect found in experimental research (Merriam, 1988). In the development of the research question and problem of practice, data was collected through anecdotal conversations with colleagues regarding the new curricular materials. Because of the rapport I built with my students through informal discussions and one-on-one conversations, I was able to have students open up to me regarding their opinions of science class and what like or dislike about the lessons they are being taught.

Teacher-Researcher

I was the teacher-research for this action research study. The study took place in my four seventh-grade general science classes at LMS. My position at the school established me as a complete insider researcher. I am designing the research that is taking place in my classroom (Merriam & Tisdell, 2016). I have taught since 1998 in a variety of educational settings including high school, middle school, and online virtual school. I was in my sixth year of teaching seventh-grade science at LMS, where the research was conducted. In order to solve the problem of practice, the teacher-researcher collected data on student perceptions and behaviors related to the implementation of the BSCS 5E Instructional Model and student-centered instruction. The data collected provided student-participants opportunities to reflect with the teacher-researcher on the workings of their science classroom. Students are often passive participants in the

classroom. The process of action research enabled them to become active participants through discussion and reflection on the data. Action Research supports this approach because "it focuses specifically on the unique characteristics of the population with whom a practice is employed or with whom some action must be taken" (Mertler, 2017, p. 4).

As the teacher-researcher, I was responsible for data collection throughout this action research study. In accordance with district guidelines, parent consent letters (Appendix A) were sent home to all study participants, describing the purpose of the study and reasons for data collection. Research data was gathered from a variety of qualitative collection tools such as observations, field notes, exit tickets, and semi-structured and informal interviews with colleagues and administrators. Due to the ability to polyangulate quantitative data with qualitative data, the student-participants took pre- and post-tests on science content and student attitudes. The science content knowledge was measured through unit assessments designed to measure student proficiency of the addressed science standards. The student attitudes toward school science were measure using the Attitudes Towards Science in School Assessment (ATSSA) (Germann, 1988) before and after the instructional unit. During the data collection process, I shared the findings with the student-participants and teacher-participants in order to reflect on the process and make adjustments on the focus of the study.

Student-Participants

The participants in the action research student were seventh-grade students assigned to my general science classes. The students range in age from twelve to fourteen years. Data collection for this study came from a sample size of one hundred

students divided between four classes. The instructional unit was provided to all students assigned to my classes, but four students did not have parental consent, three students had incomplete data, and two students moved during the study, resulting in a sample size of 100 student-participants.

The students live in a lower/middle-class area in the town of Lakeview (pseudonym), South Carolina. Of the student-participants, 70% are on free/reduced lunch. The demographics of the student participants are 47% White and 53% people of Color. The academic considerations of the student-population included two special education students with individual education plans, two students on a 504 plan for ADHD, sixteen students considered English language learners, and six student-participants who had repeated a grade since elementary school.

Research Site

The research site was a middle school located in Lakeview (pseudonym), South Carolina. The town is a suburb approximately twenty miles outside of Charleston, SC. The town of Lakeview is in a lower middle-income area. At present, 9.7% of the population of Lakeview lives at or below the poverty line (US Census Department, 2016). A majority of the student population (59%) was on free-and-reduced lunch (SC DOE, 2016). The school supports grades six through eight and had approximately seven hundred and forty students supported by forty-eight teachers and four administrators. The school day for students begins at 8:10 am and ends at 3:20 pm. Students have four core courses daily for approximately fifty minutes, two elected courses daily, and a section of the day is dedicated to a twenty-five-minute lunch period with a twenty-minute extra time and help (ETH) period to accommodate grade level lunches.

Data Collection

Throughout the action research study, data was collected in qualitative and quantitative measures for six weeks in the fall of 2018. In action research, Merriam and Tisdell (2016) suggested that data in multiple forms are collected and analyzed systematically as the research is conducted. The data consisted of qualitative and quantitative measures that were polyangulated in order to establish validity, trustworthiness, and accuracy of the information (Mertler, 2017).

Qualitative Data

According to Merriam (1988), qualitative research is concerned with the process rather than the outcome of the research, with a focus on how people make sense of their experiences. Qualitative research is naturalistic research, focused on observing, interviewing, and describing the process (1988). Due to the inductive and reflective nature of action research, qualitative data collection methods support the study. The most appropriate data collection methods for qualitative research were utilized in this study. During the collection of the data, there was no manipulation of the students' behaviors, rather a documentation of their behaviors about the pedagogical shift and the incorporation of the BSCS 5E Instructional Model. Merriam and Tisdell (2016) suggested the participants in an action research study should be viewed as co-investigators and involved in the data collection process. The teacher-researcher was transparent with the student-participants involving the data being collected and the reasons for the collection. The student-participants were not aware that lessons were designed using a specific model. Rather, they were told I was trying to determine their

opinions of different types of lessons. The methods utilized for qualitative data collection are as follows.

Student Observations/Field Notes

During lessons, the teacher-researcher wrote field notes concerning what she saw and heard during class periods. According to Mertler (2017), semi-structured observations are free-flowing and allow the teacher-researcher to shift from one event to another. The flexibility in this manner of observation was supportive of the challenges the researcher faced in her dual role as a simultaneous teacher and observer. The observations were categorized into different areas of focus such as individual students, whole-class, and small-group observations. The students were observed during times of teacher-centered instruction and student-centered instruction for a basis of comparison of the two pedagogical models. The observations were recorded on researcher-created field note forms found in Appendix B.

Informal Student Interviews

Used as a method of clarifying and reflecting on observations with the student-participants in the study, information student interviews were spontaneous and were often conducted during student-centered learning time. The information gathered from these interviews enabled me to adjust the lesson when needed. The information interviews were beneficial in recognizing the student-participants' struggles with student-centered learning when they were not sure what to do.

Semi-Structured Interviews

Merriam and Tisdell (2016) described interviews as an important tool when researchers cannot observe behavior or when the researcher is interested in past events

that cannot be replicated. I chose to interview four colleagues in a semi-structured interview format. In the semi-structured interviews, I asked a base, "Grand Tour" question such as "How would you describe student-centered learning?" to guide my interviewees in a particular direction, but also to leave the interview open for them to discuss their personal insights (Mertler, 2017).

The three teacher-participants who I interviewed included a sixth-grade science teacher, a seventh-grade science teacher, and an eighth-grade science teacher. I gathered information regarding their experiences with the new curricular materials, their perceptions of student-centered, inquiry-based learning, and the BSCS 5E Model. I also interviewed an instructional coach on the administrative team. She was chosen because she provided information from an administrative point of view regarding curriculum, inquiry, and her perceptions of student-centered instruction. The interviews were digitally recorded for accuracy and transcribed within 48 hours of collection.

Researcher Journal

The teacher-researcher kept a reflective journal during the data collection process. The teacher-researcher reflected on her feels and insights on the pedagogical shift from teacher-centered to student-centered, classroom observations, and anecdotal conversations with staff and students.

Lesson Exit Tickets

At the end of a class, students completed short, formative "exit tickets." The teacher-researcher provided the ticket in either digital or paper format. The tickets consisted of a short survey concerning the content and instructional strategy used in the lesson. According to Marzano (2012), there are four kinds of exit ticket prompts:

1. Prompts that provide formative assessment data
2. Prompts that stimulate self-analysis
3. Prompts that focus on instructional strategies
4. Prompts that are open communication to the teacher

The teacher-researcher designed the exit tickets with a prompt from each category as a way of providing students an opportunity to reflect on the lesson, the strategies used, and on their class experiences and opinions. Student-participants completed the exit tickets at the end of classes as a method of student reflection and insight on the lessons designed for specific phases of the 5E Model.

Quantitative Data

Quantitative (numerical) data can be collected and incorporated into a qualitative action research study. The methods of quantitative data collection in this study were the Attitudes toward Science in School Assessment (ATSSA) (Germann, 1988) and Pre/Post tests on the *Organization of Life* unit content information.

Attitudes toward Science in School Assessment (ATSSA)

The Attitudes toward Science in School Assessment (ATSSA) (Germann, 1988) consisted of fourteen, five-point Likert scale questions addressing student opinions of school science (Appendix C) designed for middle school students. The reliability of the ATSSA is a Cronbach alpha if .851 ad .822, the validity is cited as a variance range of 59.2-69.8 (1988). The ATSSA was given to students on the second day of school as a pre-test and again at the end of the *Organization of Living Things* unit. The student-participants were told to reflect on previous years of science classes to answer the pre-test.

Organization of Living Things Unit Test

The unit test for the *Organization of Living Things* unit was designed cooperatively with the other seventh-grade science teachers at LMS. The test consisted of thirty multiple choice questions targeted to the South Carolina Science Standards and performance indicators developed by the South Carolina Department of Education (2014). The test was designed as a summative assessment to measure student proficiency of the science standards. It was given to students at the beginning of the unit as a pre-test and again at the end of the unit as a post-test.

Action Plan

The action plan developed from this research study is a professional development plan for teachers at LMS regarding using the *Interactive Science* (Buckley et al., 2017) materials as intended with the BSCS 5E Model and student-centered inquiry instruction. The professional development sessions will share data collected from this study and reflect on the implications to the science classrooms at LMS. The plan includes instructional strategies and management suggestions for incorporating the 5E Model as the school transitions to a STEM curriculum. A future study will be developed from the professional development session.

Potential Weaknesses

Due to the nature of the research, there are potential weaknesses in this action research plan. The development of a potential bias of the teacher-researcher is the first such weakness because of the teacher's personal involvement in the study. Student-participants' responses also provide a potential weakness if student-participants provide answers they think are favorable to themselves and the course. In order to address this

possible weakness, the teacher-researcher developed a level of trustworthiness with her students. Mertler (2017) suggested that "engaging in persistent and prolonged participation at the study site (p. 142). The teacher-researcher worked at the school for six years. The students in the seventh-grader were familiar with the teacher-researcher through previous interactions at the school during their sixth-grade year. During the first two weeks of school, the teacher-researcher devoted class time to "get to know you" activities with the student-participants and developed relationships and routes prior to the start of the *Organization of Living Things* unit.

The teacher-researcher's time employed at LMS enabled her to develop trusting relationships with the administration and other teachers at the school. The teacher-research is a member of the school' STEM Committee and the Technology Team. Through these roles, the teacher-researcher worked with administration and other teachers to develop methods to incorporate more Science, Technology, Engineering, and Mathematics in the classroom. In 2018, the school began a transition to a STEM curriculum, starting with members of the STEM team. The teacher-researcher was required to apply to the school district for approval to conduct this action research study. The application needed to be approved by the school's principal and the Director of Curriculum and Instruction at the district office.

Summary and Conclusion

Dewey (1938) summarizes the difficulty in changing practices, as "the conduct of schools is so much more difficult than is the management of schools, which walk in

beaten paths" (p. 5). Educators are so ingrained into their instructional practices that it is difficult to determine where the need or problem may be found in the area of interest.

The perceptions of Dewey, almost one hundred years ago, were the catalyst for this action research study. I have been in the classroom for twenty years, in that time I have worked to develop my instructional practice, such as holding a National Board Certification in Early Adolescence Science since 2007 and continuing to attend professional development opportunities to strengthen my instructional practice. In the spring of 2017, the middle-level science teachers in the school district were asked to examine three different science textbooks and curricular materials. The district teachers voted on the materials for adoption. The *Interactive Science* (Buckley et al., 2017) materials were adopted district-wide, not on a school-by-school basis. In August of 2017, the district middle-level teachers attended a training session on the curricular materials. At this training session, I realized that I was not familiar with the BSCS 5E Model used in the development of the curriculum and there would need to be a shift in my instructional practices to utilize the materials correctly. In examining my teaching practices, I was able to identify problems of my own practice.

My action-based research focused solely on the instructional practices in my classroom and their impact on my students. My teaching practices were without an emphasis on student-centered, inquiry-based instruction and fall within the status quo of public education in the United States (Cetin-Dindar, 2016)

CHAPTER FOUR

FINDINGS AND INTERPRETATIONS

The purpose of Chapter Four is to describe the findings and implications of this action research student that involved the implementation of a science curriculum unit developed using the Biological Science Curriculum Studies (BSCS) 5E Instructional Model on a seventh-grade middle-level science class at Lakeview Middle School (LMS). The findings include:

1. **Student Engagement During the Unit**

   Student engagement refers to the students' involvement in a school setting and in activities to promote learning (Fredricks, Holfkens, Wang, Mortenson, & Scott, 2018). Researchers indicate that students who are engaged and interested in science and mathematics are more likely to pursue more challenging science classes and pursue careers in STEM (Blankenburg, Hoffler, & Parchmann, 2016; Desy, Peterson, Brockman, 2011; Fredricks et al., 2018). During the engagement, exploration, elaboration, and evaluation phases of the model, students were seen recording observations and predictions, explaining scientific phenomena, discussing possible activity outcomes, and connecting observations to previously learned material. The explanation phase is more teacher-centered than the other phases of the model, but the student-participants were observed engaging in the lesson through the discussion of topics, recording notes and vocabulary, and listening to other

students explanations and observations. During the microscope activity in the Exploration phase, student-participants made predictions, shared insights, and recorded and illustrated their observations about cells and structures they were viewing. I recorded this in my student observation field notes form (Appendix A).

2. Students' Behaviors During the Unit

I define positive student behaviors as those that contribute to a student's academic success, such as active participation with partners or groups during a lesson, discussing content, hypothesizing outcomes, progressing toward completion of assignments, and participating in class discussions. I define negative behaviors as actions that disrupt the learning process of others, such as laying hands on other students, being out of area during class, insulting or harassing other students, and improper use of lab materials. The behaviors that are neither positive nor negative, or "null" behaviors, are defined as ones that neither help nor hinder the success of others, such as not participating in discussions or taking down notes and work.

In several student-centered lessons during the unit, an average of 19 seventh-grade student-participants per class displayed positive behaviors including, working collaboratively, solving problems in an organized manner, and remaining focused on the task presented to them. An average of six students per class displayed negative behaviors such as refusing to work with a partner or a group, being off-task, talking and interrupting whole-class discussions and reflections.

3. Student Attitudes about Science Before and After the Unit

The overall student attitude toward science changed after the implementation of the unit using the 5E Model. The post-test results on the Attitudes toward School Science Assessment (ATSSA) (Germann, 1988) indicated an increase in positive attitudes and a decrease in negative attitudes toward science class. Informal interviews with 15 students reveals that these middle-level seventh-grade students "enjoyed" my science class "more" than previous science classes. I interpreted these feelings as positive attitudes based on student-participant comments such as "I love your class" and "this class is so much better than science class last year."

4. Teacher Pedagogical Shift During the Unit

During the instructional unit, I shifted my pedagogy to a student-centered and inquiry-based model following the BSCS 5E Instructional Model (Bybee, 2015). I was hesitant to undertake the shift because the culture at my school follows a more traditional lecture format. However, the research supports the positive effects that inquiry-based instruction has on students' interest and achievement in science education (Blankenburg, Hoffler, & Parchmann, 2016; Desy, Peterson, & Brockman, 2011; Fredricks et al. 2018; Marshall & Alston, 2014). "Considerable time is needed to transform practice from a classroom focused on inquiry-based instruction versus one where teacher transmissions of knowledge predominates" (Marshall & Alston, 2014, p. 810). The transformation of my practice is discussed in this chapter.

These four findings and the implications for the findings are discussed in Chapter Four and used to form the Action Plan for Chapter Five of this Dissertation in Practice.

Problem of Practice

The problem of practice addressed in the present study is based on designing and implementing an inquiry-based, middle-level (seventh-grade) science curriculum that aligns with the 2014 South Carolina State Science Standards (SCSS) (SC DOE, 2014) and engages student-participants with science course content developed using a social constructivist and progressivist pedagogy. In other words, my Deweyan pedagogy was "active" rather than "passive," like it typically is in my traditional, lecture-formatted classroom. In 2017, curricular materials were purchased by the Winter Haven District (a pseudonym) to enable science teachers to develop curriculum and pedagogy that was relational to students' cognitive, affective, and psychosocial domains. However, we were not provided with enough supporting professional development opportunities to properly design and implement such a curriculum.

The curricula materials purchased by the district are designed to support the BSCS 5E Instructional Model (Bybee, 2015), an inquiry-based model consisting of five phases: Engagement, Exploration, Explanation, Elaboration, and Evaluation (2015). When the *Interactive Science* (Buckley et al., 2017) textbooks were adopted, the BSCS 5E Model was implemented in LMS. In order to implement BSCS 5E, there needed to be a paradigm shift in the Science Department from a teacher-centered to a student-centered learning pedagogy. In recognizing my lack of experience with an inquiry-based mode, I developed this action research study driven by the following research question:

How do middle-level students, accustomed to a traditional teacher-centered curriculum, perceive an inquiry-based, student-centered classroom based on the Biological Science Curriculum Studies (BSCS) 5E Instructional Model?

The study also addressed the following sub-questions:

1. Regardless of how they perceive the student-centered curriculum, how do they negotiate the class?
2. What are some of the problems involved in facilitating teacher planning of the 5E Model science curriculum?

I designed the present action research study to examine my seventh-grade students' perceptions of a BSCS 5E Model unit of study.

Data Collection Strategy

In order to gain a comprehensive representation of student-participant perceptions on the BSCS 5E Model, data was collected from 100 seventh-grade students at LMS in the form of content pre- and post-tests, student attitude surveys, student observations, field notes, exit tickets, and information student-participant interviews. I collected and analyzed the qualitative data using the constant comparative. Using a chart of identifiable student behaviors in the different phases of the BSCS 5E Model (Appendix D), data was color-coded to represent behaviors representative of each phase (Bybee, 2015). The data was coded according to traits representing the changes in student behaviors, attitudes, and student engagement in the classroom. Through a series of notations and categorizations, the data was polyangulated with the results of the content tests and the attitude surveys to support the umbrella themes of "changes in student

behavior" and "changes in teacher behavior." Through discussion and reflection on the data with colleagues and academic professionals, the following four sub-themes emerged:

1. Student Engagement During the Unit
2. Student Behavior During the Unit
3. Student Attitudes About Science Before and After the Unit
4. Teacher Pedagogical Shift During the Unit

Purpose Statement

The primary purpose of the present study was to describe the implementation of a unit based on the BSCS 5E Model with a seventh-grade science class at Lakeview Middle School. The secondary purpose was to describe my transition, as a middle-level science teacher-researcher in South Carolina to an inquiry-based, progressivist, student-centered pedagogical model.

The tertiary purpose was to develop an Action Plan for professional development to share the findings of the present study with the other teachers at LMS. Due to the reciprocal nature of action research through professional development, I was able to design a professional development plan to work with other middle school science teachers in developing units that are progressivist and constructivist, using the *Interactive Scien*ce (2017) materials and the BSCS 5E Model.

The data was collected for six weeks in the fall of 2018 at LMS in the teacher-researchers seventh-grade general science class.

The BSCS 5E Instructional Model

The BSCS 5E Instructional Model has a specific sequence of phases. Each of the five phases in the model is characterized by the specific functions and behaviors of the

teachers and the students (Bybee, 2015). The data collection strategies were designed to document student engagement, behaviors, and attitudes as they we taught with lessons based on the BSCS 5E Instructional Model.

The Organization of Living Things Unit

The *Organization of Living Things U*nit was developed by the teacher-researcher to address the required science standards for seventh grade science. The instructional unit is comprised of six weeks of lesson plans based on the BSCS 5E Model. The topics covered in the instructional unit are cells, cellular processes and organization, cell division, and microscopes. The lessons include inquiry-labs, group projects, station labs, notes, web quests, task cards, and summative assessments.

Attitude Survey

Rating scales are effective methods of measuring students' attitudes and perceptions (Mertler, 2017). A Likert-type student attitude scale was used to gather data regarding students' attitudes and perceptions of middle school science before and after the implementation of the instructional unit. The *Attitude toward Science in School Assessment* (ATSSA) (Germann, 1988) consisted of 14, five-point Likert scale questions addressing the 100 student-participants' opinions of middle-school science (Appendix C). The ATSSA was designed for middle school students. The reliability of the ATSSA is a Cronbach alpha of .851 ad .822, the validity is cited as a variance range of 59.2-69.8 (1988). The ATSSA was given to students on the second day of school as a pre-test and then again at the end of the *Organization of Living Things* unit. The student-participants were told to reflect on previous years of science classes to answer the pre-test and reflect on the past six weeks for the post-test.

Lesson Exit Tickets

At the end of several lessons, students completed a lesson exit ticket. An exit ticket is a short, formative assessment used to gather information regarding students' impressions and reflections of student learning (Marzano, 2012). The exit tickets were designed to gather data on student opinions and perceptions regarding the specific phase that was the focus of lesson of the day.

Informal Interviews/Discussions

Reflective and informative data was gathered through informal interviews with students. Informal interviews are more spontaneous and are conducted throughout the data collection period (Mertler, 2017). During class, I asked students generalized questions about the lessons and activities in class. Because I arranged the class in groups, small group discussions were possible at tables to gather student insight and information. The use of informal interviews was a previously established method in my classroom for determining student engagement and understanding of the content material. In order to formalize the data, I transcribed student responses to my questions. I used the responses from the small groups to develop specific questions to address the strategies. These questions were directed at students during informal interviews after class.

Student Observations/Field Notes

I monitored student behaviors during the different stages of the BSCS 5E Model. In order to gather information regarding student behaviors, I made a checklist and took field notes to monitor the attributes of each phase of the model's implementation (Appendix E). This checklist is designed for use with only a few students in each class

period. The field notes were taken when observations were made on groups during student-centered instruction.

Researcher Journal

During the data collection period, I recorded and reflected on observations and experiences in a teacher-researcher journal. The journal provided me with a narrative account of my instructional practice (Mertler, 2017). This journal was comprised of daily written observations on the lessons, students, and reflections of my teaching practice. The purpose of this study focused on transition from a teacher-centered pedagogy to a student-centered pedagogy. During this transition, I recorded the challenges faced and student reactions to the changes. In order to determine if there was an actual pedagogical shift from teacher-centered to student-centered instruction, I monitored the amount of time spent on teacher-centered learning and student-centered learning in the journal.

Colleague Semi-Structured Interviews

I interviewed four colleagues in a semi-structured interview format. I started with a "grand tour" question; "How would you describe student-centered learning?" to guide my interviewees in a particular direction but also to leave the interview open for them to discuss their personal insights (Mertler, 2017). The teacher-participants included a sixth-grade science teacher, a seventh-grade science teacher, and an eighth-grade science teacher. I gathered information regarding their experiences with the new curricular materials, their perceptions of inquiry-based learning, and student-centered instruction. The teacher-participants provided insight into their knowledge of the BSCS 5E Model as well their opinions on incorporating inquiry-based learning into their classrooms. I also interviewed an instructional coach on the administrative team. She was chosen because

she provided information from an administration point of view regarding curriculum, inquiry, and her perceptions of "student-centered" instruction. As part of her position, the administrative-participant observes various teachers in their classrooms and provides instructional coaching on a weekly basis. The interviews were digitally recorded for accuracy and transcribed immediately within 48 hours of collection. After the interviews, I reflected with the participants about their responses, my classroom observations, as well as common themes I connected through their responses. The teacher-participants shared a frustration of the lack of professional development in inquiry-based instruction and curriculum materials. They also shared the common obstacles to inquiry-based instruction implementation of time, money, and student behaviors (Walan et al., 2016). The data provided through the teacher-participant interviews determined the focus of the Action Plan outlined in Chapter Five.

Ongoing: Analysis and Reflection of Student Data

The data collected for this Action Research Study consisted of pre- and post-tests on content, attitude, and inquiry processing skills. Data was collected through whole class and small group observations, exit tickets, a teacher-researcher reflective journal, and field notes based on monitoring students during the BSCS 5E Model lesson implementation. Using the constant-comparative method, data was collected and immediately reflected on by the teacher-researcher and with the student-participants. Through informal discussions and interviews, I reflected with the student-participants and adjusted the direction of the study. The ongoing analysis of the data is described below.

Pre-Tests

The initial data collection consisted of all students taking pre-tests to provide baseline data on content knowledge and attitudes towards science. The pre-tests were the *Attitude toward Science in School Assessment* (ATSSA) (Germann, 1988) consisting of 14, five-point Likert scale questions addressing student-participants' opinions of school science and the second pre-test was the content-based unit test developed by the seventh grade science teachers at LMS (Appendix C).

Attitude toward Science in School Assessment Pre-Test

One hundred and nine students took the ATSSA on the second day of school. I analyzed the data from one hundred students. Nine students were not included in the Action Research study as five students did not have parental consent, two students had incomplete information, and two students moved during the data collection. All students enrolled were given the pre-test to avoid any student-participants feeling excluded from my classroom activities. Some of my student-participants did not answer all questions on the survey, accounting for uneven numbers in some of the data.

Initial analysis of the ATSSA data revealed a surprising number of students who had positive attitudes towards science in school. This survey was conducted on the second day of school to avoid my influence as the teacher-researcher. Student-participants were asked to base their responses on science experiences prior to the start of the school year. Students were also asked to reflect back on their science classes from the previous school year before they responded to the questions.

The ATSSA (1988) had ten questions focused on positive attitudes regarding science class such as "Science is fun" and "Science is interesting, and I enjoy it." There

were four questions reflecting a negative attitude of science class such as "Science is Boring" and "I do not like science and it bothers me to have to study it". The student choices for all of the questions are "Strongly Agree, Agree, Neither Agree or Disagree, Disagree, and Strongly Disagree." In an ATSSA survey, the "Neither Agree or Disagree" choice collectively held a large number of responses. Of the 14 questions, 31% of the responses fell into the neutral category.

As seen in Table 5.2, approximately 47% of the students had a positive attitude towards science, 31% had a neutral viewpoint, and 22% of the students had a negative attitude towards science class. Based on my previous research (NRC, 2012; Kim, 2016), I anticipated the negative attitudes towards science to be at a higher percentage. When discussing the results of the survey with the students, several students indicated that they like science as a subject, but they did not like science during their previously school year. This prompted further informal interview discussions in which students indicated they did not do any labs, they took many notes, and were bored in the classroom. The descriptions of the student-participants' previous science classes support a classroom with a lack of an inquiry-based instructional model. When reflecting with the student-participants on the results of the pre-test, I questioned why many students who indicated they had positive feelings towards science had more negative responses to Question 11 ("Science is a topic which I enjoy studying"). The student-participants indicated they do not like studying any subject and focused their rating on the word studying rather than on the topic of science.

Table 4.1

Pre-Test Positive Questions Responses
n=100

Question Number	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
One	12	47	23	4	14
Three	12	39	35	7	7
Four	15	42	21	16	6
Five	10	18	29	22	21
Six	13	42	25	6	8
Eight	15	42	24	9	10
Nine	6	40	31	12	11
Eleven	4	30	30	20	16
Twelve	4	35	31	19	11
Thirteen	6	38	30	16	10

Table 4.2
Pre-Test Negative Question Responses
n=100

Question Number	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Two	11	14	25	36	14
Seven	8	9	21	40	22
Ten	9	8	27	39	17
Fourteen	11	18	24	33	14

Organization of Life Unit Pre-Test

I developed a thirty-question pre/post-test based on the 2014 South Carolina Science Academic Standards (SC DOE, 2014) as a summative content assessment. I administered the pre-test to the students prior to the *Organization of Life Unit*. The test addressed science process skills and scientific content of cells, cellular organization, and microscopes. Of the 100 student-participants who took the content pre-test, ninety-three

students scored a 59% or below, indicating a failing grade. Seven student-participants scored a 60% or higher on their pre-test, resulting in a 7% pass rate.

Table 4.3
Content Knowledge Pre-Test

	Below Passing	Passing
Percentages	93%	7%

Exit Tickets

I designed the exit tickets to provide students an opportunity to express their opinions on the day's lesson. Exit tickets consisted of five to eight short answer or multiple-choice questions. One challenge with the exit tickets was the lack of students completing it. Students were told to complete the computer-based form at the end of the class period. The highest return rate on the exit tickets was 61% of the 100 students in the study. Although this did not provide data from all students, the information gave insight into their opinions on the class. The exit tickets used for data collection were selected because they represent different instructional methods. The exit tickets provided student-participant information on teacher-centered notes-based lessons, student-guided notes, whole-class interactive game review, station labs, small group inquiry labs, and exhibition station/task cards. An example of an exit ticket can be found in Appendix F.

Student Observations

Field notes were taken in two of the teacher-researcher's science classes that were held in the middle of the instructional day. I recorded detailed observations on whole class behaviors, student groups, and two individual students from each class. I collected the student observations and compiled them nightly to code for data and identify emerging themes.

Informal Student Interviews

Informal student-participant interviews developed because of reflection with the students on the results of the pre-tests and on teacher-researcher observations. I recorded student-participant comments on field notes and in the teacher-researcher journal. The informal student-participant interviews served as the primary method of reflecting on the data with the students. The student-participants' reflections are incorporated into the interpretation and analysis of each data set.

Initial Data Collection Challenges

Due to my role as a teacher-researcher, some challenges were faced in the data collection process. All of the students enrolled in my seventh-grade general science course received the *Organization of Living Things* unit. Due to the restrictions of time and class size, I was unable to take detailed observations on all of my classes. I chose to collect observations and field notes on two classes. I noticed that, when I grabbed my clipboard, some students focused on what I was doing rather than on what they should have been doing. In the process of recording students' participation in the 5Es and following a constructivist approach to education, some students did not produce work or exhibit the 5Es. These observations resulted in a concern of students not learning the material. My concerns are to be expected in a shift from teacher-centered instruction to a student-centered classroom.

Reflective Stance

Action research is reflective in nature. The process begins with a reflection of a current practice or problem and continuous reflection propels the process forward

(Mertler, 2017). Throughout the data collection, minor changes were involved in order to address questions and complications that were observed. For example, in order to answer the research question, I needed a pedagogical shift in my teaching practices from a teacher-centered classroom to a more student-centered classroom. This shift required not only educating myself on the BSCS 5E Instructional Model in our new texts, but also implementing the model into classes that had no experience in this instructional practice. Due to this new pedagogical practice, I decided to reflect on my own teaching practices by monitoring the time spent in each class on teacher-centered instruction and student-centered activities. I used the data collected to self-monitor my own teaching practices during the study. An example of this data collection sheet is found in Appendix G

I am a member of a professional learning community (PLC). My PLC meets several times a week to share best practices, develop lessons, design formative and summative assessments, and reflect on the successes and areas of improvement for our classes. The other member of my PLC has instructional experience using the BSCS 5E Model. Throughout the collection of data, we discussed and reflected on the behaviors, attitudes, and engagement of the student-participants. The ability to reflect with an experienced professional enabled me to adjust the unit of study when additional scaffolding and management techniques were needed.

Because of my role as a teacher-researcher, it is difficult at times to take notes on student observations while supporting and instructing the class. This has resulted in a form of bulleted, shorthand notes. The students have become accustomed to my note taking during class, evidenced on Friday September 21st, when a student asked me if I was "taking down notes on the lesson for your degree." I feel I established a base of trust

with many of my students. This aided my data collection of discussions since students were open to talking with me about what was on their minds. This observation brings about the question of "what would the data show if the collection was started later on in the school year, after the student-participants have established a stronger relationship with the teacher-researcher?"

Analysis of Student-Participant Data

Data collection began in the first week of September. However, collection was disrupted for one week due to class cancellations for Hurricane Florence, one day for Hurricane Michael, and four days for school-mandated activities. Throughout the data collection process, I utilized the constant comparative method as a means of inductively analyzing my qualitative data. Constant comparative data is characterized by comparing one data sample with another in order to determine similarities and differences (Merriam & Tisdell, 2016). The constant comparative method was supportive of the data collected due to the various methods of data collection utilized in this study. Constant comparative data collection is a way to identify emerging themes in the data before the data is analyzed at the end of the collection period. Merriam and Tisdell (2016) posited "The data in qualitative action research studies is going to focus not only on what happens but also how it happens over the course of the ongoing action research cycle of plan, act, observe, reflect" (pg. 235).

Data Collection Challenges

The initial data collection plan proved to be over-ambitious for someone in a teacher-researcher role. Due to the time needed to record student-participant

observations and discussions, I adjusted and combined the data recording charts to streamline the process and reduce time repeating observations on the various forms. I made the decision to record observations on two forms rather than several.

An early challenge presented itself at the beginning of the data collection. When I walked around with a clipboard recording my observations, the students stopped what they were doing to watch me. The presence of the teacher-researcher collecting data can change the behaviors of the students (Mertler, 2017). The students questioned if they were getting into trouble and if I was writing their names down, mistaking my notes as a behavior management plan. In order to address this concern, I explained to the student that the notes were mine to see how the lesson was going not to get them in trouble.

I held a pre-conceived notion going into this action research study that the students would thrive in a student-centered environment and direct their own learning. I was surprised with the number of students who did not know how to direct their own learning and needed continuous scaffolding and support throughout the lesson. The students would become frustrated with me when I would not tell them what to do or give them the answers they were looking for. This was more evident at the beginning of the data collection process and improved as the students became more comfortable in the structure of the classroom. My initial plan was to hold completely student-centered instruction, but the plan was adjusted when the need for more teacher modeling and scaffolding was established. Action research is about improving the lives of the student-participants (Mertler, 2017). The implementation of the unit was adjusted to meet the needs of students who were demonstrating negative behaviors towards learning (heads on

desks, not participating, just giving up, etc.). The shift included more teacher-centered instructional time for students who needed additional teacher modeling and scaffolding.

Attitude toward Science in School Assessment (ATSSA)

I gave the ATSSA to the student-participants on the second day of school and again nine weeks later, at the end of the *Organization of Living Things* unit. This data set had a longer collection period than the rest of the study due to the teacher-researcher wanting to get a baseline of student-participant attitudes before building relationships with them. This data set was collected before any science content was taught. The results of the ATSSA pre-test indicated a higher than anticipated number of student-participants who indicated they had positive attitudes towards science, with 47% of the respondents indicating they had a positive attitude towards science, 31% with a neutral response, and 22% with a negative attitude.

The teacher-researcher discussed the results of the survey with the students-participants. During whole class discussions, the student-participants reflected with the teacher-researcher on their responses. When asked about the high number of neutral responses to many questions, some student-participants indicated they were not clear on what the question was asking. Student-participants indicated they were answering based on their experiences from the previous school year. Student-participants reflected that they felt science was “boring” and they “only took notes.” One interesting point some students made was that they had a long-term substitute during the previous year and they preferred the substitute to their assigned classroom teacher. The teacher-researcher asked the students “what would help you enjoy science more this year?” Student-participant responses were broad with negative feelings such as “nothing” or “it doesn’t matter I hate

science" to more hopeful and positive answers such as "it is already better" or "more labs and experiments," indicating students are interested in participating in inquiry-based science.

The post-test was given to student-participants the day they took their *Organization of Living Things* unit test. The results of the post-test indicated an increase in the percentage of students who responded, with 63% of the students choosing "strongly agree" and "agree" to the positive attitudes towards science questions. This indicates a 16% increase in positive attitudes towards science. The post-test resulted in a decrease in the percentage of student participants who responded with "strongly agree" and "agree" to the negative attitude towards science questions. The pre-test results indicated an average of 22% of the student-participants "strongly agreed" or "agreed" to negative attitude questions about science. The post-test results indicated and average of 16% of the students "strongly agreed" or "agreed" to negative science attitude questions, resulting in a decrease of 6% between the pre and post-tests.

Table 4.4
Post-Test Positive Question Survey Results
n=100

Question Number	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
One	24	54	13	7	2
Three	14	60	9	15	2
Four	21	46	13	13	7
Five	11	32	27	16	14
Six	21	45	18	13	3
Eight	28	42	13	10	7
Nine	18	49	18	9	6
Eleven	11	32	23	22	12
Twelve	11	52	19	11	7
Thirteen	17	46	20	13	5

Table 4.5
Post Test Negative Question Responses
n=100

Question Number	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
Two	6	13	19	27	35
Seven	2	14	14	38	32
Ten	5	11	12	47	25
Fourteen	7	6	22	33	32

Science Unit Pre- and Post-Tests

The *Organization of Living Things* unit test is the pre- and post-test for the instructional unit. I developed the test to measure mastery of the South Carolina Science Standards (SC DOE, 2014) assigned to the first instructional unit of the school year. The student-participants received the same test as the pre- and post-content exam. Of the 100 student-participants who took the content pre-test, 94 students scored a 59% or below, indicating a failing grade, seven student-participants scored a 60% or higher on their pre-test resulting in a 7% pass rate. The post-test results indicated a gain in the scores. Of the 100 student-participants who took the post-test, 75% of the students passed with a score of 60% or higher and 25% of the student-participants failed the unit test with a score of 59% or below. The average total score on the pre-test was 38% and the post-test score was 68%.

Table 4.6
Content Test Pre and Post Test Scores

Pre-test Score-Mean	Post-test Score-Mean	Difference	SD
38.88	67.71	28.83	20.35

Student Exit Tickets

The student-participant exit tickets provided the teacher-researcher with student opinions and reflections on the different lesson formats. Unlike the content test and the attitude survey, the exit tickets did not produce a 100% student-participant return rate. The highest return rate came from a lesson designed for the Evaluation Phase, including a unit review using an online game site called Kahoot. This lesson had the highest percentage of students enjoying the lesson. The exit tickets provided student-participant information on teacher-centered notes-based lessons, student-guided notes, whole-class interactive game review, station labs, small group inquiry labs, and exhibition station/task cards. I analyzed the results of the exit tickets at the end of the day and used these results to direct the instructional strategies in future lessons.

One question incorporated into exit tickets was "Did you enjoy the lesson today?" Student-participant responded both positively and negatively to this question. The student-centered, inquiry-based lessons had more positive results from students than the teacher-centered notes-based lessons. For example, sample responses from an osmosis lab lessons designed to incorporate the BSCS 5E Model Elaboration phase were as following:

1. "No"
2. "Not really but it wasn't that bad"
3. Yaas, because it was very fun and interesting"
4. "Yes, because it was more fun than doing notes."

When asked the same question on a teacher-centered, notes taking lesson for the Explanation phase of the BSCS 5E Model, the results were less positive:

1. “No I don’t like doing work”
2. Sort of it was not interesting but I am not annoyed that I had to do it”
3. “Notes can be fun to take”
4. “I felt like the lesson was pretty effective and there isn’t really a need for improvement although it was kind of boring. There isn’t really a way you can get around that because we have to learn the information some way”

When reflecting with the students on their responses, the overall perception was that notes are boring but they are a part of every class at school. The students enjoyed the inquiry-based lessons but some students indicated they do not like working with groups of other students and were uncomfortable with the amount of noise from other students.

Student Observations

I created two forms to record observations of student comments and behaviors during the data collection period. The Field Notes Form was used to record small group behaviors in the class and the 5E Model Student Behaviors Form was used to monitor individual student behaviors that supported the BSCS 5E model phases. I collected daily data in two designated science classes. I felt some difficulty balancing the role of researcher and teacher when recording field notes due to having to present information to the student-participants as well as record the class. This dual role resulted in some observations not being recorded on the forms or possibly missing observable moments. In order to address this, observations were taken down with abbreviations on the form. The recorded information was coded for behaviors and emerging themes. Teacher-researcher perceptions were recorded in a reflective journal. I used the journal to

summarize whole class observations and the teacher-researcher's feelings on the lesson presentation.

Emergent Patterns and Themes

During the data collection process, two umbrella themes were identified as "Changes for Students" and "Changes for Teachers." Under the two umbrella themes, sub-themes were identified relating to changes for students during the unit; classroom behavior, student engagement, and student attitudes towards science. The fourth emergent theme, *teacher pedagogical shift during the unit* is discussed in the teacher-participant data collection section of this chapter.

Student Engagement during the Unit

The first emerging sub-theme of student "engagement" developed from lessons based on the Exploration, Elaboration, and Engagement phases of the BSCS 5E Model. According to student responses on lesson exit tickets and informal observations, the students enjoy these lessons. As expected, the lessons based on the Explanation phase of the BSCS 5E Model are not as enjoyable to the students. The exit tickets on the teacher-centered instruction lessons include comments such as "notes are boring but I know we have to do them," and "I am prepared for notes because we do them all the time in school."

Student Behavior during the Unit

The second emerging sub-theme of "student behavior during the unit" developed from student observations. Using field notes, the teacher-researcher documented if the student-participant was learning through peer interactions and socializing. The students

were observed discussing concepts and talking through the solutions of problems. When students did not agree on the answer, they were observed arguing their points and reasoning through the possible solutions. This is supportive of Vygotsky's (1978) social constructivism educational methodology. Vygotsky's (1978) constructivist method supports the belief cognitive functioning originates and develops through social interactions and vocalizations.

I observed that when the student-participants were not actively engaged in their learning, there were more negative student behaviors, such as excessive talking, playing around, and being off task. During whole class observations while conducting teacher-centered instruction, students were observed laying their heads on their desks, talking over instruction, throwing objects and doing work for other classes. As previously indicated, these behaviors were observed predominantly during the Explanation Phase of the 5E Model. During this phase, there was a focus on teacher-centered instruction as content topics and phenomena were explained (Bybee, 2014, 2015).

Student Attitudes toward Science before and After the Unit

A third emerging theme was the shift in student attitudes towards science. Exit tickets revealed that, after some lessons, one hundred percent of the students indicated that they enjoyed the lesson and indicated why they enjoyed the class. Through small group discussions, students mentioned "they do not like science but they like my science" or a negative comment actually becomes a more positive comment, such as "I hate science but you make me hate science less." During Exploration lessons, students were observed being focused on the information, calling me over to share their own observations and theories of the inquiry, as well as one student yelling out "Yes, I love

science." Although the ATSSA results indicated an improvement in attitudes towards school science, the informal discussions and reflections with students provided timely and honest feedback regarding the class.

Gaps in the Data Collection

Based on my research questions, the largest gap in my data was due to a lack of information from the student-participants' perceptions of the BSCS 5E Model. I gathered class observations, but the data was based on my interpretation of these observations. I needed to expand my data set with more student perception information. This gap was addressed through additional, informal discussions with students during and after class. This instantaneous feedback enabled me to reflect on the process and further expand on the student-participants' perceptions. In order to encourage a greater response on student-participant exit tickets, the students were reminded that the exit ticket was a classroom expectation and participation credit was given to the student-participants who submitted on time. Photos were taken during inquiry-based activities to document student engagement, participation, and emotional responses.

Coding

According to Mertler (2017), a coding scheme is used to group data that provides similar types of information. As described by Merriam and Tisdell (2016), during Action Research, researchers present themes at various stages of the Action Research study. Initially, themes are identified at the beginning of the study, but varying themes may present themselves as the research unfolds. This description is supported in the coding scheme utilized in the present action research study. I collected and coded data based on

the emerging themes throughout the Action Research process. The two umbrella themes identified were "Changes for Students" and "Changes for Teachers."

As patterns emerged in student-participant and teacher-researcher behaviors in the process, I then categorized the data for findings under these two themes. Axial coding (2016) was used to divide the different data themes into fewer, but more comprehensive, groups as the themes became more streamlined. The subthemes identified through similarities in the data were Student Engagement during the Unit, Student Behavior during the Unit, Student Attitudes about Science Before and After the Unit, and the Teacher Pedagogical Shift during the Unit. I notated the similar findings in the margins or directly in the text. This coded data was then divided under the four subcategories.

In order to address student perceptions of the 5E Instructional Model, data was coded for the five phases of the model. As I collected data, behaviors and evidence of the 5E model were color coded according to what phase of the model was being represented. For example, Engagement-Pink, Exploration-Green, Explanation-Yellow, Elaboration-Orange, and Evaluation-Purple. Student reactions, comment, and behaviors were highlighted blue in the field notes, exit tickets, and observations. I grouped this information with the other identified themes. I used a table based on the expected student behaviors Bybee (2015) indicates should take place during the phases of the BSCS 5E Model to identify the specific behaviors in the data sets (Appendix D).

Reflecting with the student-participants on the collected data provided support for the development of the themes. Students who indicated they liked to take notes and enjoyed the solitary process shifted these findings from a boredom category to an engaged category. Student-participants sharing their frustrations and misdirection during

class coded under Changes for Teachers because these findings supported a change in the instructional procedures of the teacher-researcher.

Student-Participant Data Interpretation

I polyangulated the data collected in the present action research study in order to answer the research question, *How do middle-level students, accustomed to a traditional teacher-centered curriculum, perceive an inquiry-based, student-centered science classroom based on the Biological Science Curriculum Studies (BSCS) 5E Instructional Model?* The data was also interpreted to answer the following sub-question *Regardless of how they perceive the student-centered curriculum, how do they negotiate the class?*

Quantitative Data

The Organization of Living Things test and the Student Attitudes toward Science pre- and post-tests are the sources of quantitative data for this Action Research study.

Organization of Living Things Unit Test

Several studies indicated an increase in student academic performance and motivation when they are taught using the BSCS 5E Instructional model (Dasdemir, 2016; Duran & Duran, 2004; Liu, 2009; Kim, 2016). I collected and disaggregated the pre- and post-test scores for 100 student-participants using a t-test. The results indicated an increase in student achievement, but it is not statistically significant. Although the t-test results may not be statistically significant, the student-participants' scores showed growth in content knowledge. The average increase in the student participant scores is a growth of 28%. When discussing the pre- and post-test scores with the student-participants, it was established the student-participants were unfamiliar with the amount

of reading and critical thinking skills incorporated into the unit test. In order to prepare the student-participants, formative assessments supporting this questioning style should be included in the curriculum. It is expected there will be an increase in student content knowledge based on exposure to the information presented during class. The results of the post-test are not considered successful to the teacher-researcher.

Table 4.7
T-Test Science Unit Test

	Pre-test	*Post-test*
Mean	38.88	67.71
Variance	283.6824242	383.6423232
Observations	100	100
Pearson Correlation	0.52420636	
Hypothesized Mean Difference	0	
df	99	
t Stat	-16.07992824	

Table 4.8
Pre and Post-test Content Scores
n=100

Pre-test score-mean	Post-test score-mean	Difference	SD.
38.88	67.71	28.83	20.35

Table 4.9
Pre and Post-test Correct Responses
n=100

Pre-test	Post-test	Difference	SD.
12	19	7	4.949

Attitudes toward Science Student Survey (ATSSA)

The ATSSA is a fourteen question, Likert-style survey measuring the student-participants' attitudes towards science. The responses to the questions were assigned a point value of Strongly Agree (5), Agree (4), Neither Agree or Disagree (4), Disagree (2), and Strongly Disagree (1). The average scores for each question on the pre-test and post-

test were compared to determine whether there was an increase or a decrease in the scores. The table below presents the average scores for each question. Prior research studies have indicated students' attitudes towards science will improve after exposure to the BSCS 5E Instructional Model (Bybee, 2014; Kim, 2016; Scott et al, 2014). The results from the present study show an increase of one point for seven of the positive attitude questions. Three of the questions had no change in the average score between the pre- and post-tests. There was a decrease in the average score for the questions measuring negative attitudes towards science. All four questions demonstrated a decrease of one point. These results are proportional to the positive question results.

Table 4.10
Attitudes toward Science Survey Results

Question	Pre-test	Post-test	Difference
One: Science is fun.	3	4	1
Two: I do not like science and it bothers me to have to study it.	3	2	-1
Three: During science class, I usually am interested.	3	4	1
Four: I would like to learn more about science	3	4	1
Five: If I knew I would never go to science class again, I would feel sad.	3	3	0
Six: Science is interesting to me and I enjoy it.	3	4	1
Seven: **S**cience makes me feel uncomfortable, restless, irritable, and impatient.	3	2	-1
Eight: Science is fascinating and fun.	3	4	1
Nine: The feeling I have towards science is a good feeling.	3	4	1
Ten: When I hear the word science, I have a feeling of dislike.	3	2	-1
Eleven: Science is a topic which I enjoy studying.	3	3	0

Twelve: I feel at ease with science and I like it very much.	3	3	0
Thirteen: I feel a definite positive reaction to science.	3	4	1
Fourteen: Science is boring.	3	2	-1

Qualitative Data

The qualitative data collected through observations, exit tickets, discussions, and informal interviews was analyzed using the constant comparative method. Mertler (2017) describes the constant comparative method as “a means of applying inductive analysis to multimedia sources within a given study” (p. 177).

When using data to gauge the student-participants’ perceptions on the BSCS 5E Instructional Model, the lesson exit tickets proved to be a valuable source of student-participants’ ideas and opinions on the lessons. As mentioned previously, exit tickets provide students with an opportunity to reflect on the lesson but also open up a dialogue with the students regarding their learning (Marzano, 2012). The student-participants were able to privately comment on the day’s lesson and make suggestions. Despite the complication of not all students submitting their exit tickets, the data collected supported the research claims that students enjoy student-centered, inquiry-based lessons (Kim, 2016). The figures below represent the students’ responses to two different lessons: one inquiry-based and one teacher-centered notes-taking lesson. The first figure representing the students’ answers to the question “Did you like today’s lesson?” is from the inquiry-based lesson. The second figure represents the students’ responses to the question “Did today’s lesson hold your interest?”

Figure 4.1 Responses to an Inquiry-Based Lesson Question

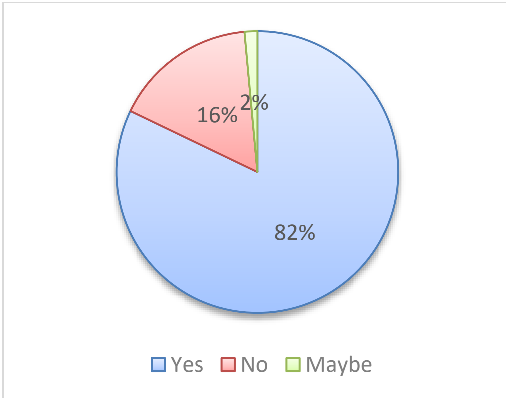
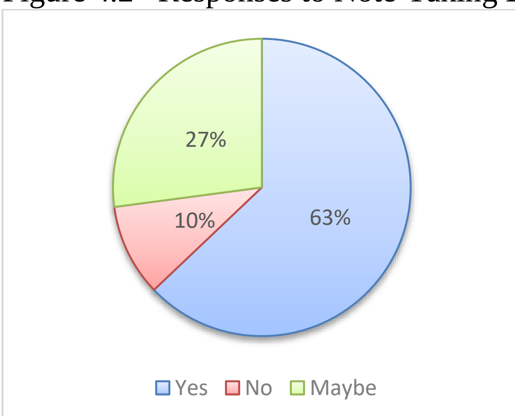


Figure 4.2 Responses to Note-Taking Lesson Question



Student Observations

"We learn best when we are actively engaged in the process of our own learning" (Buoncristiani & Buoncristiani, 2012 p. 5).

The above quote is supported by the teacher-researcher's observations of the student-participants working through the BSCS 5E Model lessons. Throughout the Action Research study, I observed the students when they were actively engaged in their own learning. I observed the student-participants discussing possible outcomes to different solutions, repeating a task until they reached a conclusion they were satisfied with, and making connections to the world outside the classroom. One particular student-

participant looked at images of plant cells, recognized the beauty in the image, and told me it would be a beautiful necklace. She then took the time to draw the image she observed and asked me where she could buy the slide with the plant cell.

The teacher-researcher observed an intense argument between two of the student-participants. When attempting to intervene, I realized they were arguing over what they felt was the correct answer to the problem they were presented with. This example of students becoming actively involved in their own learning supports Freire's (2014) position that the students were no longer passively receiving information from the teacher but were instead involving their emotions, insights, and personal feelings are with the process of learning.

The teacher-researcher did observe the student-participants' difficulties in directing their own learning. Often, the students were observed exhibiting null behaviors, sitting still, and not actively working or socializing in small groups. The behaviors did not disrupt the learning of others but prevented the student-participants from participating in their learning. Although these behaviors were not considered to be concerning enough to eliminate student-centered instruction, they were enough to address the lesson delivery. In the BSCS 5E Model, teachers should steer students in the right direction without giving them the answer, providing students with additional opportunities to build their understanding as they move through the five phases of the model (Chitman-Booker & Kopp, 2013). In order to steer students in the right direction, they need to be on the right path. To address the need for guidance, scaffolding of information needs to be incorporated into the BSCS 5E model. The process of scaffolding, building on information, is a necessary part of the model and constructivist teaching (Bates, 2016;

Bybee, 2014, 2015; Duran & Duran, 2004). Through small group discussions with students, I was able to reflect with them about where they were having problems in a lesson and what can be used to help clarify the information.

Answering the Research Questions

This Action Research study was guided by the following student-centered research question. *How do middle-level students, accustomed to a traditional teacher-centered curriculum, perceive an inquiry-based, student-centered science classroom based on the Biological Science Curriculum Studies (BSCS) 5E Instructional Model*? The teacher researcher sought to answer the following sub-question of *Regardless of how they perceive the student-centered curriculum, how do they negotiate the class?*

In order to answer the question, the teacher-researcher developed an instructional unit called the *Organization of Life* based on the BSCS 5E Instructional Model. The BSCS 5E Instructional Model has been identified as being an effective instructional model in increasing student science achievement and improving student attitudes towards science education (Bybee, 2014; Kim, 2016; Scogin, 2016).

I developed the instructional unit to teach the South Carolina Science Standards (SC DOE, 2014) required for seventh-grade science at LMS. I collected qualitative and quantitative data over six weeks in fall 2018. I polyangulated the data from pre- and post- tests, attitude scales, student observations, student discussions, exit tickets, and informal interviews to answer the research question.

The data revealed a majority the 100 seventh grade students had a favorable perception of the BSCS 5E Instructional Model. Student exit tickets provided students

with a voice to the students enjoyed the inquiry-based labs and felt they were engaged in class. The exit tickets supported student boredom with teacher-centered, note-taking lessons. The student participants accepted notes were needed but do not enjoy them as much as other lessons. Some students indicated they liked taking notes, working alone, and did not enjoy the noise in the classroom when student-centered learning was taking place.

During the action research study, the student-participants were unaware we were following a specific learning model. However, they were informed of the different lesson formats and instructional activities. The 5E Model extends to various learning styles (Bybee, 2011, 2015). Lessons focused on the Exploration and Elaboration phases are more student-centered and inquiry-based. The Explanation and Evaluation phases are more teacher driven with student participation and reflection (Bybee, 2011, 2015). Student observations and discussions revealed student-participants were happy to be "doing something different" or "notes are okay but this is better." An additional perception of the model is the 5E Instructional Model was new to the student-participants. As expressed to the teacher-researcher, the student-participants did not do things like this last year.

The observations of student-participants revealed the students are unfamiliar with an inquiry-based model and unsure of how to manage themselves in the class and direct their own learning. To answer the sub-questions, a majority of the students had difficulty negotiating the student-centered learning environment, even if they had a positive perception of science. Student-participants were at times frustrated with the 5E Model because they did not know what to do or how to focus their learning. Student-

participants were overheard expressing their frustrations “I don’t know what to do” or “How do you expect me to know how to do this?” Other times, student-participants were observed not participating on the assigned tasks and instead they were doodling, talking, or playing on their laptops. These observations were clarified by reflecting with students about how they were feeling and why they were not completing their assignments. Through informal discussions with the other seventh-grade science teacher, I was informed she was seeing similar behaviors with her students and had to include more teacher-centered instruction than our PLC had intended. Because scaffolding is an essential component of constructivism and the 5E Model (Bybee, 2011, 2014), the teacher incorporated more modeling and scaffolding into lessons to build student comfort and confidence.

The ATSSA results revealed an overall improvement in attitudes towards science. Walan, Mc Ewen, and Gericke (2016) identified that some of the strongest predictors in students’ attitudes towards science and inquiry are the attitudes and behaviors of their teachers. The positive attitude the teacher-researcher presented in the classroom created a pro-science atmosphere in the classroom. This positive atmosphere was reflected in conversations with students involving statements such as “I still don’t like science but I like your class” or “Mrs. Norwood, you need to go help Mr. X so his class is good like yours.” The data supported there were students who do not like science but they enjoyed the structure and instructional model used in the classroom. A student-participant mentioned to me “I don’t like science but I like labs,” reinforcing to me the student may not like the subject but liked structure. Through the continued use of the BSCS 5E

Model, the learning community at the LMS has the possibility to develop positive student-centered, inquiry and critical thinking skills.

The positive student perceptions of the BSCS 5E Model support a pedagogical shift in the instructional "laboratory of practice" to a student-centered, inquiry-based, constructivist classroom.

Ongoing Analysis and Reflection of Teacher-Participant Data

Colleague Semi-Structured Interviews

The first three weeks of the data collection process led to the incorporation of an additional source of data in the form of semi-structured interviews with colleagues and administration. Several insightful discussions with administrators and other science instructors at my school occurred when discussing the unit design and the purpose of the action research study. These conversations provided direction for the emerging theme "Teacher Pedagogical Shift during the Unit." When my educational coach walked through my room and stated, "This is good, I like this," I asked her to explain why she liked the lesson. The conversation led me to examine how other middle-level science teachers view a student-centered or an inquiry-based classroom, and what pedagogy they were following in their classes. Conversations with sixth, seventh, and eighth-grade teachers led to vastly different teaching methods and attitudes towards student-centered teaching, prompting additional research into teacher perspectives on using inquiry-based science. The teacher-participant data seeks to answer the research sub-question of "*What are some of the problems involved in facilitating teacher planning of the 5E Model science curriculum?"*

Analysis of Teacher-Participant Data

Colleague Semi-Structured Interviews

Four semi-structured interviews were conducted with three teacher-participants and one administrator-participant. The objectives of the interviews were to gain perspective on what professional educators perceived as student-centered learning and inquiry-based instruction. The teacher-participants consisted of one sixth-grade, one seventh-grade, and one eighth-grade teacher. The administrator-participant is an instructional coach and former English Language Arts teacher. Classroom experience for the participants range between twelve and thirty years. Pseudonyms are used in order to maintain anonymity of the participants. The interviews began with broad grand tour questions, which were then elaborated on for clarification and discussion throughout the interviews. The interviews were digitally recorded and transcribed upon completion. The interviews were analyzed according to the reoccurring themes of Student-centered Instruction, Inquiry-based Instruction, and Curricular Materials. I coded and divided the information into these themes for data interpretation.

Participant One: Susan (pseudonym)

At the time of the interview, Susan has taught science for a total of fifteen years made up of two years in the high school and thirteen in middle school. Susan currently teaches eighth-grade science and is a member of the school's STEM team.

Student-Centered Learning

All teacher and administrator-participants were asked to describe what student-centered learning means to them. Susan describes student-centered learning:

> Where the student takes, leadership and they come up with questions and they start kind of working on things themselves, and I'm just the facilitator. I'll go around maybe ask a little bit of questions to guide them and mostly get them on track. Mainly it is just them doing everything (Susan, personal communication, 2018).

Susan feels her classroom is a 50-50 split between teacher-centered and student-centered learning. She indicated she starts her units out more student-centered to gain interest and engagement but transitions to teacher-centered to make sure they are hitting all of the state standards. She feels limited by the state standards because she cannot branch off her instruction to address student interests.

Inquiry-Based Instruction

Susan felt the state-mandated standards are a hurdle to incorporating more inquiry-based learning into her classroom. When she does incorporate inquiry into her classroom, she uses a model she referred to as the 4C's. Susan has heard of the BSCS 5E Inquiry Model but was unaware it was featured in the new science textbooks. She used the model a few times, several years ago when she first became a teacher. Susan's students do not like inquiry-based instruction at first because they feel it is hard and they do not understand what she wants them to do. She uses scaffolding and directed questions to guide them back to where she feels they need to be. As supported with the

research (Kirschner et al., 2006), Susan feels money, time, and lack of training are the reasons why she sees many teachers not incorporating inquiry into their classrooms.

Curricular Materials

Susan indicated she voted for the newly adopted *Interactive Science* (Buckley et al., 2017) curricular materials because she felt the texts had more connections to the standards than the other choices she was presented with at the time of voting. Her PLC does not use the texts or supportive materials in the classroom. Susan uses the book as a resource to supplement her lessons but does not incorporate the materials into her daily lessons. She was unaware of the supplemental materials for ELL students and lab activities. Susan attributed not using the materials to the lack of training and information the department received when the books were adopted. “I do not even know half of what is available through our textbook to be honest with you” (Susan, personal communication, 2018).

Susan’s students were struggling with the online resources for the program and she was unaware on how to help them. When asked, “If you could change anything with the way our district structures our science curriculum what would you change,” Susan would offer teachers a deep dive into the book and more training on incorporating the materials.

Participant Two: Mary (pseudonym)

Mary has worked at the school for two years, but has taught in a variety of settings and grade levels since 1986. Mary is currently in her sixth concurrent year of teaching middle school science. She is a part of the school’s STEM team, working to incorporate more STEM into the school. Previously, Mary taught at a project-based

learning school in another state. She has more experience with student-centered curricula than other interview subjects. Mary and I are the seventh-grade science teachers. She has also incorporated the 5E Model with her students this semester to support this Action Research study and continuity in our PLC.

Student-Centered Learning

Mary's description of student-centered learning supported a Deweyian (1938) curriculum approach. Mary (personal communication, 2018) described student-centered learning as:

> Anything that is not teacher-centered learning. I hate to be so obvious but it's the kids engaged, it is the kids doing inquiry, it is the kids doing labs, its hands on and kids exploring science for themselves. It is not note taking or textbook reading. It is getting in there and actually doing hands-on science.

Her description is similar to Susan's but was delivered with much more passion. Mary estimated she splits her instruction with 70% teacher-centered and 30% student-centered instruction. She would like to do more student-centered instruction but feels she does not have the time or the money available to incorporate more. Mary tries to dedicate a couple of lessons every week to solely student-centered instruction but has small blocks of time built into every lesson for student investigation.

Inquiry-Based Instruction

Mary is familiar with the BSCS 5E Instructional Model. She has previous experience using the model with the Next Generation Science Standards when she taught in New Mexico. She likes the model but states, "You can't use it every day. Well, I

mean you use it every day but all five E's are not utilized every single day" (Mary, personal communication, 2018).

Mary's description supported the methodology of using the 5E model as described by Bybee (2015). She likes that the model incorporates student-centered and teacher-centered learning and considers it a good model to use in the classroom. Mary saw her students' standardized test scores rise with the use of the model at her previous school. As with Susan, Mary feels lack of time, training, and funds prevents teachers from incorporating more inquiry into their classrooms. She also feels many teachers have trouble letting go of control and having their rooms in organized chaos.

Curricular Materials

Mary was not at the district when the new curricular materials were voted on but she was employed at the time of the distribution and training of the materials. She feels our training was insufficient for the amount of materials provided, and has committed several hours of her own time after work to train herself on the information. Mary feels professional development was insufficient with training on the new laboratory kits that are not affiliated with the *Interactive Science* (2017) textbooks but are labs for the unit. "Okay, so we have two curriculums going, you have to marry those together" (Mary, personal communication, 2018). Mary felt additional training on both curriculums and how to incorporate them would be beneficial. She would like to be provided with more "legit" hands-on training.

Participant Three: Georgia (pseudonym)

Georgia has taught for thirty years with twenty of those years in science education. She has taught science at Lakeview Middle School for four years. She is the

robotics coach for the school and often attends outside professional development trainings.

Student-Centered Learning

Georgia had a similar description of what student-centered learning is but had a different viewpoint of student-centered instruction at the school. Georgia's perception is the public school classroom is more student-centered than the private schools where she previously taught.

> I am coming from 1970's teacher training, which is very, very different. I've grown into it. I taught in private, small, Christian schools, so it has been very different for me when I moved into the public school teaching. It is more student-centered, than the teacher-centered that I was used to (Georgia, personal communication, 2018).

Georgia indicated her class was in the middle between teacher-centered and student-centered instruction, but was probably more student-centered in previous years. She attributed students' behaviors as one of the reasons why she cannot have more student-centered instruction. Shaking her head, Georgia (2018) stated, "They cannot handle it if they are in charge of their own learning and they are approaching it from their own angle. They can't handle it."

Inquiry-Based Instruction

Georgia is familiar with the BSCS 5E Instructional model. She learned about the model during an outside of district training she attended the previous summer. The unit she was presented with at the training was designed in the 5E Model. She was not familiar with the model before the training. She liked the model but felt she does not

have the amount of time available to incorporate all the phases of the model. Georgia indicated the lab she tried this year did not go over well due to students not following directions, poor behavior, and not working with their groups. Georgia attributed the lack of success on the lesson to the students' poor behaviors.

Curricular Materials

As with the other two participants, Georgia did not feel she had enough training in the new curriculum materials. She voted for the new texts because, like Susan, she felt the book connected with the standards better and that it was designed at the proper reading level for the students. Like Mary, her grade level was given two new lab kits to support the curriculum and had training on only one kit. She feels she has not had time to go through all the materials and had to tweak them to make the two programs work together. When asked about district provided professional development, Georgia would like a full day focusing on a week's worth of lessons. She would like to see how the 5E's work in an actual classroom rather than just reading about them. Georgia is interested in the 5E Model, and she would like to see how to use it in her classroom.

Participant Four: Jessica (pseudonym)

Jessica provided an administrative view of student-centered learning. She is an instructional coach at LMS and was an ELA teacher for twelve years. As an instructional coach, Jessica is often observing classrooms and providing instructional feedback for teachers. Jessica is also a member of the STEM transition team at the school.

Student-Centered Curriculum

Jessica described student-centered instruction as:

> The teacher being more of a facilitator, not always lecturing, the students having choices, they gear some of the assignments based on what the students like. Also, I see it where students are investigating and collaborating with each other, maybe more than just sitting and listening to the teacher (Jessica, personal communication, 2018).

When asked if she finds more student-centered or teacher-centered instruction at a middle school, she believes middle school to be more teacher-centered. She thinks this is due to teacher-centered instruction being easier for the teacher because of behavior issues in middle school. Jessica thinks the planning and structure needed for student-centered learning is a lot of work, and it is easier for teachers not to do it.

Inquiry-Based Instruction

When asked what she likes to see when she observes a science classroom, Jessica explained, "I like to see the teacher walking around, talking with them, asking them questions, but not giving them answers and especially if they raise their hand with a question, when the teacher comes back with another question and makes them think about it" (2018).

Jessica was not familiar with the BSCS 5E Model until the teacher-researcher talked with her about it in previous conversations. She is familiar with the STEM initiatives to increase more project-based learning and student-centered instruction.

Curricular Materials

Jessica was not familiar with the new science textbooks or curriculum materials. She attends weekly PLC meetings with science teachers and assists teachers with student instruction and content mastery. When asked if she thought teachers at the district and

even the state level were getting enough professional development, Jessica indicated she did not think we were getting enough and we can always do better. She provided an administrative point of view in regards to professional development. "Often, the district will offer different professional development sessions after school but no one will sign up because people's lives are busy. Due to the lack of enrollment, the district offers fewer after school sessions." During teacher in-service days, there are often district-mandated trainings that need to be covered, restricting the amount of time for additional trainings. Jessica indicated she often sees things that would be great to show teachers but there is so little time to do it.

Coding and Emergent Themes in Teacher-Participant Data

As the data from the semi-structured interviews was compared and coded, several themes emerged, including student behaviors, professional development, time allocation, and difficulties incorporating student-centered learning. I divided the interview data into these themes and color-coded comments for the different topics. In each interview, the teacher-participants were asked broad questions and the same concerns and similar beliefs were presented to the teacher-researcher.

Interpretation of Teacher-Participant Data

Semi-Structured Colleague Interviews

The results of the teacher-participant interviews supported not only the research on teacher's wanting to use inquiry-based science in their classrooms, but also the research on why they do not (Kazempour &Amirshokoohi, 2014; Lebak & Tinsley, 2010;

Pringle et al., 2015). For teachers to adopt an inquiry-based approach to teaching, they need to be familiar with what it is and how to implement inquiry in the classroom (Kazempour & Amirshokoohi, 2014). The district adopted a curriculum based on the BSCS 5E Inquiry model, but the teachers at LMS are unfamiliar with the model and the components of the curricular materials. As seen with the findings of Pringle et al., (2015), teachers want to incorporate more inquiry into their classroom but require training and professional development if they wish too effectively implement a pedagogical shift. The research of Taylor et al. (2007) supported implementing curriculum materials as designed, rather than picking and choosing parts out of order. The consistency in using the 5E Model phases in order leads to a higher achievement in science than those who do not (2007).

Lebak and Tinsley's (2010) research indicated many teachers who are focused on the rigor needed to meet content standards avoid inquiry-based instruction in an effort to meet content standards. "Because factual knowledge is easier to test than conceptual understanding, remembered information and routines have become increasingly the focus of education" (Buoncristiani & Buoncristiani, 2014 pg. 11). The teacher-participant interviews supported this concern at LMS as the need to meet all of the SC Science Standards overwhelms the classroom model. A connecting theme in the interviews was the perception of there just not being enough time in the day to properly teach a student-centered model and reach all of the required curriculum standards.

In order for inquiry to be taught effectively, the teacher must allow students to take control of the learning environment. This puts the teacher into a position of shared control. Teachers may find this method intimidating or threatening (Osisioma & Onyia,

2008; Atar, 2011). A teacher who has little experience in inquiry, or keeps a structured management style, may lack the strategies to implement inquiry and manage the unexpected results that often accompany inquiry-based science (Walan et al., 2016). The concern of student behaviors and management during a student-centered model was evident in the teacher-participant, and administrator-participant interviews. Teacher-participant Mary postulated giving up control as a reason why more teachers do not commit to a student-centered pedagogy.

Answering the Teacher-Participant Research Question

The action research study supported the research sub-question of *"What are some of the problems involved in facilitating teacher planning of the 5E Model science curriculum?"*

The interviews with the teacher-participants and administrator-participant were conducted to develop an understanding of why the student-participants had little experience or knowledge of what an inquiry-based lesson was or how to manage themselves in a student-centered classroom. The data from the interviews supported a lack of student-centered learning at all three grade levels at the school but also the teachers' desires to incorporate more.

The problems involved with facilitating teacher planning of the 5E Model are consistent with the teacher-participants and with the research previously described in this study. The financial constraints limit a teacher's ability to purchase materials for inquiry-based science, but time constraints also limit the amount of time and training needed to incorporate an inquiry-based model.

Student behaviors were a key determining factor in a teacher-participant's decision to incorporate an inquiry-based model in the classroom. This factor could be a result of students not knowing how to act in a student-centered classroom, as well as teachers not being aware of how to manage and scaffold information for students.

Between the teacher-researcher and the teacher-participants, there is a desire for more professional development and training on the 5E Model, the curricular materials, and a student-centered pedagogy. The barriers of time and other mandated district commitments of teachers' trainings inhibit time teachers can spend on professional development and what is offered to teachers in a district. There are barriers to facilitating teacher planning of the 5E Model, but no barriers are insurmountable.

Conclusion

Action research is a reflective process. As this action research study was conducted, the data was continuously compared and reflected upon. The findings of the data and the emerging themes shaped the course of this action research study.

The primary purpose of this action research study was to describe the implementation of an instructional unit based on the BSCS 5E Instructional Model. The secondary purpose was to describe my transition to teaching an inquiry-based, progressivist, student-centered pedagogical model and the tertiary purpose was to develop and action plan to share the findings of the study with the other teachers at LMS. The purposes of the study reflect the need to address the identified problem of practice of not including an inquiry-based model in my middle-level science classroom.

In order to answer the research question regarding the student-participants' perceptions of the BSCS 5E Instructional Model, data was collected on their behaviors, attitudes, and their reflections during lessons developed using the BSCS 5E Model. As the *Organization of Living Things* unit was implemented, two main themes in the data emerged, "changes for students" and "changes for teachers." Through coding and collecting data on student attitudes, engagement, and behaviors during the student-centered instruction, it became clear to the teacher-researcher this was not only a pedagogical shift for the teacher but also for her students, who had little to no experience with this method of learning. In order to gather data regarding the "changes for teachers" theme, semi-structured interviews were conducted with teacher and administrator participants. The candid, and at times uncomfortable, interviews with colleagues provided information that will be used to shape the Action Plan discussed in Chapter 5. At the beginning of the study, the intention of the Action Plan was to share the results of this study and reflect on the experiences with colleagues. The Action Plan has now developed into a much needed and desired professional development regarding implementation of an inquiry-based model, as well as the scaffolding and management techniques needed for it to be successful.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND ACTION PLAN

Chapter Five describes the focus of this Action Research study in terms of a summary of the data, conclusions, and the action plan as it relates to the identified problem of practice of incorporating inquiry-based instruction in a middle-level classroom.

The problem of practice developed from the need to implement more inquiry-based instruction in the science classroom in order to meet the South Carolina requirements for science education reform including the 2014 South Carolina Science Standards (SC DOE, 2014). In addition to the 2014 South Carolina Science Curriculum Standards the district purchased the *Interactive Science* (2017) curricular materials. Science teachers in the Winter Haven School District had the opportunity to vote for new textbooks and supporting materials.

The current national trends in science education reform, specifically STEM integration (Lesseig, Slavit, & Nelson, 2017) and the new curricular materials, supports the integration of inquiry-based science education. The *Interactive Science* (2017) curriculum was developed on the BSCS 5E Instructional Model. In order to implement inquiry-based instruction, there needed to be a pedagogical shift at Lakeview Middle School (a pseudonym) from the traditional teacher-centered to a more progressive student-centered learning environment. As a science teacher, I assumed the role of a

researcher in order to determine the students' perceptions of the implementation of the 5E Inquiry Model of science education over the fall 2018 semester at LMS.

The action research study was conducted at Lakeview Middle School, located in the Low Country of South Carolina. The town of Lakeview (a pseudonym) is identified as a lower-middle income area. With 9.7% of the population of Lakeview is at or below the poverty line (US Census Department, 2016). The school supports grades six through eight and has approximately seven hundred and forty students supported by forty-six teachers and four administrators.

The student-participants in the action research study are seventh-grade students assigned to my general science classes. The general science classes are a heterogeneous mix of seventh-grade students. The data collected for this study came from a sample size of one hundred students divided between four science classes. The *Organization of Living Things* science unit was taught to the 109 students assigned to my classes. The data set consisted of 100 students.

This Action Research study was guided by the following research question. *How do middle-level students, accustomed to a traditional teacher-centered curriculum, perceive an inquiry-based, student-centered science classroom based on the Biological Science Curriculum Studies (BSCS) 5E Instructional Model*?

The study also addressed the following sub-questions:

1. Regardless of how they perceive the student-centered curriculum, how do they negotiate the class?
2. What are some of the problems involved in facilitating teacher planning of the 5E Model science curriculum?

In order to answer the research question I designed and implemented an instructional unit titled *The Organization of Living Things* for six weeks in the fall of 2018. The instructional unit was designed using the BSCS 5E Instructional Model. The primary purpose of the present study was to describe the implementation of a unit based on the BSCS 5E Model with four seventh-grade science classes at LMS. The data collected to answer the research questions was in the forms of quantitative pre and post attitude and content tests, and qualitative data consisting of semi-structured interviews, informal interviews, field notes, lesson exit tickets, and a teacher-researcher reflective journal.

The themes emerging from the data were the student-participant attitudes about science before and after the unit, student behaviors during the unit, student engagement during the unit, and the teacher's pedagogical shift needed to implement the unit. The analysis and interpretation of the data revealed the student-participants' attitudes towards science in school improved after the unit, and they enjoyed the student-centered lessons more than the teacher-centered, note-taking lessons. It was revealed the student-participants were inexperienced with student-centered learning and faltered in directing their own learning. This inexperience resulted in negative behaviors such as playing around, excessive talking, and not completing classwork. This shortcoming was immediately addressed with additional scaffolding of information and teacher modeling student expectations for learning. I needed to direct my students in small increments in order for them to focus on the instructional tasks. The student-participant inexperience with student-centered learning was supported through semi-structured interviews with three teacher-participants, and one administrator-participant who have seen similar

behaviors in other classrooms. The findings of the semi-structured interviews supported the development of an action plan of professional development for the teachers at LMS to share the findings of the study, share best practices for implementation, and support teachers with the implementation of the 5E Model and the school's STEM transition.

Key Questions

The results of the present Action Research study revealed several key questions pertaining to the identified problem of practice and possible future research.

1. Would the student-participants' classroom behaviors and attitudes toward science be more positive in a middle-level school whose elementary feeder schools used inquiry-based science instruction?
2. What professional development would be the most beneficial for teachers who are not using inquiry-based science in their classrooms?
3. At Lakeview Middle School, is the reluctance to incorporate student-centered instruction exclusive to the science department or is it a cross-curricular concern?
4. As Lakeview Middle School transitions to a STEM-based middle school, what instructional strategies and curricular supports are available to assist teachers in scaffolding their instruction?

Role of the Researcher

As a curriculum leader at Lakeview Middle School, I continuously work to improve the education and learning experiences for the teachers and the students at the school. I have taught seventh grade science at LMS since fall 2013. The 2018-2019 school year represents my 20th year of teaching in public schools. I hold several

certifications in various subjects in all grade levels, and I have been a National Board Certified Teacher in Early Adolescence Science since 2007. As an insider at LMS, I am an active member of the faculty, serving on the STEM transition team, coaching the science academic team, and supporting new teachers at our school. I am familiar with the curriculum, district policies, and the needs of the student population at my school.

I recognized a problem in my practice as a seventh-grade science teacher. In reflecting on my professional practice, I realized I was conducting a more teacher-centered classroom, with little inquiry-based lessons for my students. Inquiry-based learning is supported and encouraged by the National Science Teachers' Association (2011) and the National Research Council (2012).

The newly adopted *Interactive Science* (2017) curriculum is based on the BSCS 5E Instructional Model. I have never used the BSCS 5E Model, so I did not have any opinions on the model and remained neutral during the implementation of the study. As an insider, expected to follow the district curriculum it was frustrating to be held accountable to a program with which I had no experience or training. This action research study developed from a district expectation to use the curricular materials purchased for science teachers and a curiosity of how students would perceive this shift in instructional pedagogy.

The first challenge I faced in this study was the need to train myself on the program and learn how to develop lessons using the 5E Instructional Model. The 5E Model is a student-centered, inquiry-based model based on the constructivist pedagogy (Bybee, 2015). To implement this learning model, I needed to shift my pedagogical practice from teacher-centered to student-centered. Although I have included student-

centered lessons in my practice, I had not made the commitment of time and training to shift my instructional practices to follow an instructional model.

My school supports subject and grade-level professional learning communities (PLCS). The teachers in a PLC are expected to share instructional practices, plan together, and develop common assessments. In the planning stage of this action research study, being a member of a PLC was a challenge because the other seventh-grade science teacher did not want to change her teaching methodology. Fortunately, at the time of development and implementation of the instructional unit, the new seventh-grade science teacher was supportive of the shift and reflected on the data with me throughout the process. The process of reflecting teaching is an important aspect of an action research study (Mertler, 2017).

In the development and implementation of this action research study, my role is that of teacher-researcher. I am the leader of the action research study, in its development, implementation, data collection, and in the development of the action plan based on the findings because I am choosing to conduct this research to better my own instructional practices. The study and data collection was conducted at Lakeview Middle School (LMS), located in the Low Country of South Carolina. In order to conduct an action research study at the school I needed permission from my principal and the school district. A proposal was developed and approved prior to the implementation of the study. The action research study was conducted in my four seventh-grade, general science classrooms with 100 student-participants.

On the first day of school, a parental consent letter (Appendix A) was sent home with the students, of the letters sent home, five parents did not give their consent for data

collection. These students were involved in all aspects of the class and the study with the exception of their work and responses being removed from the data collection. According to Merriam and Tisdell (2016), my teacher-researcher status is an insider. I am considered an insider because I am conducting research in my own classroom in order to improve my teaching (2016). My status as an insider affords me the opportunities to collect data using a familiar classroom and curriculum.

In my role as a teacher-researcher, I was responsible for developing the data collection instruments. The data was collected through a variety of qualitative methods, including field notes, informal interviews with student-participants, and lesson exit tickets and quantitatively through pre and post-tests on content and attitudes toward science. Mertler (2017) suggested using a variety of instruments, methods and sources to collect data in order to support the validity and trustworthiness of the data.

I collected data from 100 seventh-grade students enrolled in my general science classes for six weeks in fall 2018. The student-participants took the attitude pre-test on the second day of school and as a post-test on the last day of the instructional unit. The field notes and informal interviews with students were taken daily for six weeks during the study. At the mid-point of the study, I conducted semi-structured interviews with three teacher-participants and one administrator-participant as a method of collecting data on their instructional practices but also to reflect on the observations I had made on my students. The data was analyzed and coded for themes as it was collected. The data was analyzed using a constant-comparative method, in order to adjust the study as it unfolded (Merriam & Tisdell, 2016). Two main umbrella themes emerged from the data, “changes for students” and “changes for teachers,” under these themes the subthemes of student

attitudes, student behaviors, student engagement, and teacher pedagogical shifts. The data was coded and categorized under these subthemes.

Due to the reflective process involved in action research, the findings of the data were shared and reflected on with the student-participants. The student-participants were unaware I was using a specific learning model. When the data was shared, it was about the specific lessons and activities conducted on a daily basis. The attitude scale was discussed during the first full week of school to allow student-participants to expand on the reasons for their responses. The student-participants were open to giving me feedback on the structure of their lessons. They were told they had an opportunity to shape the way the class was conducted by sharing their opinions of the lessons. A difficult truth to accept was that I had student-participants who did not like the pedagogical shift in my classroom. I hoped a change from the traditional teacher-centered curriculum would development a love of science in all my students. This was not the case; according to the data, some student-participants still find science boring.

The most significant challenge in my role of a teacher-researcher was balancing data collection, specifically student observations while conducting my class. At times, it was difficult to monitor students, conduct class, and record my observations. This led to feeling overwhelmed by the information and questioning the accuracy of some of my observations. Developing a system of personal shorthand notes aided in the ease of the observations. Taking the time to reflect with students in regards to my observations enabled me to clarify my observations and include individual student-participant's opinions and comments to the recordings.

Despite the reflective nature of action research, the role of a teacher-researcher can be quite solitary. The administrators of the school and the members of my PLC were supportive of my action research project and reflected with me on my observations but ultimately I was the only one conducting and collecting research. As I mentioned, I am an active member of the faculty of the school but due to the time commitment of an action research study, I was unable to make a commitment to additional school-wide programs.

One of the findings of the teacher-participant interviews is they identify the time commitment as an obstacle to implementing inquiry into their classrooms and using the new curricular materials. Incorporating a new instructional model is time consuming, and requires, planning. An uncomfortable truth is that I do not believe many teachers at my school are interested in pursuing this commitment to shift to a student-centered, constructivist pedagogy.

This action research study began as an opportunity to improve my teaching practice. I have solidified my commitment to be a curriculum leader through:

1. Creating a classroom climate that promotes social learning and group work.
2. Developing lessons which incorporate the 5E Model and the SC State Science Standards.
3. Creating an atmosphere to more toward an interdisciplinary transition to STEM.

Developing the Action Plan

This Action Research study began with the identification of the problem of practice, relating to a lack of an inquiry-based science model in my science classroom. I researched student-centered, inquiry-models and discovered the BSCS 5E Instructional Model. In 2018, the Winter Haven District adopted new science textbooks and curricular materials developed using the BSCS 5E Model.

An instructional unit titled the *Organization of Life* was designed using the BSCS 5E Instructional Model and implemented in the teacher-researcher's classes for six weeks. Implementing an inquiry-based model supports the STEM driven curriculum model in South Carolina's Science Curriculum Standards (SC DOE, 2014), but if the students are not engaged, achieving, or developing a positive attitude toward science with the model, then it would not be beneficial to the teachers or the students to implement this model into science classrooms.

The results of the investigation support the implementation of the BSCS 5E Model in middle-level science classrooms. The data collected through student observations, lesson exit tickets, informal interviews, and attitude surveys indicated students had positive perceptions of the BSCS 5E Model. Student-participants' attitudes toward science increased, and the student-participants revealed in exit tickets that they enjoyed the lessons and were engaged in class.

Action Research is conducted to improve a problem of practice and reciprocally improve the quality of education for the students (Mertler, 2017). By reflecting with student-participants on the data, I was able to identify the needs of the students when using an inquiry-based model. The student-participants enjoyed the lessons designed in

the BSCS 5E Model and were engaged, but the teachers at the school were not familiar with the model and were not using it in their classrooms. As LMS transitions to a STEM-based curriculum, an inquiry-based model will need to be implemented at the school. I developed an Action Plan to provide professional development for teachers at LMS regarding how to implement the BSC 5E Instructions Model in their classrooms for the benefit of the students.

The Action Plan

The school-level Action Plan developed from the Action Research study was designed to address a key question that developed from the research:

As Lakeview Middle School transitions to a STEM based middle school, what instructional strategies and curricular supports are available to assist teachers in scaffolding their instruction and aid in STEM curricular integration?

LMS is in the process of transitioning to a STEM based middle school. The data from the Action Research study indicated the middle-level science teachers are not using an inquiry-based model in their classrooms and the teachers have expressed an interest in learning more through professional development. The data also supports the claim that students enjoy learning in an inquiry-based classroom, but are often not given such opportunities.

The Action Plan will focus on determining the curricular supports offered for teachers at the school as well as what professional development can be offered to assist science teachers in establishing an inquiry-based learning model in their classrooms. The Action Plan is specifically designed for the instructional staff at LMS. The students at the school will benefit from the instructional strategies the teachers will implement in

their classrooms. The teacher-researcher of the study is responsible for designing and implementing the first phase of the Action Plan.

The administration at Lakeview Middle School will be consulted for the design and implementation of the Action Plan. At Lakeview Middle School, the administration needs to approve the implementation of the Action Plan. Because the plan seeks to answer a key question from this study, the teacher-researcher will meet with administration and the STEM team at Lakeview to determine the curricular supports in place for the STEM transition and the professional development needs to be in place at the subject and school-wide levels.

Action Plan Phases

Phase One

In the spring, the teacher-researcher will meet with school administration to share data and findings of the Action Research study. The involved parties will reflect on the data and pose questions for future research. The teacher-researcher will propose an action plan with two stages. The first stage of the plan involves professional development in STEM and the BSCS 5E Instructional Model for science teachers at LMS. The second stage of the plan involves providing professional development on inquiry-based learning and STEM integration to all disciplines at the school. A survey will be developed with administration to collect data on the curricular support the staff at LMS feel they would need for a STEM transition.

Phase Two

The following month, the teacher-researcher will present the findings of the Action Research study to science teachers at the school. The professional development will provide information and instructions on the 5E Model and tips for scaffolding information to help students transition to an inquiry-based model. A presentation will be developed highlighting the phases of the 5E Model as well as sharing the challenges of implementation of the model. The teacher-researcher will walk participants through lessons developed using the 5E Model. A follow-up survey will be created and shared with science teachers to collect data on the curricular needs of science teachers.

Phase Three

After the first professional development, science teachers using the 5E Model will present the model to the staff during a professional development session. Teachers will be provided support in how to scaffold information during the phases of the model for their students. Teachers will present sample lessons using the 5E Model for school subjects outside of science. During the training, the grade-level professional learning communities will have the opportunity to choose a content standard or topic they would like to develop a lesson on using the 5E Model. Information regarding the STEM integration will be shared with teachers, based on the results of the survey sent to staff members.

Phase Four

The teacher-researcher and administration will analyze the survey data collected after the professional development sessions. Additional professional development will be designed and implemented based on the needs of the staff. As the school continues its

transition to a STEM based curriculum, there will be a need for supportive professional development.

Facilitating Educational Change

"The goal of action research is to address a specific problem in a practice-based setting, such as a classroom, a workplace, a program, or an organization" (Merriam & Tisdell, 2016, p. 4).

This Action Research study was developed around a problem of practice regarding inquiry in the classroom, but the ultimate goal was to improve as an educational professional. It is my future goal to continue to improve in my educational practice. When I improve my practice, my students' education will improve. As I improve in my student-centered, inquiry-based instruction, it is my hope I will encourage my students to pursue careers and higher-level courses in science education.

Through the development and implementation of the action plan, my goal is to produce a positive educational change in teachers of all disciplines, as they are trained in student-centered teaching and build their management and scaffolding skill sets in their classrooms.

It is not easy to step out of our comfort zone, especially when it involves changing something you have done for years. As seen in the interview with Georgia, she has been teaching a certain way for thirty years. It will not be an easy transition for her to change her teaching pedagogy from teacher-centered to learner-centered. Incorporating STEM and inquiry-based learning is a time and effort commitment. A challenge to this implementation could be teachers being unwilling to devote the time and effort needed to learn a new pedagogy and use it in their classrooms. I have often heard teachers say "I

don’t have enough time to meet my own standards let alone add new material” when discussing STEM integration.

This Action Research study demonstrated that students must have information and procedures scaffolded to help them adjust to a new instructional pedagogy. This plan of action will be part of the preparation to address the challenges faced in this positive educational change. Conceptually, if the information and changes are chunked into smaller, more manageable changes, it will be less overwhelming and time consuming for the participants.

Lakeview Middle School supports a positive learning community. In the fall of 2018, the school administration developed a team to lead the implementation of a STEM program at the school. This learning community will be working on incrementally implementing a STEM program at the school, starting with the team’s classrooms. The teachers and administrators are supportive of developing student-centered, inquiry-based lessons. They have expressed interest in the 5E Model and incorporating it into our transition. As discussed previously in this study, the seventh-grade PLC is supportive of the 5E Inquiry Model and works together on implementation and sharing best practices. By sharing the success of the seventh grade, other grade level teachers will be encouraged to step out of their comfort zone.

Summary of Research Findings

I sought to explore the implications of incorporating a student-centered, inquiry-based instructional model in a seventh-grade science class through this action research study. One hundred seventh-grade student participants, three-teacher participants, and

one administrator-participant were a part of the six-week implementation of an instructional unit based on the BSCS 5E Instructional Model.

The BSCS 5E Instructional Model is an inquiry-based model consisting of five phases of instruction, Engagement, Exploration, Explanation, Elaboration, and Evaluation (Bybee, 2015). There is a purpose for each phase, resulting in the students' constructing and developing a better understanding of content and skill development (2015). The foundation of the 5E Model is the psychology of learning, specifically the constructivist perspective, but is also developed from Dewey's progressivism, and the learning cycle theory of Atkins and Karplus (2015). Constructivist learning is a dynamic learning process in which the students bring their established knowledge, attitudes, and feelings to learning, and the teacher develops strategies to redefine, reconstruct, and expand on the students' prior knowledge. Learning is not acquired passively but through the students actively controlling their learning (Brooks & Brooks, 1999; Bybee, 2015; Yager, 2000).

During the implementation of an instructional unit based on the BSCS 5E Model, the teacher-researcher was able to obtain data through student attitude surveys, a teacher-created content, pre and post-tests, student-reflection exit tickets, student observations, and semi-structured interviews with colleagues. The collected data sets were polyangulated to provide a comprehensive examination of the student-participants' perceptions of the 5E Model and student-centered instruction. The semi-structured interviews with the teacher-participants and administrator-participants allowed the teacher-researcher to explore the teachers' opinions of the model and why or why not the use inquiry in their classrooms. The interpretation of the data revealed findings related to

the student-participants' attitudes towards the 5E Model, student engagement in a student-centered class, the students' classroom behaviors during the implementation of an inquiry-based model, and the teacher curriculum shifts needed to incorporate an inquiry-based model.

Student Perceptions

The collected data revealed students had positive perceptions of the lessons taught using the 5E Instructional Model. A surprising observation from the initial Attitudes toward Science in School Assessment (ATSSA) was the student-participants had favorable opinions towards science. The data suggested approximately 47% of the students had a positive attitude towards science, 31% with a neutral viewpoint, and 22% of the students with a negative attitude towards science class. This is in contrast to research supporting the belief that adolescents tend to lose interest in science and science-based professions once they enter middle school (Basu, & Barton, 2007; Kim, 2016). The results indicated the students liked science but also found it was boring and did not like to study it. The post-test scores revealed the student-participants' attitudes towards science had improved and shifted away from the predominant neutral category of opinion. The post-test results indicated an increase in the percentage of students who responded, with 63% of the students choosing "strongly agree" and "agree" to the positive attitudes towards science questions. This indicates a 16% increase in positive attitudes towards science. Three specific questions had an increase of 19% or more in student attitude towards science. One question designed to measure negative attitudes towards science showed a 16% decrease in negative student responses. This question had

the greatest shift away from a negative attitude. The other questions had little or no changes.

Table 5.1
ATSSA results

Question	Pre-test	Post-test	Increase
During science class I am usually interested.	51%	74%	23%
The feeling I have towards science is a good feeling.	47%	66%	19%
I feel at ease with science and I like it very much.	39%	63%	24%
Science is boring	29%	13%	16%

The findings of the attitude survey support student enjoyment of and engagement in lessons taught in the BSCS 5E Model. Yager (2005) hypothesized that, in a middle school setting, it is easier for teachers to focus instructional strategies and assessments that are personally relevant to middle-level students' lives, increasing engagement and relevancy of the topic. The middle-level science curriculum is not as specialized as high school curriculums, enabling teachers to incorporate more engaging topics and problem-based learning approaches (2005). Some student-participant's attitude scores did not improve. These students admittedly do not like science, and do not enjoy the class. These students were also observed not interacting with others during exploration phase inquiry-labs or in class discussions.

Student Behaviors

Observations of student-participant behaviors and informal discussions with students provided an awareness of how students behaved when they are following the phases of the 5E Model and their behaviors when they were unable to direct their own

learning. Student-participants were observed behaving negatively during class, displaying such behaviors as running around, grabbing at each other, laying their heads on the desks, and talking about non-relevant issues. When the behaviors were addressed with the teacher-researcher it was often revealed students did not know what to do or were confused by my expectations of them. The student-participants indicated that they needed me to tell them what to do and were exhibiting more dependent behaviors than independent behaviors. The student-participants indicated they had little or no experience with inquiry-based activities or student-centered learning. As supported by Chapman and King (2012), the students lacked the strategies and skills to learn independently and often gave up when they perceived the work to be too difficult. The admitted lack of experience was supported by the sixth grade science teacher-participant. She indicated that, due to student behaviors and the need to teach to the standards, she did very little student-centered learning. The dependent learning behaviors of the students resulted in a need to scaffold the information for the students. Scaffolding information is an integral part of the constructivist pedagogy (Bates, 2016). Just as a building in progress needs more scaffolding for support at the beginning of construction, student learning does as well. As the students learn, the scaffolding support can be slowly withdrawn. "Instruction must provide scaffolds for solving meaningful problems and supporting learning for understanding" (Taylor, Van Scotter, & Coulson, p. 44, 2007). In order for the students to become independent learners, I needed to scaffold behavior expectations and independent learning behaviors such as self-reflection, team roles, and supporting claims with evidence and reasoning.

Student Engagement

Engagement is not only the first phase of the BSCS 5E Instructional Model; it is a cornerstone of student-centered learning. When students are engaged and involved in their learning process, they are able to think metacognitively by reflecting on their own learning process (Buoncristiani & Buoncristiani, 2012). Observations on and reflecting with student-participants revealed they are positively engaged in when lessons are taught using the 5E Model. In the exit tickets designed for lesson feedback, student-participants were asked if the lessons held their interest or if they felt engaged in the lessons. Participant responses indicated the inquiry-based lessons in the Exploration and Elaboration phases held their interest more than the note-taking or teacher-centered lessons. As indicated by Halpern, Heckman, and Larson (2013), adolescent learners can be, and want to be, fully engaged in their learning, but, in the middle-level of schooling, we see a decline in interest and motivation to learn because students are not provided the time or opportunities to become engaged in their learning. In this Action Research study, students were observed demonstrating engagement through connecting information to their own lives, hypothesizing possible solutions to presented problems in the world, and, at times, being focused on the task at hand without exhibiting negative behaviors.

Teacher Pedagogical Shifts

In order to transition from a teacher-centered classroom to a student-centered classroom, there needs to be a pedagogical shift for the teacher. The teacher is no longer the center of the classroom and is no longer in sole control of the learning. In a constructivist classroom, the teacher becomes a facilitator who creates the environment for students to learn, while the students create meaning through social interactions,

engagement, questioning, and effective thinking (Buoncristiani & Buoncristiani, 2012). In order to shift to an inquiry-based, progressivist pedagogy, teachers need to provide students with engaging inquiry opportunities. The teacher also facilitates the environment as students learn through experiences and reflection (Bates, 2016; Dewey, 1938).

The National Research Council (2012), the National Science Teachers Association (2018), and the Next Generation Science Standards (2013) support the inclusion of an inquiry-based pedagogical model in science education incorporating engineering practices and reflective teaching, but it is not a common practice. As seen in the semi-structured interviews with teachers and an administrator at Lakeview Middle School, there is a deficit of student-centered, inquiry-based lessons. The teacher-participants unanimously supported the benefits of scientific inquiry and a student-centered classroom, but also indicated they are not following the model. The participants' reasons for the lack of a structured model are reflective of the research of Lebak and Tinsley (2010): a lack of time, ineffective training, beholden to state science standards, and classroom management issues.

The transition to a student-centered model is not an easy undertaking for a teacher accustomed to an essentialist, teacher-centered pedagogy. The interviews revealed the teachers are reluctant to make the transition due to the amount of time and training required to shift their classrooms. A commonality found in all the participant interviews was the desire for more relevant professional development in inquiry-based instruction, and with the new curricular materials recently adopted by the district. With the exception of one teacher-participant, the interviewed participants are only casually aware of the

BSCS 5E Inquiry Model and its incorporation in the new *Interactive Science* (Buckley et al, 2017) textbooks. This lack of familiarity with the curricular materials could result in science education weakness at Lakeview Middle School. The research of Taylor, Van Scotter, and Coulson (2007) indicated instructional models are the most effective when they are taught with a basic level of fidelity. Suggesting that well-designed curriculum materials are used only as a resource or haphazardly in the classroom, there can be a lack of coherence to the learning sequence in the classroom (2007).

As described in the Action Plan for this study, relevant and engaging professional development in the 5E Instructional Model and student-centered teaching is fundamental to the pedagogical shift the teachers need to transition to a STEM curriculum. Taylor at al. (2007) posited that professional development should focus on the scientific learning model so teachers can apply their experiences to the classroom.

Suggestions for Future Research

Based on the findings of this Action Research study, the predominant suggestion for future research is to study the impact of a science program using the 5E Instructional Model for a full academic year. A study of this length would take a significant amount of preplanning in order to incorporate the 5E model for the entire curriculum. This would be beneficial to the study as the teacher-researcher would be able to monitor student attitudes throughout the school year and not rely on only a pre and post-test.

Time is one of the biggest deterrents to implementing an inquiry-based model due to the amount of planning lessons in the new methodology, allowing enough time to scaffold student learning, and reflecting with students on their learning (Lebak and Tinsley, 2010). All of this must happen in the context of teaching students the content

required by the state science standards. The time commitment can lead to teacher burnout and teachers reverting to their previous teacher-centric approach. A potential area of research is the best time management strategies for teachers. Would the solution be longer planning periods, additional professional development, or a pre-developed curriculum to take lesson planning away from teachers' responsibilities?

As more and more schools are transitioning to a STEM or STEAM based model, another area of future research is to investigate how subjects outside of science can use the 5E model to include interdisciplinary activities into a STEAM program. Taylor, Van Scotter, and Coulson's (2007) research supported increased student learning when the 5E instructional model was followed with high fidelity. A potential action research study would be to investigate student engagement and inquiry skills when the model is followed across curriculum. Because of the teaming model at Lakeview Middle School, interdisciplinary teams could incorporate the model outside of science.

The science teachers at Lakeview Middle School indicated they are not using the new textbooks and curricular materials as designed. They state a lack of professional development and training as the reasons for this action. An opportunity to expand this current research study would be to investigate if this behavior is a district-wide occurrence or if it is localized to the school. If the sentiment regarding unpreparedness in using the curricular materials is a district-wide concern, professional development could be offered to train teachers in the implementation of materials as they are designed.

Conclusion

The present action research study began as an investigation into my own instructional practices. As a middle-level science teacher, I knew I was not offering students the hands-on, inquiry-based activities needed to support scientific phenomena. I undertook this study as a way to examine methods to improve my instructional practice. As Mertler (2017) states, “more important, action research is characterized as research that is done by teachers for themselves” (p. 4). I developed the study as a method to reflect on and improve my instructional practices, in turn improve the education for my students. The ultimate goal for a teacher is for her students to learn, but I also want the students to enjoy the process of learning. Based on previous conversations, I knew many students enjoyed hands-on activities but I was often surprised when they told me they had never done a lab before or had done very few. How could this be when inquiry-based instruction has been part of science education for several years?

As I researched student-centered teaching and inquiry-based science instruction, I consistently found articles and references to the BSCS 5E Instructional Model. The BSCS 5E Instructional Model was developed in the mid 1990’s (Bybee, 2015) but has developed and grown into an established scientific learning model. Several research studies support the use of the model to improve science achievement and engagement (Dademir, 2016; Kim, 2011, 2016; Scott et al., 2014). Coincidentally the 5E Model is the instructional format used in the *Interactive Science* (2017) text and curricular materials purchased by my school district.

Because of the reciprocal nature of action research (Mertler, 2017), this study focused on the student-participants’ perceptions of the 5E model and how they would

handle a pedagogical shift from a traditional teacher-centered classroom to an inquiry-based, student-centered classroom. The pedagogical changes in the classroom needed to benefit the teacher-researcher as well as the student-participants.

An instructional unit titled “The Organization of Living Things” was developed using the BSCS 5E Instructional model and implemented in the fall of 2018. Quantitative data was collected as pre and post-tests in the forms of the Attitude toward Science in School Assessment (Germann, 1988) and a teacher-researcher developed content unit test. The results of the quantitative data showed student growth in positive attitudes toward science and content knowledge. The predominant data collected was qualitative in the forms of semi-structured interviews, informal interviews, field notes, lesson exit tickets, and a teacher-researcher journal. The lesson exit tickets were valuable sources of student-participant perceptions and opinions. The exit tickets allowed student-participants to provide the teacher-researcher feedback on different lessons and instructional strategies but also input on what would improve the lessons. The qualitative data and quantitative data was polyangulated to support trustworthiness and reliability of the data (Mertler, 2017). The data was analyzed using the constant-comparative method for six weeks. Merriam and Tisdell (2016) indicated data analysis in a qualitative action research study focuses on not only what happens but also how it happens over the course of data collection.

The results of the action research study revealed students have a favorable perception of lessons conducted using the BSCS 5E Instructional Model and with student-centered instruction. The results also revealed students are unaware of how to negotiate learning in a student-centered classroom. Vygotsky (1978) supported learning

through social interaction in a zone of proximal development in which learners develop knowledge by interacting with others with more knowledge. It was recognized early in the study that the students would need additional scaffolding of not only the content, but in the process of how to learn content as well. It was often seen there were few students who had the knowledge needed to help others with their learning. The student-participants had little to no knowledge of how to direct their own learning in a student-centered classroom.

The student-participants' lack of inquiry experience and the teacher-participants' challenges with implementing student-centered instruction led to the development of the action plan. The action plan's focus is to provide instructional support and training in using the 5E Model in order to improve learning and classroom experiences for the students at Lakeview Middle School.

At the time of this writing, I reverted to a teacher-centered instructional model in order to manage a limited amount of time and resources due to an increased amount of professional responsibilities outside of my own classroom. The results of this shift back to a teacher-centered classroom resulted in a negative learning experience for my students and myself. The students have complained that they are bored in class and negative behaviors have increased. The students were accustomed to an inquiry-based model of instruction. They have expressed their unhappiness with the teacher-centered instruction. This experience has furthered my resolve to bridge the gap for my Science department and provide the leadership needed to plan and execute inquiry-based 5E Instructional Models of curriculum. The ultimate goal is to provide a high quality science education for all students.

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APPENDIX A

PARENT CONSENT LETTER

August 20, 2018

Dear Parents and Students:

My name is Michelle Norwood and I am excited to spend the school year with you. I am looking forward to a fun and exciting year in 7th grade science. This is my sixth year at SRM but my 20th year of teaching. I love teaching but I also love learning. I am always working to improve on my teaching practices. I am currently completing a doctoral program in Curriculum and Instruction at the University of South Carolina. This year, I will be collecting research on my teaching practices in the classroom. I am conducting research on inquiry-based science instruction in the middle school. There is a lot of evidence supporting the effectiveness of inquiry-based science on science achievement and engagement. I hope the students will benefit from these instructional changes by increasing their interest in science and making science a lot more fun. The instruction in class will follow the SC Science Standards and the sequence determined by BCSD schools.

During the fall, I will be collecting data for my research. This data will include class observations, informal interviews, and surveys focusing on the students' attitudes about science and what we will do in class. This information is important to the success of my study. Through this information, I will be able to draw connections between teaching inquiry-based science and how my students respond to this method of teaching.

All of the data I am collecting will be kept confidential and anonymous. The results of this study will be incorporated into my dissertation and may possibly be published, but there will be no names or identifying characteristics used in my writing. The data collected for my research will not be shared with anyone and will be destroyed within one year of completing the study.

I hope to include data from all of my students. If you chose not to participate, there will be no penalty, I will just remove the scores from the data collection. If you have any questions or concerns please feel free to reach out to me through email at norwoodm@bcsdschools.net or by phone at (843) 821-4028.

Thank you for your support,

Michelle Norwood

Please check one and return to Mrs. Norwood

_______I will allow my child to participate in the study

______ I will NOT allow my child to participate in the study

Parent's Name:____

Child's Name:____

Parent Signature: ____

Student Assent:

Student Name:____

Student Signature:____

Date:____

Student Signature:____

APPENDIX B

FIELD NOTES

Student Group	Activity	Observations	Interpretations
Student Group	**Activity**	**Observations**	**Interpretations**
Student Group	**Activity**	**Observations**	**Interpretations**

APPENDIX C

ATTITUDE TOWARD SCIENCE IN SCHOOL ASSESSMENT

Please use this scale to answer the following question:

SA - Strongly Agree
-

A - Agree
-

N - Neither Agree Nor Disagree
-

D - Disagree
-

SD - Strong Disagree
-

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

APPENDIX D

BSCS 5E MODEL BEHAVIORS

<table>
<tr><th colspan="3">The BSCS 5E Instructional Model</th></tr>
<tr><th>Stage of the Instructional Model</th><th>What the Student Does:</th><th>What the Teacher Does:</th></tr>
<tr><td>Engagement</td><td>Asks questions such as “Why did this happen?” “What do I already know about this?” “What can I find out about this?”
Shows interest in the topic</td><td>Creates interested
Generates curiosity
Raises questions
Elicits responses that uncover what the student knows about the concept and topic</td></tr>
<tr><td>Exploration</td><td>Thinks freely, within the limits of the activity
Tests predictions and hypotheses
Forms new predictions and hypotheses
Tries alternatives and discusses them with others
Records observations and ideas
Asks related questions
Suspends judgment</td><td>Encourages the students to work together without direct instructions from the teacher
Observes and listens to the students as they interact
Asks probing questions to redirect the students’ investigations when necessary
Provides time for the students to puzzle through problems
Acts as a consultant for students
Creates a “need to know” setting</td></tr>
<tr><td>Explanation</td><td>Explains possible solutions or answers to others
Listens critically to others’ explanations
Questions others’ explanations
Listens to and tries to comprehend explanations that the teacher offers
Refers to previous activities
Uses recorded observations in explanations
Assesses own understanding</td><td>Encourages the students to explain concepts and definitions in their own words
Asks for justification (evidence) and clarification from students
Formally clarifies definitions, explanations, and new labels when needed
Uses students’ previous experiences as the basis for explaining concepts
Assesses students’ growing understanding</td></tr>
<tr><td>Elaboration</td><td>Applies new label, definitions, explanations, and skills in new but similar situations
Uses previous information to ask questions, propose solutions, make decisions, and design experiments
Draws reasonable conclusions from evidence
Records observations and explanations
Checks for understanding among peers</td><td>Expects students to use formal labels, definitions, and explanations provided previously
Encourages the students to apply or extend the concepts and skills in new situations
Reminds the students of alternative explanations
Refers the students to existing data and evidence and asks, “What do you already know?” “Why do you think…?” (Strategies for exploration also apply here)</td></tr>
</table>

Evaluation	• Answers open-ended questions by using observations, evidence, and previously accepted explanations • Demonstrates an understanding or knowledge of the concept or skill • Evaluates his or her own progress and knowledge • Asks related questions that would encourage future investigations	• Observes the students as they apply new concepts and skills • Assesses students' knowledge and skills • Looks for evidence that the students have changed their thinking and behaviors • Allows students to assess their own learning and group-process skills • Asks open-ended questions such as "Why do you think…?" "What evidence do you have?" "What do you know about *x*?" "How would you explain *x*?"

APPENDIX E

STUDENT 5E BEHAVIOR OBSERVATION

Student Number

Date

5E Model Stage	Observed	Not Observed
Student shows interest in the topic (Engagement)		
Tries alternatives and discusses ideas with others (Exploration)		
Explains answers and possible solutions (Explanation)		
Uses previous information to ask questions, make decisions or propose solutions (Elaboration)		

APPENDIX F

SAMPLE LESSON EXIT TICKET

1. Student Name:
2. Class Period:
3. What's one important thing you learned in class today?
4. Did you feel prepared for today's lesson? Why or why not?
5. Did you like today's lesson (pick one)

    Yes

    No

    Maybe

6. What do you think would improve today's lesson?
7. Did today's lesson hold your interest?

    Yes

    No

    Maybe

APPENDIX G

TIME ON LEARNING

Date:

Class Period:

Active Teaching	**Total Time**	**Student-Centered**	**Total Time**	**Observations**