NEXT GENERATION SCIENCE STANDARDS ALIGNED CURRICULUM'S IMPACT ON STUDENTS' ACADEMIC SCORES AND ATTITUDE TOWARDS SCIENCE

by

Jessica Priester

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2019

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2019

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ABSTRACT

The purpose of this causal-comparative study was to compare student test scores and attitude toward science before and after the implementation of a curriculum aligned to the Next Generation Science Standards. The Next Generation Science Standards are built on The Framework which include science and engineering practices, crosscutting concepts, and disciplinary core ideas. The approach of The Framework is to allow for student-centered rather than teacher-led lessons. The Framework shares similar outcome goals as those with constructivist views as this theory focuses on learning by experience. The participants in this study were a convenience sample of 7th and 8th grade students who were taught using a NGSS aligned curriculum. Ex post facto data was collected to compare NWEA MAP test scores and MATS data prior to and after implementation of the curriculum. To determine if a NGSS aligned curriculum impacts NWEA scores and the MATS scores between students who participated in TCI's NGSS aligned curriculum and those who received curriculum aligned to the state standards, *t*-tests were used. The results of this study show an increase in both the mean of the science scores and attitude toward science, but the increase is not statistically significant.

Keywords: Next Generation Science Standards, inquiry-based learning, science, middle school students

Acknowledgements

I would like to express my deepest appreciation to my chair, Dr. Tracey Pritchard. It was your guidance, patience, and encouragement that allowed me to continue persevering. I am forever grateful for your wisdom and the effort you put into helping me throughout this process. I would also like to thank my committee member, Dr. Scott Watson. Your knowledge and guidance allowed this dissertation to be successful. I feel truly blessed to have such a committed team behind me.

In addition, I would like to extend my greatest gratitude to my husband, Shawn. Your endless patience and support is the only reason I am where I am today. Thank you for understanding when I needed to spend just one more hour analyzing data or spend another Saturday researching. Without you, I would not have had the support I very much needed throughout all of my graduate courses and the dissertation process.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

American Association for the Advancement of Science (AAAS)

Analysis of Variance (ANOVA)

Common Core State Standards (CCSS)

Expectancy-Value Theory (EVT)

Experiential Learning Theory (ELT)

Grade Point Average (GPA)

International Review Board (IRB)

Measure of Academic Progress (MAP)

My Attitude Toward Science (MATS)

National Assessment of Educational Progress (NAEP)

National Research Center (NRC)

National Science Education Standards (NSES)

National Science Teachers Association (NSTA)

Next Generation Science Standards (NGSS)

Northwest Evaluation Association (NWEA)

Performance Expectation (PE)

Rausch Interval Unit (RIT)

Scholastic Aptitude Test (SAT)

Science Education for Public Understanding Program (SEPUP)

Science, technology, engineering, and math (STEM)

Statistical Package for the Social Sciences (SPSS)

CHAPTER ONE: INTRODUCTION

Overview

The following section provides an overview of the historical background on the topic of constructivism, inquiry-based learning, and the Next Generation Science Standards (NGSS). In this chapter, the gap in the literature is identified and the statement of the problem is provided. The purpose of the study is explained, and the research questions are listed. The final segment of this chapter contains a list of terms pertinent to this study and their definitions.

Background

Reforms in education often come and go in trends. Teachers may be hesitant to adapt a new method, standards, or curriculum without empirical evidence that these methods are effective. Some teachers are resistant to change because they feel as though it’s pointless if things will simply change again in the near future. This may be true for the Next Generation Science Standards if their effectiveness is not proven through research. The development of the Next Generation Science Standards (NGSS) has its roots in constructivism, which proposes that students take an active role in their learning (Peoples, O’Dwyer, Wang, Brown, & Rosca, 2013; Ural & Bümen, 2016) and that students learn through social interactions (Lynch, 2016; Bächtold, 2013).

The theoretical framework of this study was influenced greatly by the theories of Vygotsky, Dewey, and Piaget. While very different in some respects, all had constructivist views and believed that humans learn by experience and by piecing together past experiences to understand new learning (DeVries, 2000). Being constructivists, they also believed that learning has a social aspect and that humans learn better when they can explore their learning in a social setting (Lynch, 2016).

When students have the opportunity to discuss what they are learning, it is believed they will learn better and retain that information. Children are able to realize how to construct their own thoughts when they have had the opportunity to discuss what they are learning with others (Piaget, 1929). It is through these social interactions that children are given the opportunity to truly dig deep into the content and make connections with their prior knowledge. Learning is also dependent upon other's ideas in order to build upon them (Dewey, 1917). It is through this process that scientists have developed new theories and ideas. When students are able to combine what they know, they will be able to develop ideas that are beyond what they are capable of individually. The three dimensions of NGSS provide ample opportunities for students to take control of their learning and interact with others.

Along with learning in a social environment, constructivists viewed learning as a process. In this process, students have prior knowledge they come to each class with. That knowledge is sometimes confirmed, but other times it is challenged. It is in these challenging times that students have the opportunity to create new thinking and construct new beliefs about a topic. Dewey (1909) equates this process to mankind's belief about the shape of the world. People believed the world to be flat until Christopher Columbus challenged that thinking with evidence that the world may, in fact, be round (Dewey, 1909).

Blossoming from the idea of constructivism is inquiry-based learning (IBL). Inquiry-based learning "engages students in an authentic scientific discovery process" (Pedaste, et al., 2015, p. 48). Providing students with these authentic experiences will allow them the opportunity to discover as scientists would. This does not necessarily mean they are discovering new knowledge, however they are discovering knowledge that is new to them in a way that enables them to take responsibility for that discovery (Pedaste, et al., 2015). In an IBL lesson, students may be observing phenomenon, asking questions to obtain more data, interpret and evaluate data, or discussing solutions and arguing from evidence (Dorier & Garcia, 2013). Inquiry-based learning gives students a why. They are able to relate what they are doing to a real-world scenario.

Inquiry-based learning provides students with authentic learning experiences. Authentic learning experiences are ones that replicate a real-world scenario that are "meaningful and useful" to students (Fernandez, 2017, p. 2). When students are examining real-life problems, they are going to become more invested and have a stronger desire to discover a solution. When provided with these experiences, students will be able to see how they can use what they are doing later in life and how what they are investigating impacts them. These authentic learning experiences provide students with skills they may not have gained otherwise, such as judgment, patience, synthetic ability, and flexibility (Swartz, 2016).

One of the key elements of inquiry-based science is cooperative learning groups (Woods-McConney, Wosnitza, & Sturrock, 2016). In a real-world scenario, many scientists would work together to conduct experiments or synthesize data to determine an explanation for a phenomenon. The same is true for students when learning with IBL. Modeling the methods used by scientists has been shown to improve student interest and achievement (McConney, Oliver, Woods-McConney, Schibeci, & Maor, 2014). This includes working cooperatively in a group. Allowing students to work in collaborative groups prepares them for the type of environment they will encounter as adults in the work place.

Another key element of inquiry-based learning is the 5E structure that is typically followed. According to Pedaste, et al. (2015), these five parts are typically identified as "Engagement, Exploration, Explanation, Elaboration, and Evaluation" (p. 48). While these are the phases most commonly used in inquiry-based learning, Pedaste, et al. (2015) found that these should not be a prescribed set of steps, but rather a fluid process in which students may go back and forth between the phases in order to reach the final phase. In fact, the new model created by Pedaste, et al. (2015) includes orientation, conceptualization, investigation, conclusion, and discussion. In their model, discussion is occurring throughout all of the other four phases. Their model also allows students to move backwards from investigation to conceptualization if their results were not valid. This is a more realistic model as it provides students with an experience similar to scientists.

The difficulty of implementing these methods of teaching science in a classroom was the lack of standards that support this style of teaching and learning. Standards provide a guide for teachers on what their students should know and be able to do by the end of the year. Standards are typically developed within each state's Department of Education (Great Schools, 2015). The need for standards developed in the early 1990's when the realization was made that many poor and minority students were not meeting standards and the fact that expectations varied so greatly from state to state (Great Schools, 2015). The problem remains that standards vary state to state. Of course, expectations have been set within each state, but there is still a call for national standards. The math, science, English, and social studies is the same in every state, and the idea of developing a set of national standards has validity (Ravitch, 1996). When a student moves from one state to another, it's difficult to ensure they've learned the necessary material or that they're not ahead of others in their new state. With national standards, students would learn the same material in the same grade level no matter where they go to school. This is where the Next Generation Science Standards (NGSS) are beneficial.

The Next Generation Science Standards are based on a Framework in which students are engaged in three dimensions: crosscutting concepts, disciplinary core ideas, and science and engineering practices (NGSS, 2013). Typically, states have these three items separately in their standards, but the NGSS work all three of these items into each performance expectation (PE) (NGSS, 2013). Also, before NGSS, states kept inquiry and content separate from their standards which can lead to classroom instruction being focused primarily on content. The NGSS integrate inquiry into the PE, so instruction includes a well-balanced and quality science education (Pruitt, 2015).

Prior to developing the standards, the National Research Center (NRC), American Association for the Advancement of Science (AAAS), National Science Teachers Association (NSTA), and Achieve worked together for three years to develop A Framework for K-12 Science Education (Pruitt, 2014). According to Pruitt (2014), “the goal of the Framework was to articulate the vision for science education in the twenty first century and to articulate what students need to know in their K-12 experience to be considered scientifically literate” (p. 146). This Framework consists of the three dimensions of what we now know as the NGSS (practices, crosscutting concepts, and disciplinary core ideas). However, the Framework is simply an idea of what needs to be taught by the time students graduate from high school. After much deliberation, the disciplinary core ideas were broken down by grade level and paired with a crosscutting concept and a few practices. The entire endeavor took three years to complete, but the result is a comprehensive set of national standards that encourage inquiry in science and seek to challenge students.

There are multiple ways science can be taught: science as a product, science as a process, or science as problem solving (Schuster, Cobern, Adams, Undreiu, & Pleasants, 2017). The

Next Generation Science Standards still identify core ideas students need to know before they graduate high school, much like previous standards. This would be teaching science as a product. Having the students know facts and specific information. However, the way in which these performance expectations are written allows for a deeper understanding of those core ideas by students (Pruitt, 2015). This is because the core ideas are not the sole focus of the PE. They are only a small part of the PE and are combined with the practices and crosscutting concepts. This allows students to connect principles with practice (Feinstein & Kirchgasler, 2014). These core ideas are combined with the science and engineering practices in order to allow for teaching science as a process or as a problem.

The science and engineering practices are actions that are carried out by the students. For example, one of the practices is constructing explanations (NGSS, 2018). This will be combined with a disciplinary core idea, for example the history of planet Earth and a crosscutting concept of patterns (NGSS, 2018). Rather than the teacher providing students with an explanation for the patterns the emerge in Earth's history, students will explore this topic by gathering information and construct their own explanation. Creating the performance expectations in this manner provides students an opportunity to become responsible for their own learning and move from a teacher-directed classroom to a student-centered class (Pruitt, 2014). The performance expectation for this particular topic would be, "Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history" (NGSS, 2018, "Earth's Place in the Universe", para. 1).

The NGSS are designed to prepare students for college and careers. By developing 21st century skills such as collaboration and teamwork, students are preparing for life after high school (NGSS, 2013). The practices used by students also help foster these skills. The NGSS are also designed to work cooperatively with the Common Core State Standards (CCSS). Many of the practices in the math and language arts CCSS seamlessly overlap with the NGSS practices (NGSS, 2013). This overlap allows for common language to be used across content areas.

According to Albarracin and Shavitt (2018), attitudes are "partly memory based and partly constructed on the fly" (p. 302). This means that part of what makes an attitude is ingrained in one's memory and is not likely to change while the other part is dependent upon one's mood at that point in time. Attitude also varies in strength, which can influence the way one behaves (Howe & Krosnick, 2017). If someone has a strong attitude towards a topic, it is likely to affect their "thoughts, intentions, and behaviors" (Howe & Krosnick, 2017, p. 328). Attitude is not the only factor that influences behavior, but it is does impact learning (Lovelace, & Brickman, 2013). The way science is taught can be interpreted differently for students. If a student is a kinesthetic learner, his/her attitude about the topic may change if involved in an inquiry-based learning activity. Because of this impact, it is important to assess students' attitudes towards science.

Student attitudes toward science have become increasingly important as researchers are seeing a decline in the number of students going into careers that involve science, even though the number of jobs available in science are increasing (Hillman, Zeeman, Tilburg, & List, 2016; Kennedy, Quinn, & Taylor, 2016). However, determining students' attitude towards science has proven difficult. One key reason for this is that individuals' attitudes can change (Bohner & Dickel, 2011). If an individual is given new information at the time of data collection, it is possible that may influence their attitude toward the topic in the moment (Bohner & Dickel, 2011). Another reason is there are two distinctly differing thoughts on attitude. One thought is that attitudes are stable and stored in memory while the other thought is that attitudes are temporary and formed from the information on hand at that moment in time (Gawronski, 2007). In order to measure attitude, psychologist have historically used self-report scales where individuals respond to items that relate to attitude and how they feel about a topic using a Likert-type scale (Bohner & Dickel, 2011). Providing individuals with a range of options to choose from allows them to relate the question to their thoughts on the topic easier than coming up with responses on their own. This type of response is still able to provide researchers with an accurate representation of the participant's thoughts and feelings about a particular question.

Problem Statement

The research on constructivism and inquiry-based learning is quite extensive. Not only are there great philosophers like Dewey, Piaget, and Vygotsky to provide insight as to how individuals construct knowledge, there are many researchers who have studied their way of thinking and conducted studies on the use of constructivism in science. It is through the results of these studies that information has emerged confirming the importance of implementing a constructivist approach to teaching science (Colburn, 2018; Barak, 2017; McCauley, Gomes, & Davison, 2017; Lynch, 2016; Bachtold, 2013). Researchers have found that allowing students to construct new knowledge through social experiences increases their understanding of the material (Barak, 2017) and allows them to make connections to real-world situations (Bachtold, 2013). Although the research is extensive in the use of a constructivist approach to science, there is little research that investigates the connection between a constructivist approach to science and the Framework behind the Next Generation Science Standards (NGSS) and a three-dimensional approach to teaching (crosscutting concepts, disciplinary core ideas, and science and engineering practices).

Research has emerged in the last 20 years regarding inquiry-based learning and the impact it has on students in the classroom. More recently, research has been conducted that focuses on using an inquiry-based learning approach in science to help students obtain 21st Century skills they'll need in the workplace (Alozie, Grueber, & Dereski, 2012) as well as provide them with real-world problems with which they can make deeper connections (Fernandez, 2017). There is no available research that makes any connection between the Framework of the Next Generation Science Standards and inquiry-based learning, however researchers have noted the difference between the two, which is that inquiry-based learning doesn't always focus on the building of knowledge (Duncan & Cavera, 2015).

Of course, teachers want to teach in a way that will allow their students to reach their full potential. One way for teachers to determine if their students are making gains is to determine whether or not they are growing academically throughout the year. With the barrage of testing that is bestowed upon students, it makes sense to use the data in this way. It has become apparent more recently that a greater focus should be placed on measuring academic growth because it is more beneficial to look at a students' progress over time rather than focus on one static point (Anderman, Gimbert, O'Connell, & Riegle, 2015). While teacher buy-in of educational reforms and curriculum has been researched (Lee & Min, 2017), there is a lack of research that focuses on the ideas of the NGSS Framework and whether they impact academic growth in the area of science.

The other question is whether or not this three-dimensional teaching has any impact on students' attitudes toward science, particularly in the middle school classroom. While attitude in and of itself has been researched, attitude toward science has been historically difficult to capture based on the mixed data retrieved from a variety of instruments (Hillman, Zeeman, Tilburg, &

List, 2016 and Kennedy, Quinn, & Taylor, 2016). Although attitude can be measured using a self-rating scale, it has yet to be determined if this shift of teaching from a teacher-directed approach to student-centered learning has any impact on students' attitude toward science.

The focus of research thus far in research has been what NGSS is and the Framework that was established in order to build the standards. Tools have been developed to evaluate the curriculum (Houseal, 2015; O'day, 2016; and Krajcik, 2015), but educators don't know how students will react to a NGSS aligned curriculum or if it will allow them to become better thinkers. The problem is the lack of empirical research on the impact of a three-dimensional curriculum on students' attitude toward science and academic growth in science.

Purpose Statement

The purpose of this causal-comparative design study was to compare students' academic scores and attitudes towards science before and after implementation of a curriculum incorporating three-dimensional learning (crosscutting concepts, disciplinary core ideas, and science and engineering practices). This research study employed a causal-comparative design. In a causal-comparative design, determining whether or not there is a cause-and-effect impact is the sole purpose (Gall, et al., 2007). In ex post facto research, the data is collected from a naturally occurring scenario, in this case the NWEA and survey data from previous years (Gall, et al., 2007). The rationale for using this design was to determine if there was a cause-and-effect impact between the NGSS aligned curriculum and student test scores or their attitude towards science. Data analysis was conducted between each grade level (7-8) and their NWEA scores and MATS scores. *t*-tests were used to determine if there was a statistically significant difference of groups on each of the dependent variables (Gall, et al., 2007). The independent variable, presence of Next Generation Science Standards aligned curriculum, is generally defined as lessons developed by curriculum creator TCI that align to the NGSS and meet the needs of all aspects of the standards which incorporate three-dimensional learning. The first dependent variable, NWEA science, is generally defined as a nationally normed standardized assessment used to assess students' knowledge of the NGSS. The second dependent variable, attitude towards science, is generally defined as students' thoughts and feelings about science as measured by the My Attitude Toward Science (MATS) survey (Hillman, Zeeman, Tilburg, & List, 2016).

Significance of the Study

This study is significant at the local, state, and national level. While 18 states have adopted the Next Generation Science Standards and are beginning the transition from their old state standards to the new national ones (NGSS, 2018), the adoption or adaption of curriculum is a daunting task. There are companies, like TCI, that have put forth efforts to align their curriculum to NGSS in hopes of states implementing their curriculum into schools. However, whether or not these new standards, and the curriculum that is aligned to NGSS, will have an impact on students has not yet been determined.

Having empirical data that shows improvement in academic scores or in attitude towards science would show these states that the NGSS have a positive impact on students. The information from this study would also inform decisions for professional development for pre-service teachers to ensure they're properly prepared for the new science standards. As noted by Bybee (2014), "The changes implied by the Framework … imply dramatic changes in teacher education programs" (p. 217). Professional development for teachers already in the classroom may be necessary as well to ensure their understanding of the new Framework. The data from this study also added to an increasing amount of research regarding the theory of constructivism as many researchers interested in inquiry-based science have started focusing on students being the focus of the lessons, as is the case with NGSS aligned curriculum.

Research Questions

This study sought to answer the following questions:

RQ1: Is there a difference between science scores of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards?

RQ2: Is there a difference between attitude towards science of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards?

Definitions

1. *Attitude*- In this study, attitude will refer to one's attitude toward science, which is "the emotional reactions of students towards science… interest, satisfaction, and enjoyment" (Gardner, 1975, p. 2).
2. *Inquiry-based Learning*- Activities that engage "students in an authentic scientific discovery process" (Pedaste, et al., 2015, p. 48).
3. *Constructivism*- Situations in which students take an active role in their learning (Peoples, O'Dwyer, Wang, Brown, & Rosca, 2013; Ural & Bümen, 2016). In this study, constructivism will also refer to students learning through social interactions (Lynch, 2016; Bächtold, 2013).
4. *Authentic learning experience*- Learning experiences that replicate a real-world scenario that are "meaningful and useful" to students (Fernandez, 2017, p. 2).
5. *NGSS*- Next Generation Science Standards (NGSS, 2018)

6. *NWEA*- Northwest Evaluation Association (NWEA, 2018)

7. *MAP*- Measures of Academic Progress (NWEA, 2018)

CHAPTER TWO: LITERATURE REVIEW

Overview

When comparing American students' success in science with other students around the world, scores remain much lower than those living in other advanced industrial nations (DeSilver, 2017). To enhance students' learning in science, the Next Generation Science Standards (NGSS) were developed. The problem is determining whether the new standards have allowed students the ability to improve in science. A thorough review of the research was conducted to identify studies that explore the integration of the NGSS in middle school science classrooms. This chapter will provide an overview on the existing literature related to the study. The first section will discuss the theories of constructivism which was selected as a framework and how it relates to the central phenomenon. The constructivist theory focuses on the learner and how students construct their own knowledge of a topic, which is similar to the NGSS Framework. Another theory closely related to NGSS is the experiential learning theory which is founded on the belief that students learn best when provided with real-life experiences. The final theory, expectancy-value theory, will relate attitude to the students' desire to accomplish a task. The second section will synthesize the recent literature pertaining to the Next Generation Science Standards focusing on the background of what they are, the Framework that makes up the standards, and the three-dimensional learning that they encompass. This section will also focus on defining attitude in the classroom, specifically what this means in the science classroom as well as inquiry-based learning as it relates to NGSS.

Theoretical Framework

In quantitative research, a theoretical framework is important as it guides the research design of the study. This particular framework is influenced greatly by the theories of Vygotsky and Piaget. While very different in some respects, both had constructivist views. Vygotsky and

Piaget believed that humans learn by experience and piecing together past experiences to understand new learning (DeVries, 2000). Being constructivists, both also believed that learning has a social aspect and that humans learn better when they can explore their learning in a social setting.

Constructivist Learning Theory

The development of the Next Generation Science Standards (NGSS) has its roots in constructivism, which proposes that students take an active role in their learning (Peoples, O'Dwyer, Wang, Brown, & Rosca, 2013; Ural & Bümen, 2016) and that students learn through social interactions (Lynch, 2016; Bächtold, 2013). When students have the opportunity to discuss what they are learning, it is believed they will learn better and retain that information. The NGSS provide ample opportunities for students to take control of their learning and interact with others. According to Gall, Gall, and Borg (2007), constructivism is based on the idea that "social reality is constructed by the individuals who participate in it" (p. 21).

While there are differing views surrounding constructivism as a theory of learning, the consensus is that "knowledge is not discovered but is rather constructed by the human mind" (Krahenbuhl, 2016, p. 98). Believers of this theory see the acquisition of knowledge as reliant on experiences rather than direct instruction from a teacher. In a constructivist approach, students are provided opportunities to discover new concepts on their own, gather information, and form their own knowledge through this process.

Constructivism has its roots in the theory of Piaget (1952) who believed that children use their interaction with the environment to construct knowledge. These actions with the environment could be ones physical in nature where they encounter hands-on experiences or ones in which they gain knowledge to expand their schema (Harlow, Cummings, & Aberasturi, 2007). When an interaction with the natural world does not coincide with the schema that exists, new knowledge must be constructed in order to make sense of this phenomenon. It is then that an individual will have a better understanding of the topic and will have come to this conclusion on their own.

One way a curriculum can offer activities conducive to a constructivist approach is to allow student to be engaged in hands-on experiences that allow them to be physically involved with their learning (Krahenbuhl, 2016). However, providing students with situations in which their prior knowledge is challenged can also promote the construction of knowledge (Bachtold, 2013). In this case, they will become curious about the phenomenon and develop a desire to figure out where the gap in their current knowledge exists. This motivation for information discovery will allow students to gather additional data and construct knowledge on their own.

Another aspect of the constructivist learning theory is that learning is a social experience, not one completed individually (Barak, 2017; Colburn, 2000; Kruckeberg, 2006; Lynch, 2016). Students, when provided with experiences that allow them to discuss ideas with others, can construct knowledge in a social setting. This social constructivism could include debates, group projects, class discussion, etc. Providing students with an opportunity to discuss new knowledge allows them the platform to develop new ideas about a topic. Oftentimes, this social interaction allows an individual to think at a higher level and develop deeper connections with the phenomenon.

Kolb's Experiential Learning Theory

The experiential learning theory (ELT) was first established by David Kolb (1984) who believes "learning is the process whereby knowledge is created through the transformation of experience" (p. 38). Believers of this theory in education feel that learning happens when students are engaged in real-life experiences. According to McCarthy (2016), ELT combines "experience, perception, cognition, and behavior" and each of these lead to knowledge when combined with grasping and transforming experiences (p. 92). This theory has roots in Dewey's beliefs that experiences lead to learning, however Dewey did not place an emphasis on the relationship between the creation of knowledge or learning and those experiences (as cited in Seaman, Brown, & Quay, 2017). Although varying in their exact definitions of learning experiences, both Kolb and Dewey believed that learning happens on an individual level (as cited in Yardley, Teunissen, & Dornan, 2012). These beliefs tie in with a constructivist view that each learner constructs their own knowledge based on their individual experiences. The idea that every learner's experience is unique due to the fact that their interpretation of the experience is going to vary based upon their own previous knowledge and feelings toward the topic.

The experiential learning theory has been researched in the area of science learning as many curricula offer opportunities for learners to engage in real-life experiences. In many of the studies conducted on this topic, there was a positive reaction from the students involved. In one study, students gained information about how science can be used in a career they wish to pursue and were provided realistic situations they may face (Malone, Rickard, & Tudor, 2016). In this study, animal science students were provided with hands-on opportunities to experience what it would be like to develop and manage a pen of beef cattle. Other studies showed an increase in student motivation and attitude regarding science with experiential learning (Swanson, 2011; Rihtarsic, Avsec, & Kocijancic, 2016; Dzan, Tsai, Lou, & Shih, 2015; Scogin, Kruger, Jekkals, & Steinfeldt, 2017). It has been found that students who feel as though they are going to use what they're learning later in life, or if what they are learning in science has real-life applications, they are not only more motivated to participate but they are also more likely to enjoy the learning process.

Expectancy-Value Theory

Originally developed by John Atkinson (1957) with a focus on what causes individuals to conduct risk-taking behaviors, the expectancy-value theory (EVT) has since evolved. Supporters of the expectancy-value theory believe "individuals' choice, persistence, and performance can be explained by their beliefs about how well they will do on the activity and the extent to which they value the activity" (Wigfield & Eccles, 2000, p. 68). Eccles, Wigfield, and colleagues have conducted several studies in which they test the EVT and determine exactly what it is that influences one's expectancy and values and how they are developed (Eccles, et al., 1983; Eccles & Wigfield, 1995; Eccles, Wigfield, & Schiefele, 1998; Wigfield, 1994; Wigfield & Eccles, 1992). In this theory, it is believed that students' motivation for certain tasks is directly related to whether they feel they will succeed or fail during that task.

The expectancy-value theory can be broken down slightly to focus directly on the value aspect of the theory. When an individual begins making a decision, he or she must weigh the different valuations of the given options in order to make a decision (Galla, Amemiya, & Wang, 2018). This decision could be whether or not to complete an activity in science class. If the student views the task as either unimportant or too difficult, he or she may not place a high value on the completion of that assignment. However, if a student feels as though he or she can be successful or feels the assignment is valuable, the student is more likely to become motivated to complete the task.

Focusing just on the expectancy piece of the EVT, individuals have a more positive attitude or feel more confident in an area, they will expect to do better in this area. Guo, Marsh, Parker, Morin, and Dicke (2017) found in their study that students who performed well in a specific area of science (physics, chemistry, biology, or earth science) expected to always do well in this area and valued this particular domain more than any of the others. In turn, students who performed well in a specific domain showed more intrinsic motivation to continue to do well in this domain (Guo, et al., 2017). While expectancy and value are separate and can be measured separately, they are very much connected. When individuals feel confident, they place a higher value on that topic and expect to continue to do well. Their attitude toward this subject will mirror their expectations and values.

In regard to this study, the expectancy-value theory is directly related to beliefs about attitude. If a student is not confident about their abilities and expect to do poorly on a task, their attitude toward that task, and inevitably the subject, will be negative as well. It was found that students' beliefs about their abilities become more negative the older they get (Wigfield & Eccles, 2000). Students have learned up to this point that their abilities will be evaluated, and they begin to compare themselves to their peers. With this study's focus on middle school students, these findings are relatable to the participants.

Related Literature

Science is defined as "the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment" (Science, 2018, p. 1). The way in which students observe and conduct experiments is dependent upon the teaching style of the instructor. Some teachers instruct through lecture, providing students with all the information they need. Other teachers believe students learn best when they are responsible for their learning and provide them opportunities to obtain information on their own. The former is becoming a less frequent method of instruction, while the latter is gaining in popularity. The NGSS (2013) support this style of learning for students, encouraging students to become active in their learning. This format of science instruction is often referred to as inquiry-based learning.

Inquiry-based Learning

The NGSS relate closely with inquiry-based learning (IBL) as, according to Pedaste, et al. (2015), it “engages students in an authentic scientific discovery process” (p. 48). Providing students with these authentic experiences will allow them the opportunity to discover as scientists would. This does not necessarily mean they are discovering new knowledge, however they are discovering knowledge that is new to them in a way that enables them to take responsibility for that discovery (Pedaste, et al., 2015). Allowing students to engage in kinesthetic activities has been shown to increase engagement and motivation (Pyatt & Sims, 2012). These kinesthetic activities are the foundation of inquiry-based learning.

One of the key elements of inquiry-based science is cooperative learning groups (Woods-McConney, Wosnitza, & Sturrock, 2016). In a real-world scenario, many scientists would work together to conduct experiments or synthesize data to determine an explanation for a phenomenon. The same is true for students when learning with IBL. Modeling the methods used by scientists has been shown to improve student interest and achievement (McConney, Oliver, Woods-McConney, Schibeci, & Maor, 2014). This includes working cooperatively in a group. Students who experience real-life scenarios are more likely to show interest in that activity because they can relate their learning to the real world. There isn’t a question of, “When am I every going to use this skill?” because they are learning through a possible real-life application of that skill.

Another key element of inquiry-based learning is the 5E structure that is typically followed. According to Pedaste, et al. (2015), these five parts are typically identified as “engagement, exploration, explanation, elaboration, and evaluation” (p. 48). While these are the phases most commonly used in inquiry-based learning, Pedaste, et al. (2015) found that these should not be a prescribed set of steps, but rather a fluid process in which students may go back and forth between the phases in order to reach the final phase. In fact, the new model created by Pedaste, et al. (2015) includes orientation, conceptualization, investigation, conclusion, and discussion. In their model, discussion is occurring throughout all the other four phases. Their model also allows students to move backwards from investigation to conceptualization if their results were not valid. This is a more realistic model as it provides students with an experience similar to scientists.

Inquiry-based learning challenges the science classroom to go beyond memorizing facts. Students are not asked to regurgitate information on tests but are instead challenged to learn through exploration and show what they know in a more natural way. Students are able to ask their own questions about the world and discover the answers on their own. “Science inquiry encourages the development of problem solving, communication, and thinking skills” (Cuevas, Lee, Hart, & Deaktor, 2005, p. 338), which will enable them to obtain important and necessary skills in the area of science. The goal of the Next Generation Science Standards is to improve science literacy across the United States. In a study conducted by Cuevas, et al. (2005), the researchers found that allowing students to experience science rather than just learning about it developed students’ inquiry ability regardless of their age or background. This improvement in inquiry abilities will help to develop a life-long love of science.

Authentic learning experiences. Inquiry-based learning provides students with authentic learning experiences. Authentic learning experiences are ones that replicate a real-world scenario that are "meaningful and useful" to students (Fernandez, 2017, p. 2). When students are examining real-life problems, they are going to become more invested and have a stronger desire to discover a solution. When provided with these experiences, students will be able to see how they can use what they are doing later in life and how what they are investigating impacts them. These authentic learning experiences provide students with skills they may not have gained otherwise, such as judgment, patience, synthetic ability, and flexibility (Swartz, 2016).

Authentic learning experiences can be defined differently based on the situation, however all instances where authentic learning experiences are present have similar characteristics. The key word in this approach to learning is authentic. Providing students with real, relatable experiences is necessary. These experiences allow students to make meaning from their learning. This meaning comes from making connections between what they already know and what they are learning across all content areas. It also comes from making connections with what they're learning and what they know about the real world. In a study conducted by Chen, et al. (2013), students found they were better able to focus during class and enjoyed the learning process more when being taught in an authentic learning environment. The researchers took a skill that was already being taught in the school and created an authentic learning experience. One group received this method of learning while the other group was taught using traditional methods the school always used. This study found that students who were taught using the authentic learning experience had greater improvement from pre- to post-test scores than those in the control group (Chen, et al., 2013).

Making science learning more meaningful for students will allow them to make connections between what they're learning in the classroom and the work that is being done by scientists and engineers all over the world. The Next Generation Science Standards' focus on creating science literate students can be greatly supported by introducing authentic learning experiences in the science classroom. This connection becomes even more meaningful when students are able to apply these experiences to their own environment. While it may take re-teaching teachers and revising the curriculum in schools, the way to create science literate citizens is through authentic learning (Quigley, 2013).

Challenges. While many studies have shown inquiry-based learning to increase student achievement (Woods-McConney, et al., 2016; Pedaste et al., 2015) and engagement in science (McConney, 2014), there are challenges that arise when implementing IBL in the science classroom. One problem that may hinder progress when using an inquiry-based learning approach is that students who have no prior experience with IBL may not have the skills needed to engage in this type of learning properly. Woods-McConney, et al. (2016) recommends that teachers provide students with explicit teaching when it comes to working cooperatively in groups. Students need to know how to discuss what they are learning, argue about their findings, and share their conclusions in the end. Teachers must be able to identify when students need scaffolded instruction, where they provide some support at first and then slowly pass the responsibility over to the student (Woods-McConney, et al., 2016).

Teachers themselves also pose a challenge in inquiry-based learning. Often, teachers have a role as the leader in the classroom. They may feel their job is to impart their knowledge on students through explicit teaching. Some teachers have difficulty relinquishing this responsibility (Dorier & Garcia, 2013). Inquiry-based learning forces teachers to become active by-standers whose purpose is to guide students and provide support when necessary. Many teachers are used to being the main source of information for their students and may have difficulty letting go of this role. It would be necessary to provide teachers with professional development that enables them to understand their role in an inquiry-based learning setting and provides them with support and strategies for making IBL work in their classroom (Dorier & Garcia, 2013).

Attitude

Defining attitude can be quite the task as there are many thoughts as to what makes up one's attitude. In research that has been conducted thus far regarding attitude toward science, it is difficult to compare results as the researchers used a variety of criterion for defining attitude. One study used self-variables as a means for determining attitude such as self-concept and self-efficacy (Marsh, 1992), while another used perceived value of science, or its usefulness, and science affect (Rennie, 1986). When measuring attitude, it is important to understand that it is multidimensional.

According to Albarracin and Shavitt (2018), attitudes are "partly memory based and partly constructed on the fly" (p. 302). This means that part of what makes an attitude is ingrained in one's memories and is not likely to change while the other part is dependent upon one's mood at that point in time. Attitude also varies in strength (Howe & Krosnick, 2017), which can influence the way one behaves. If someone has a strong attitude towards a topic, it is likely to affect their "thoughts, intentions, and behaviors" (Howe & Krosnick, 2017, p. 328). Attitude is not the only factor that influences behavior, but it is does impact learning (Lovelace, & Brickman, 2013). Because of this impact, it is important to assess students' attitudes towards science.

Measurement of attitude towards science. As noted previously, science attitudes are multidimensional, and it is important to understand the varying aspects of attitude toward science when attempting to measure attitude. Hillman, Zeeman, Tilburg, and List (2016) saw four key aspects of attitude emerge in the literature on science attitude which are students' feelings about science, their interest in seeking a science-related career, their stereotypical beliefs about scientists, and their feels towards technological advances in the field of science. Through exhaustive research in the field, this combination of self-concept variables, value, and effect of science allow a wide range of attitude concepts to be addressed.

Student attitudes toward science have become increasingly important as researchers are seeing a decline in the number of students going into careers that involve science, even though the number of jobs available in science are increasing (Hillman, et. al., 2016; Kennedy, Quinn, & Taylor, 2016). However, determining students' attitude towards science has proven difficult. There are multiple instruments that have been used, but challenges have arisen because of their lack of reliability and/or validity. Two instruments were recently developed. In both cases, researchers conducted extensive research on previous instruments and sought to improve upon both reliability and validity of their instruments. In both cases, students' attitude towards science is assessed. However, in the instrument developed by Hillman, et al. (2016), My Attitude Towards Science (MATS), attitude was measured in respect to four different categories: attitude toward school science, desire to become a scientist, value of science to society, and perception of scientists. The MATS instrument was used to determine not only students' attitudes towards science, but their desire to seek a career in science as well. On the other hand, the instrument developed by Kennedy, Quinn, and Taylor (2016) focuses more on students' attitude towards science in relation to their attitude towards school in general. This instrument allows researchers to gather data about how a student's attitude can change over time. Both instruments were determined to be valid and reliable.

Attitude and achievement. The relationship between attitude and achievement has been widely researched. Several studies have been conducted reviewing students' attitudes towards science and their achievement in this topic (Mattern & Schau, 2002; Willson, 1983; Steinkamp & Maehr, 1983; Weinburgh, 1995). In all of the studies, a correlational relationship was found between science attitude and science achievement. In each of these studies, students who had a greater self-concept and a more positive attitude toward science experienced greater achievement in science.

One factor that influences attitude is interest. If a student is more interested in science, they are more likely to perform better in science (Romine, Sadler, & Wulff, 2017). Some students are naturally interested in science. They may have parents who have instilled a love for science in them from a young age. This interest could also come from a natural curiosity about the world. However, interest can also be influenced by a students' experiences at school (Romine, et al., 2017). If a student has had a positive experience with a science teacher, lesson, or classroom environment they may show interest in science for this point in time. This temporary interest could be influenced by a curriculum or an engaging lesson. If a student is more interested in what they're learning, it makes sense they will perform better academically.

Another factor that influences attitude is motivation. This motivation can either be intrinsic, which comes from within the student, or extrinsic, which comes from an outside source. Motivation can be defined as behavior that is goal-directed, and individuals who are motivated, show a greater amount of effort than individuals who are unmotivated (Masgoret & Gardner, 2003). If a student is putting forth more effort on a task or towards a specific class, it is likely that they will show greater academic gains that an individual who isn't putting forth as much effort. This could be true regardless of the ability of the student. If a student with great general ability does not apply himself and put forth a certain amount of effort, it is likely they would not show achievement in that subject area.

One study determined that motivation has just as great of an impact on achievement as it does on students' attitudes (Bernaus & Gardner, 2008). The key in increasing motivation is in understanding motivation and how to properly motivate students. In order to effectively motivate students, it is necessary to focus on effort rather than ability, developing relationships with students, and setting small, attainable goals (Bernaus & Gardner, 2008). All of these have the ability to not only provide extrinsic motivation, but to help foster an intrinsic motivation with students. Students who place high expectations on themselves tend to be motivated more intrinsically because they want to reach these expectations for personal validation while students who want to please others will be motivated more extrinsically, which could be goals or rewards set by someone else (Mills & Blankstein, 2000).

Both interest and motivation can influence attitude, which then has an effect on achievement. When students are more interested in a topic or are motivated to reach goals in a subject area, they are also more likely to have greater achievement in this area. In science, creating engaging lessons can create interest for students. Allowing students to become part of the lessons and having students actively involved in their learning can create motivation. Both of these are goals of the Next Generation Science standards.

Attitude and grit. Another important factor to consider when it comes to success and one's attitude towards a topic is grit. Grit is important in the area of education as it is what allows students to continue through difficult tasks and, eventually, master skills and obtain knowledge. Whether that is learning why trees look different at different times of the year or studying advanced biochemistry, without grit, the learner wouldn't be able to continue when concepts became difficult.

Grit is defined as a combination of both perseverance and passion for long-term goals (Weisskirch, 2018; Duckworth, et al. 2007). When an individual has grit, a common characteristic is working tirelessly at a task, regardless of whether or not they feel they can accomplish the goal. Oftentimes, grit is shown when a student fails, but makes a conscious choice to continue trying to solve the problem or accomplish the goal.

Grit is a characteristic that can be shaped in many ways. One way to increase a student's grit is to foster perseverance. Lewis and Özgün-Koca (2016) discovered that the only way to develop perseverance is to use tasks that warrant perseverance. If teachers provide students with tasks that do not challenge their abilities, students will never have to reach the point of frustration. It is at this point of frustration that a student is able to make the decision between giving up and continuing on. When the decision to continue trying is made, perseverance exists. If a student then goes on to have success, they will create a connection between the effort they put into the task and the reward that was rendered at the end. Building perseverance is only done through these challenging tasks. It is also important for teachers to allow students to struggle productively. There is a point when a teacher may need to intervene so the child doesn't give up and regress, but allowing a child to struggle is important for building perseverance. It is important for teachers to provide their students with a variety of problem-solving strategies so they are able to be successful (Lewis & Özgün-Koca, 2016).

Grit is also influenced by an individual's experiences in life (Weisskirch, 2018). Experiences of success and failure can shape an individual's level of grit. Depending on the personality of the individual, when met with failure, their level of grit may increase or decrease. One person may see failure as an opportunity to approach the problem in a different way while another person may give up entirely, especially if it is not the first time at failure. Grit is not a fixed trait, and can increase or decrease depending on the individual's experiences and current circumstance (Duckworth, et al., 2007).

The other key component of grit is passion. Jachimowicz, et al. (2018) define passion as "a strong feeling toward a personally important value/preference that motivates intentions and behaviors to express that value/preference" (p. 9980). In this definition, passion can be both negative and positive. Passion is an important aspect of grit because passion is what allows a topic or goal to be meaningful to the individual. If a student is provided with a challenge problem, and they don't feel passionate about solving the problem, they may persevere through the task, but it doesn't mean they enjoy the process. Rather, if a student isn't passionate about the challenge, they're just moving through the motions in order to appease their teacher or to obtain the grade for the course. Passion also allows an individual to become immersed in the topic (Jachimowicz, et al., 2018). The intensity of a student's focus on the topic, and ultimately the knowledge they acquire through the task, is dependent upon their level of passion about the challenge problem.

Several studies have shown positive correlation between students' level of perseverance and their academic achievement (Bowman, et al., 2015; Strayhorn, 2013; Weisskirch, 2018; Wolters & Hussain, 2014). Wolters and Hussain (2014) discovered in their study that college students who scored higher in perseverance of effort, which is one aspect of grit, performed better academically. The opposite was also true, individuals with low perseverance did not perform as well academically as compared to their peers. Bowman, et al. (2015) conducted a study using college students' levels of grit and GPA scores. Through their study, they discovered a positive association between grit and GPA. Students who scored higher on the survey in areas pertaining to grit also obtained higher GPA scores. A third study found that, when controlling for previous achievement, grit still was a predicting factor in academic success of students (Strayhorn, 2013). Regardless of their previous academic success in high school, students' GPA was successfully predicted by the amount of grit the student possessed.

Historical Overview of Science Reform

The need for educational reform was first recognized in 1983 a report written by then Secretary of Education Terry Bell entitled *A Nation at Risk*. President Ronald Regan stood before television cameras and read this report to the nation in order to enlighten the public on just how far behind America was when it came to education. In this report, Bell lists the effects of America's declining education system which are a decline in test scores, low teacher salaries, poor teacher training programs, high turnover rate for teachers, a steady decline in SAT scores, a steady decline in science achievement, the fact that 23 million American adults are illiterate, and a decline in other necessary skills for high school seniors (US Department of Education, 1983). US Department of Education (1893) noted that all of this is happening at a time when America needs a generation of individuals who are skilled at working with computers and understanding technology using science and math. If high school and college students continue to emerge from their educational experiences unprepared for work in the ever-changing world, unforeseen problems will begin to arise. It is with this report that the government recognized a need for a reform in education.

The reform for science education began in the 1980's with Project 2061. In 1989, Project 2061 published *Science for All Americans* which outlined what individuals need to know and be able to do in science, math, and technology in order to create a generation that is science literate. This publication includes chapters outlining specific items that need to be added to educational curriculums in elementary through higher education. Project 2061 is focused on the long rather than short-term goals of science education. It was initiated in 1985, which was the last year Halley's comet was seen from Earth, with the idea that improvements needed to be made in order for this generation of individuals to have a better understanding of science before they see Halley's comet again (AAAS, 2013).

In the 1980's, many educational reports summarized similar issues that were beginning to arise in American education. America's domestic affluence and international power began to decline drastically as other countries rose to replace America (Rutherford & Alhgren, 1994). This decline was due to several trends that were found by Rutherford and Alhgren (1994) including "low test scores, students' avoidance of science and mathematics, a demoralized and weakening teaching staff in many schools, low learning expectations compared to other technologically advanced nations, and being ranked near the bottom in international studies of students' knowledge of science and mathematics" (Chapter 14, para. 2). Of course, reform in education cannot happen overnight. The first step is to identify the areas in which education needs to improve, then convince educational entities of the need to implement these improvements.

In order for changes to occur in education, the teachers have to understand the warrant for the change and become invested in the process. Many times, demand for change that comes from the top down without any regard to the teachers' interests or ideas will not be readily accepted (Rutherford & Alhgren, 1994). In fact, teachers are often skeptical of change because of how often ideas about the "right" way to do things come and go. This is the reason

Rutherford and Alhgren (1994) suggest including teachers in the process, listening to their ideas and prospective from inside the classroom, having administrators collaborate with teachers, and ensuring that the needs of teachers in regards to resources are met in order to establish teacher buy-in.

In 1987, The Science Education for Public Understanding Program (SEPUP) began developing hands-on science curriculum at their site at the University of California-Berkeley. SEPUP began after the report *A Nation at Risk* was released in order to develop hands-on materials that would educate the public (SEPUP, 2019). Today, their resources are readily available to schools and their focus has shifted in order to create curriculum for school districts. The focus of the material that SEPUP creates is on current issues of the world. The goal of issue-oriented science is to “engage students in the process of learning science, encourage students to use scientific evidence to make decisions, and help educate tomorrow’s citizens about the application of science to everyday life” (SEPUP, 2019, para. 5). In their lessons, students are shown evidence that supports a real-life issue. Naturally, questions arise regarding the information they’ve been presented, and students are able to explore the issue further. This is the first time curriculum has been created that approaches science education in this manner.

In 1996, The National Research Council (NRC) developed the National Science Education Standards (NSES). Included in this document are “standards for teaching, professional development, assessment, content, program, and the educational system” in order to develop more science literate citizens (Bybee & Champagne, 2000, p. 54). It was important to include the education of teachers in these standards in order to develop a better understanding of science for teachers in preparation programs in their college courses as well as professional development for established teachers. It wouldn’t be possible to educate students fully without having educated teachers in the classroom. The NRC worked together with many science-oriented groups including the National Science Teachers Association and the National Science Foundation to establish areas of focus and the breakdown of these areas (Collins, 1998). The standards are not a prescription of curriculum and assessments, but instead are a suggestion of changes and improvements that should be made as well as what students should know and be able to do in science (Bybee & Champagne, 2000).

Over the next few years, the focus of education reform moves to math and reading with the introduction of the No Child Left Behind Act. It is not until 2007, when the National Academy released the report *Rising Above the Gathering Storm*, that the focus returned to science. This report was a review of trends between the United States and other countries. The findings in this report gave actual numbers of the decline in science, technology, engineering, and math (STEM) literacy. This decline raises concerns about the future prosperity of the United States in the 21st century. In order to reverse the trend, the National Academy made four recommendations. These recommendations were to: add 10,000 qualified math and science teachers in schools, increased federal funding for basic research, increasing the number of U.S. citizens earning STEM degrees, and to address economic policies that reward innovation (Byko, 2007). After the release of this report, federal, state, and local agencies began stepping up to support the recommendations. Bills were sent to congress and private organizations donated money for programs supporting STEM courses in high schools.

The next big change in the reform of science education came in 2011 with the Next Generation Science Standards (NGSS). Considering over 15 years had passed since the implementation of the National Science Education Standards, much has changed in the world of science. This was initiated in 2009 by the Carnegie Corporation's report *The Opportunity*

Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy. When nothing was being done after the release of the 2007 report *Rising Above the Gathering Storm*, the Carnegie Corporation felt they had to do something in order to address the fact that "the world has shifted dramatically-and an equally dramatic shift is needed in educational expectations and the design of schooling" (Carnegie Corporation, 2009, p. vii). The Carnegie Corporation, after realizing the standards were outdated, funded a project to create new standards that would address the needs of the 21st century learner. With funding from Carnegie, school leaders, governors, scientists, educators, and the National Research Council (NRC) worked together to develop the Framework, which would be the Next Generation Science Standards (NGSS) (Carnegie Corporation of New York, 2019).

The nation's report card, provided by the National Assessment of Educational Progress (NAEP) showed a slight increase in the national average in science from the previous assessment to the most recent in 2015 for students in grades four and eight, however there was no change in the average for students in grade 12 (NAEP, 2015). The increase in 8th grade was two points from 2011 to 2015 and four points from 2009 to 2015 for 4th grade students (NAEP, 2015).

In the state from which the students in this study reside, 8th grade students scored significantly lower on the National Assessment of Educational Progress (NAEP) testing for science in 2015 (NAEP, 2015). The percent of students proficient on this test has remained stagnant since 2009. With the majority of 8th grade students not meeting proficiency in science, there is definitely a need to change the way science is taught in this state.

Science Standards

Standards provide a guide for teachers on what their students should know and be able to do by the end of the year. Standards are typically developed within each state's Department of

Education (Great Schools, 2015). The need for standards developed in the early 1990's when the realization was made that many poor and minority students were not meeting standards and the fact that expectations varied so greatly from state to state (Great Schools, 2015). The problem remains that standards vary state to state. Of course, expectations have been set within each state, but there is still a call for national standards. When a student moves from one state to another, it's difficult to ensure they've learned the necessary material or that they're not ahead of others in their new state. With national standards, students would learn the same material in the same grade level no matter where they go to school. There are also states that expect less of their students than other states, which causes discrepancy with whether or not students are meeting their potential. This is where the Next Generation Science Standards (NGSS) are beneficial.

Currently, 30% of students entering college need remedial science courses (Leshner, Malcom, & Roseman, 2018). This is appalling, especially when compared to other developed countries. With the development of a new set of standards, the problems of today's world can be address, realistic expectations can be set, and rigor can be established. This would set the United States up to be comparable to other developed countries, almost all of which have a national set of standards. Having this national set of standards is "the only way to ensure that the country produces enough scientifically literate graduates to keep the United States competitive in a global economy" (Bhattacharjee, 2007, p. 595).

Next Generation Science Standards

The Next Generation Science Standards (2013) are based on a Framework in which students are engaged in three dimensions: crosscutting concepts, disciplinary core ideas, and science and engineering practices. Typically, states have these three items separately in their standards, but the NGSS work all three of these items into each performance expectation (PE)

(NGSS, 2013). Also, before NGSS, states kept inquiry and content separate from their standards which can lead to classroom instruction being focused primarily on content. The NGSS integrate inquiry into the PE, so instruction includes a well-balanced and quality science education (as cited in Pruitt, 2015).

There are currently 18 states that have adopted the NGSS, but very few of these states are fully aligned with their curriculum (NGSS, 2018). This alignment will take time. In the meantime, many states are working on professional development. Teachers are being provided with knowledge and skills they will need in order to integrate these new standards in their classrooms in the way in which they are intended.

The Framework for Science Education

Prior to developing the standards, the National Research Center (NRC), American Association for the Advancement of Science (AAAS), National Science Teachers Association (NSTA), and Achieve worked together for three years to develop *A Framework for K-12 Science Education* (Pruitt, 2014). According to Pruitt (2014), "the goal of the Framework was to articulate the vision for science education in the twenty first century and to articulate what students need to know in their K-12 experience to be considered scientifically literate" (p. 146). This Framework consists of the three dimensions of what we now know as the NGSS (practices, crosscutting concepts, and disciplinary core ideas).

The Framework essentially provides states with answers to the questions "what do we want students to do and what do they need to know in order to do it?" While the three dimensions can be discussed separately, it is imperative they are interwoven in order to teach to these standards effectively. The first dimension, science and engineering practices, consist of eight items that replicate the processes scientists and engineers use in daily tasks. These eight practices are: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematical and computational thinking, construction explanations and designing solutions, engaging in arguments from evidence, and obtaining, evaluating, and communicating data (Houseal, 2015).

The science and engineering practices are not a prescription for what teachers should be doing in their lessons. Instead, they are a possibility of what students could be doing. If you walked into a classroom that was following the Framework of the NGSS, it is possible to see students using one or more of these practices to develop a deeper understanding of the material. In a study conducted by Goldberg, Davis, and Eitel (2013), students were taught a lesson that followed the Framework of the NGSS and used several different practices, focusing on developing and using models. Students were shown a variety of landscapes made by erosion and tasked with engineering a model of a landscape that could be resistant to change. After the lesson, 91% of students felt they had developed a good understanding of the affect erosion has on landscape, which was an 11.4% increase from lessons taught that did not use the science and engineering practices (Goldberg, et al., 2013).

One may question the inclusion of an engineering focus in science standards. Science and engineering do have different goals; however, both work together to allow students to develop 21st century skills as well as become more creative thinkers and problem solvers. “The goal of science is to create theories that explain how the world works… [and] the goal of engineering is to find a solution to a need or a want” (Lachapelle, Sargianis, & Cunningham, 2013, p. 70). The Framework combines these goals to allow students opportunities to both explain a phenomenon and create a solution for any problems that arise with that topic.

Allowing students to do both enables them to think more creatively and collaborate with their peers.

The second dimension, crosscutting concepts, consists of seven themes that can bridge the various topics in science. The seven crosscutting concepts are: patterns, cause and effect, scale, proportion, and quantity, systems and system models, energy and matter, structure and function, and stability and change (Duschl, 2012). The crosscutting concepts provide students with a means of explaining a phenomenon. One crosscutting concept has the potential to be covered in lessons that focus on life, physical, and earth sciences. For example, students could look for patterns among life cycles in different types of insects. Later in the year they may look for patterns in the state of matter of certain materials depending on temperature. In these same topics, students may look for cause and effect relationships. Allowing students the ability to make connections between different types of science can solidify their understanding of the big idea behind each topic. The crosscutting concepts, according to Duschl (2012), "are best thought of as the learning goals for science literacy" (p. 6).

The third dimension is disciplinary core ideas. These core ideas are consistent K-12 as well. Each core idea has a beginning and end point for each grade level band. The idea behind this is that students are able to learn more each year to build on their previous knowledge and be better able to explain phenomena as well as explain more phenomena as they progress through their education. The disciplinary core ideas are grouped into four domains: life science, earth and space science, physical science, and engineering, technology, and the application of science (NSTA, 2014). Within each of these domains are separate topics to be covered. Each one of these become the first part of each performance expectation. For example, ESS1 is Earth's place in the universe, which falls under the Earth and space science domain (ESS) (NSTA, 2014).

ESS1 will be addressed within each grade level band (K-2, 3-5, 6-8, 9-12), but will of course get progressively more difficult and go further in depth at each grade level band.

In creating science literate students, consistency is key. Using consistent language across grade levels and throughout the state will allow for this. When all three of these dimensions are combined, a performance expectation is created. By combining a disciplinary core idea, crosscutting concept, and science and engineering practice, teachers have an understanding of the big idea their students should know, what their students could be doing, and how they can connect what they're learning to a phenomenon. The performance expectations "require that students demonstrate knowledge in-use" (Krajcik, 2013, p. 31).

However, the Framework is simply an idea of what needs to be taught by the time students graduate from high school. There was not a progression from Kindergarten on through twelfth grade. Therefore, a team of 40 individuals from all over the United States came together to write the performance expectations (Pruitt, 2014). These individuals had to consider the difficulty of each disciplinary core idea at various grade levels. They also had to determine which content would be taught at different grade levels and combine those with appropriate practices and crosscutting concepts. The entire endeavor took three years to complete, but the result is a comprehensive set of national standards that encourage inquiry in science and seek to challenge students.

Why NGSS?

The Next Generation Science Standards still identify core ideas students need to know before they graduate high school, much like previous standards. However, the way in which these performance expectations are written allows for a deeper understanding of those core ideas by students (Pruitt, 2015). This is because the core ideas are not the sole focus of the PE. They are only a small part of the PE and are combined with the practices and crosscutting concepts. This allows students to connect principles with practice (Feinstein & Kirchgasler, 2014).

The science and engineering practices are actions that are carried out by the students. For example, one of the practices is constructing explanations (NGSS, 2018). This will be combined with a disciplinary core idea, for example the history of planet Earth and a crosscutting concept of patterns (NGSS, 2018). Rather than the teacher providing students with an explanation for the patterns the emerge in Earth's history, students will explore this topic by gathering information and construct their own explanation. Creating the performance expectations in this manner provides students an opportunity to become responsible for their own learning and move from a teacher-directed classroom to a student-centered class (Pruitt, 2014). The performance expectation for this particular topic would be, "Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history" (NGSS, 2018, "Earth's Place in the Universe", para. 1).

The NGSS are designed to prepare students for college and careers. By developing 21st century skills such as collaboration and teamwork, students are preparing for life after high school (NGSS, 2013). The practices used by students also help foster these skills. The NGSS are also designed to work cooperatively with the Common Core State Standards (CCSS). Many of the practices in the math and language arts CCSS seamlessly overlap with the NGSS practices (NGSS, 2013). This overlap allows for common language to be used across content areas.

Science Literacy

One of the goals of the Next Generation Science Standards is to develop a generation that is scientifically literate. Much like the Common Core State Standards focused on developing skills that would allow students to be literate in math and reading, the NGSS focus on developing skills that allow individuals to be literate in science. Scientific literacy is “an understanding of science concepts and processes” which lead to “an informed citizenry being able to enact their knowledge in personal and societal issues” (Cavagnetto, 2010, p. 336). In essence, scientific literacy is what individuals should know about science. It is important for students to gain an understanding of concepts that they can then apply to real-world scenarios and be able to apply later in life.

Scientific literacy is not an entirely new concept, but it is a new focus of science education with the installation of the Next Generation Science Standards. The term science literacy was coined in the 1950’s by Paul Hurd when he published the article *Science Literacy: Its Meaning for American Schools* (as cited in Laugksch, 1999). This sudden interest in what the public should know about science came at a time when all of America’s attention was on the Space Race. This is at a time in history when science was a focus in the news and in politics. The concern became one in which parents wondered if their children would have adequate scientific knowledge to adapt to the new age and new scientific knowledge and technology that was being developed. The importance of scientific literacy only increased from here as America competed for economic power and industrial leadership (Laugksch, 1999).

One of the issues with scientific literacy is in defining what, exactly, the public should know about science. While the idea of what students should learn has changed over time, there are consistencies among recent literature about what individuals should know. When broken down, the consensus is that, by the time they graduate, students should be knowledgeable enough to become an active member of a science and technology driven society. In order to accomplish this, a basic understanding of science concepts in all areas (biology, physics, chemistry, earth, and life sciences) as well as mathematics, technology, and engineering in real-world situations is needed (Bybee, McCrae, & Laurie, 2009; Cavagnetto, 2010; Laugksch, 1999; and Yacoubian, 2018).

The difficulty for students is in the application of skills learned in the classroom to issues in life. The reason this is so difficult is because students cannot simply regurgitate information they've learned in a previous science lesson. According to Cavagnetto (2010), they must be able to integrate "science concepts and processes, metacognitive processes, critical reasoning skills, and cultural aspects of science" (p. 337). This ability does not come naturally. These skills must be taught, which is what the NGSS seeks to accomplish.

One way scientific literacy is developed is through argument, which is one of the science and engineering practices of the NGSS. In science, argument is a collaborative discussion where individuals work towards a common goal using evidence to support their claims along the way (Cavagnetto, 2010). Rather than being strictly competitive with only one correct answer or one "winner" of the argument, argument in science lends itself to allowing individuals to work together to uncover scientific data. This allows students to develop critical reasoning skills as they process scientific information. In a study conducted by Cavagnetto (2010), it was discovered that argument in science helps students to develop a better understanding of when to enact their science knowledge and the most appropriate science knowledge to enact for the scenario in which the student was engaged.

Another way scientific literacy is developed is through collecting and analyzing data, which is another NGSS science and engineering practice. For students in school, this can be accomplished by allowing students to carry out investigations in which they collect data and analyze the data they collected. Allowing students to participate in investigations that have real-world applications would allow for an increase in science literacy for students. This increase in scientific literacy also applies to adults in a real-life application of skills. Citizen science projects have been used for the last couple of decades. Citizen science is "a research technique that enlists the public in gathering scientific information" (Bonney, et al., 2009, p. 977). Companies develop a project design then reach out to the general public for help collecting data. Once they have found individuals willing to gather data, they provide them with the appropriate training, so they are able to collect the data accurately. Bonney, et al. (2009) discovered in a study conducted on a citizen science project that individuals involved with the project had an increase in their scientific literacy. Areas of scientific literacy that were discovered to improve in the pre- and post-project surveys were understanding of science content, understanding of science process, better attitude toward science, improved skills for conducting science, and increased interest in a science career (Bonney, et al. 2009).

The Next Generation Science Standards were developed because of a need to foster a "scientifically and technologically literate society" (Yacoubian, 2018, p. 313). Having a population that is more scientifically literate will enable citizens to make more informed personal decisions. These individuals will also be better equipped to "critically address science-related societal, economic, ethical, and environmental issues" (Yacoubian, 2018, p. 313). With an ever-changing world with constantly evolving technology, individuals must be better informed in order to make personal decisions about healthcare, in their workplaces, retirement, etc.

Summary

Since the development of the Next Generation Science Standards five years ago, an increasing number of states and districts have begun embracing change as they align their curriculum to the new standards (Pruitt, 2015). The NGSS were develop around a Framework of three-dimensional learning which places students at the center of instruction. Rather than a teacher lecturing and guiding discussion, the students become responsible for their own learning. The students become active members of the discussion and take the lead in their learning, much like the methods used in inquiry-based learning (IBL). Also similar to IBL, the NGSS seek to provide students with authentic learning experiences that will enable them to analyze real world problems and devise solutions to those problems.

A gap in the literature exists. Little to no study has been conducted to explore the impact a NGSS aligned curriculum has on middle school students' academic growth and attitude towards science. Thus, this study was necessary to provide curriculum directors and educators with an understanding of the impact using a NGSS aligned curriculum could have on their students. This study aimed to discover valuable information in this newly adopted set of standards. With no studies focused on the effects of NGSS on academic growth and attitudes towards science in the middle school, this study was a much-needed addition to the empirical research currently available.

CHAPTER THREE: METHODS

Overview

The NWEA test scores and attitudes of seventh and eighth grade students were compared before and after the introduction of a Next Generation Science Standards aligned curriculum. This chapter will provide an overview of the research design and data analysis used to effectively compare these measures between groups. The research questions and hypotheses will be presented along with an explanation of the participants and setting involved in this study. This chapter will also review the instruments used to collect the data.

Design

This research study employed a causal-comparative design. In a causal-comparative design, the purpose is to identify if there is an impact on one variable caused by another variable (Gall, et al., 2007). This study determined if there was any impact of the Next Generation Science Standards (NGSS) aligned curriculum on student scores or their attitude towards science. In ex post facto research, the data is collected from a naturally occurring scenario, in this case the Northwest Evaluation Association (NWEA) assessment and MATS survey data from previous years (Gall, et al., 2007). A causal-comparative study determines if there is an impact on the dependent variables by the independent variable (Warner, 2013). One dependent variable was the NWEA science scores, which is a measure of change in the score from fall to spring. The second dependent variable was students' attitude toward science. Attitude is defined as how students feel about the subject of science (Hillman, et al., 2016). The independent variable was the NGSS aligned curriculum created by the curriculum company TCI that was used in all seventh and eighth grade classes. The design is appropriate because of the proposed group comparison on a dependent variable.

Research Questions

This study sought to answer the following questions:

RQ1: Is there a difference between science scores of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards?

RQ2: Is there a difference between attitude towards science of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards?

Hypotheses

The null hypotheses for this study were:

$H_0$1: There is no statistically significant difference between science scores of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards as measured by the NWEA MAP Science assessment.

$H_0$2: There is no statistically significant difference between attitude toward science of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards as measured by the MATS survey.

Participants and Setting

The participants for the study were drawn from a convenience sample of middle school students located in a northeastern state. The sample was convenient as the participants were not selected randomly but were ones readily available to the researcher using ex post facto data (Warner, 2013). The school is located in a middle-to-upper income suburban area. Participants for Group A were selected based upon their participation in the TCI curriculum in grades seven and eight during the 2018-2019 school year. Participants for Group B were selected based upon their participation in curriculum aligned to the state's standards during the 2017-2018 school year. For this study, the number of participants sampled was 312 which exceeds the required minimum for a medium effect size (Gall, et al., 2007). The population total was 312 students as this school has exactly 78 students per grade level every year. Students who were new to the school in the school year of data collection were removed if they did not have NWEA MAP data from their previous school. The participants reflected the general makeup of the population of the area.

Table 1

Area Demographics

Ethnicity	Percentage		Gender	Percentage
Caucasian	63%		Female	55.5%
African American	27%			
Asian	3%		Male	45.5%
Hispanic/Latino	7%			

The population in the area consisted of 63% Caucasian, 27% African American, 3% Asian, and 7% Hispanic/Latino with 4.8% living in poverty. There were 55.5% female and 45.5% male (U.S. Census Bureau, 2017).

Sample

Six seventh and three eighth grade classes from one middle school were used in the sample for a total of twelve classes. Participants for this study were selected from all of the seventh and eighth grade science classes. There were 78 seventh grade students per group, where 42 were male and 36 were female. There were 78 eighth grade students per group, where 33 were male and 45 were female. Students ranged in age from 12 to 14 years in age, with an average age of 13-years-old. Participants were 55.7% Caucasian, 23% African American, 11.6% Asian, 7.1% Hispanic/Latino, and 2.6% Multi-Racial. 6.3% of the participants were living in poverty.

Instrumentation

In 1977, Allan Olson and George Ingebo established the Northwest Evaluation Association, or NWEA, as a way to create assessments that would precisely measure students' academic achievement and growth (NWEA, 2018). The data gathered from the NWEA Measures of Academic Progress (MAP) assessment has been informing teachers' classroom instruction for the past 40 years. Over half of the schools in 49 of the 50 U.S. states utilize NWEA MAP. This provides data from over 10.2 million students and creates national norms in which to place students (NWEA, 2018). NWEA is a not-for-profit organization that is committed to continuing research and constantly reviewing data to make improvements on the assessment. This instrument has been used in numerous studies (Amrein-beardsley, Polasky, & Holloway-libell, 2016; Marshall & Alston, 2014; Slavin, Lake, Hanley, & Thurston, 2014) to collect data regarding student growth in science.

The NWEA MAP science 6-8 NGSS aligned test is a computer adaptive test. The level of difficulty changes for each question as students progress through the assessment. The questions become more difficult if a student answers correctly and remain the same or become slightly easier if the student answers incorrectly (NWEA, 2018). The number of questions on the test differs for each grade level. The average number of questions on the 6-8th grade science test is 45. The test may adapt and add up to two questions if necessary to determine the student's score more accurately. At the end, the assessment is automatically scored, and the student receives their Rausch Interval Unit (RIT) score. The RIT score is “an accurate measure of student performance, regardless of whether they’re performing on, above, or below grade level” (NWEA, 2018, para. 4). The RIT score will fall between 100 and 350. The average RIT score for seventh graders is 207.2 in the fall and 210.9 in the spring. For eight graders, the average RIT score in the fall is 210.3 and 213.5 in the spring. The purpose of using this assessment was to obtain an accurate estimate of the students’ achievement status in science as well as their growth over the course of a school year.

NWEA MAP determines students' academic growth (NWEA, 2018). This instrument should be administered at the beginning of the school year, preferably before academic instruction begins. Students will receive their RIT score and a predicted growth score is determined based on the average growth of other students in that RIT range, grade, and age (NWEA, 2018). Then, academic instruction will take place throughout the year. The instrument can be administered again in the winter, but it is not mandatory. It must, however, be administered at the end of the year. The students' RIT score will again be given, and the system will determine if they met their growth goal. NWEA also tracks data over years to determine patterns and growth over time. Growth goals can also be set from spring to spring rather than fall to spring. Because the scoring of the instrument is automatically completed by the computer program, no training is necessary in this aspect. As the test is not timed, teachers must ensure there is enough time for students to complete the assessment. The average time for students to complete the science NWEA MAP test is 45 minutes (NWEA, 2018). However, because this is an average, teachers should assume there will be students who need more than 45 minutes to complete the assessment.

A new feature, developed in August of 2017, notifies the proctor of the assessment of any student who is showing signs of rapid guessing. If students move too quickly through a question, meaning their answer was selected in significantly less time than is average for that question, an alert is provided to the teacher so that intervention with the student can take place (Wise, 2017). Another feature of NWEA's ability to identify rapid guessing is the assessment will maintain the test items' difficulty level for the time being. Once the student is engaged in a question, the test will then become adaptive once again. This ensures that teachers are receiving the most accurate achievement data for every student.

The NWEA MAP science 6-8 test was tested for reliability. In order to determine if the assessment is reliable, researchers from NWEA (2004) tried to determine if the same child took the test twice, what the likelihood would be of them obtaining the same score each time. The results were stated using the Pearson correlation coefficient, where 1.0 is a perfect correlation. The 6-8 science MAP test received a score of r = 0.94 (NWEA, 2004). A Pearson correlation coefficient of 0.5-1.0 shows a strong correlation, so this test was determined to be reliable based on these results.

The validity of the NWEA MAP science test for 6-8 was also tested. If a test is valid, it means that it assesses what it claims to measure. In order to determine the validity of the NWEA MAP test, the researchers developed a study that allowed the same child to take the NWEA and another standardized test that claims to measure similar standards. The results of several tests were compared to the results of the same child's NWEA results. As in the reliability results, the validity results are reported using the Pearson correlation coefficient. When looking at the results for reading, there were several assessments with a Pearson's correlation coefficient above .80. The NWEA MAP test measures only the learning objectives that are listed (NWEA, 2018).

The My Attitude Towards Science (MATS) survey is administered annually by the school to determine if students have an overall positive or negative attitude towards science. The ex post facto data was collected and analyzed for this study. In an effort to create a valid and reliable instrument for measuring students' attitudes towards science, Hillman, Zeeman, Tillburg, and List (2016) developed MATS. After completing extensive research, they determined there were four areas that make up attitude: attitude towards science, desire to become a scientist, perception of scientists, and value of science to society (Hillman, et al., 2016).

The researchers pulled 46 items from various instruments to test validity and reliability of those items. To test the validity of the items, 32 teachers and graduate students were provided a numbered list of items and asked to determine which of the four areas that item fell into. In the initial review, 19 items were not considered valid and were rewritten. The researchers again tested for validity of these items. The instrument's items were all valid above 80% inter-rater agreement with most reaching above 90% (Hillman, et al., 2016).

The items were also tested for reliability using field tests in 24 classrooms in 4 different districts. Cronbach's alpha coefficient was used to determine reliability. The participants in this study represented a wide range of the population from grades 3 through 12 so the results could be generalized to a larger area. After field testing 549 participants, the researchers determined the instrument was reliable in three of four areas. The one area that received an alpha level lower than .70, receiving .658, was desire to become a scientist (Hillman, et al., 2016). The researchers determined this is likely due to only having two items directed toward this area. The perception of scientists scored low most likely because students do not perceive scientists in the stereotypes listed.

The instrument consists of 40 Likert-type questions. Participants respond on paper and pencil to 40 questions which are stated both positively and negatively. When scoring, all negatively stated items' score must be reversed. All items are rated on a 5-point Likert scale with 1 being "disagree a lot" and 5 being "agree a lot". The higher the score, the more positive their attitude towards science, stronger desire to work in science, the more science is valued, and the more stereotypical ideation a student holds.

Since the instrument is relatively new, there are few studies that have used the MATS survey. There are a few researchers that have used the research done by Hillman, et al. (2016) when created their survey (Kaur & Zhao, 2017; Summers & Abd-El-Khalick, 2018; Toma & Villagra, 2019). Summers and Abd-El-Khalick (2018) found that the MATS survey was acceptable to use for students in elementary, middle, and high school, but some of the questions didn't fit with what they needed. These researchers needed the ability to include theories of science in their questions (Summers & Abd-El-Khalick, 2018). Other studies, which also used research completed by Hillman, et al. (2016) discovered that the MATS survey did not meet their needs in accurately determining a student's attitude toward physics (Kaur & Zhao, 2017) or for Spanish-speaking students (Toma & Villagra, 2019) and created their own attitude survey to include questions more specific to their topic. Kaur and Zhao (2017) used a similar approach to Hillman, et al. (2016) in that they broke their survey down into sections with positively and negatively stated questions. Many of the questions created by Toma and Villagra (2019) in their instrument were used directly from the MATS survey.

Procedures

Permission to conduct this study was secured through Liberty University's International Review Board (IRB) prior to gathering data(see Appendix A). The participants were selected out of convenience due to the proximity and availability to the researcher. The Head of School was contacted via email for participation to conduct this study (see Appendix B). Once permission to participate in the study was obtained, further communications about procedures and data collection were discussed with the school's principal via email and phone conferences (see Appendix C). There was only one teacher for all seventh and eighth grade science classes at this school.

The NWEA MAP science 6+ test and MATS survey was administered to all seventh and eighth grade students in the fall and spring. These instruments were already in use by the school for their own purposes. For the NWEA MAP science 6+ test, students logon to the NWEA portal via a secure internet browser and are given as much time as needed to complete the test. For the MATS survey, the school bi-annually requires students take this digitally via Google forms where the questions have been entered exactly as they are noted in the instrument. The archived data from the NWEA MAP and the MATS for the 2018-2019 school year were provided to this researcher by the school administrator. All identifiable information for each student was removed prior to the researcher receiving the data. Results from the MATS survey were coded by adding the total points for each question, ensuring reverse scoring of negatively stated questions, and assigning that value to each participant. Data was then entered into an Excel spreadsheet and uploaded to SPSS for analysis.

Data Analysis

In order to determine if the NGSS aligned curriculum impacts NWEA science scores and the MATS scores between students who participated in TCI's NGSS aligned curriculum and those who received curriculum aligned to the state standards, a *t*-test was used. A *t*-test is used to analyze two sample means and determine the significance of the difference (Gall, et al., 2007). Two *t*-tests were conducted in total in order to analyze the data for each hypothesis. The researcher also conducted data screening prior to analysis to screen for errors. To determine if any outliers existed a Box and Whisker plot was utilized. This gives a visual to any abnormal data, which would have been removed prior to analysis (Warner, 2013). Descriptive statistics, such as the mean and standard deviation, were created for each data set prior to analysis.

A *t*-test was determined to be the appropriate analysis as each participant was assessed on two occasions using a single measure (Warner, 2013; Green & Salkind, 2014). In this case, the two occasions were the scores prior to after implementation of the NGSS aligned curriculum and the single measure was the NWEA or MATS survey. The *t*-test requires normally distributed data across groups. Histograms were used to determine if the data was normally distributed (Warner, 2013). The *t*-test was used to determine if the mean difference between these sets of scores was different from zero (Green & Salkind, 2014). For all assumptions tests an alpha level of 0.05 was used. The *t*-test significance was discussed using Wilks lambda.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this causal-comparative study was to compare student test scores and attitude toward science before and after the implementation of a curriculum aligned to the Next Generation Science Standards. Because this study used a causal-comparative design, independent samples *t*-tests were used to investigate the impact of Next Generation Science Standards aligned curriculum on middle school students' science scores and attitude toward science. Data was collected from the school's administration. This chapter will review the research questions and hypothesis. Descriptive statistics will be discussed on the two dependent variables as well as the results from the *t*-tests.

Research Questions

RQ1: Is there a difference between science scores of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards?

RQ2: Is there a difference between attitude towards science of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards?

Null Hypotheses

$H_0$1: There is no statistically significant difference between science scores of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards as measured by the NWEA MAP Science assessment.

H_02: There is no statistically significant difference between attitude toward science of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards as measured by the MATS survey.

Descriptive Statistics

This study used data from two sets of 7th and 8th grade students. One set of data is from the 2017-2018 school year before the implementation of the Next Generation Science Standards aligned curriculum, and the second set of data is from the 2018-2019 school year after the implementation of the Next Generation Science Standards aligned curriculum. Descriptive statistics for these groups are displayed in Table 2.

Table 2

Study Participants (N = 312)

School Year	*n*	%
2017-2018	157	50.3%
2018-2019	155	49.7%

Table 3 displays the descriptive statistics for the results of the NWEA data for each year analyzed (2017-2018 and 2018-2019). These statistics include mean, median, mode, and standard deviation.

Table 3

NWEA Data Descriptive Statistics

Year	*N*	Mean	Median	Mode	Std. Deviation
2017-2018	151	220.04	220	220	9.949
2018-2019	155	221.83	221	219	9.519

The dependent variable of attitude toward science came from the MATS survey data. Table 4 displays descriptive statistics for the results of the MATS survey data for each year analyzed (2017-2018 and 2018-2019). These statistics include mean, median, mode, and standard deviation. The survey contains 40 Likert-type questions. The data obtained for this study was gathered from those items on the survey related to attitude toward school science as determined by the author of the survey. The highest possible score on this section is 70.

Table 4

MATS Survey Data Descriptive Statistics

Year	*N*	Mean	Median	Mode	Std. Deviation
2017-2018	150	51.45	53	62	10.192
2018-2019	139	51.69	52	59	9.052

Results

Two independent samples *t*-tests were used in the analysis of the data for this study. One *t*-test was used to compare the NWEA scores before and after the implementation of the Next Generation Science Standards aligned curriculum and the other to compare the MATS survey scores before and after implementation. This section contains a description of the tests used to ensure the assumptions needed for a *t*-test were met. A presentation of the results from both *t*-tests are included as well. An alpha level of .05 was used for both hypotheses.

Assumptions Tests

There are three assumptions that must be met when conducting an independent samples *t*-test: normally distributed data, equal variance across groups, and independent observations between and within groups (Warner, 2013, p. 189-190). The first assumption is that the data is normally distributed. A box and whisker plot (see Figure 1 and Figure 2) was created for each of the dependent variables and no extreme outliers were found. Histograms were also created and the researcher determined the data was normally distributed among each of the data sets. The second assumption that must be met is there must be equal variance across the groups. In order to test this assumption, a Levene's test was conducted (see Table 5). The Levene's Test for Equality of Variances had a significance of .822 for the NWEA scores and .405 for MATS survey scores. According to Warner (2013), with a significance greater than .05, the researcher can assume the variances are equal across the groups. The third assumption is an independent observation between and within groups. According to Warner (2013), because each participant was only in one group and scores in each group were not paired, this assumption is also met.

Table 5

Levene's Test for Equality of Variances

Data Set	F	Significance
NWEA scores	.050	.822
MATS survey scores	.696	.405

Hypothesis One

The first null hypothesis was: There is no statistically significant difference between science scores of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards as measured by the NWEA MAP Science assessment. For this first hypothesis, an independent sample *t*-test was used to calculate the statistical significance of NWEA scores before and after implementation of the NGSS aligned curriculum. Data screening was conducted prior to conducting the *t*-test. A box and whisker plot was used to analyze the data for any outliers in the NWEA data (see Figure 1). No outliers were identified in the NWEA data.

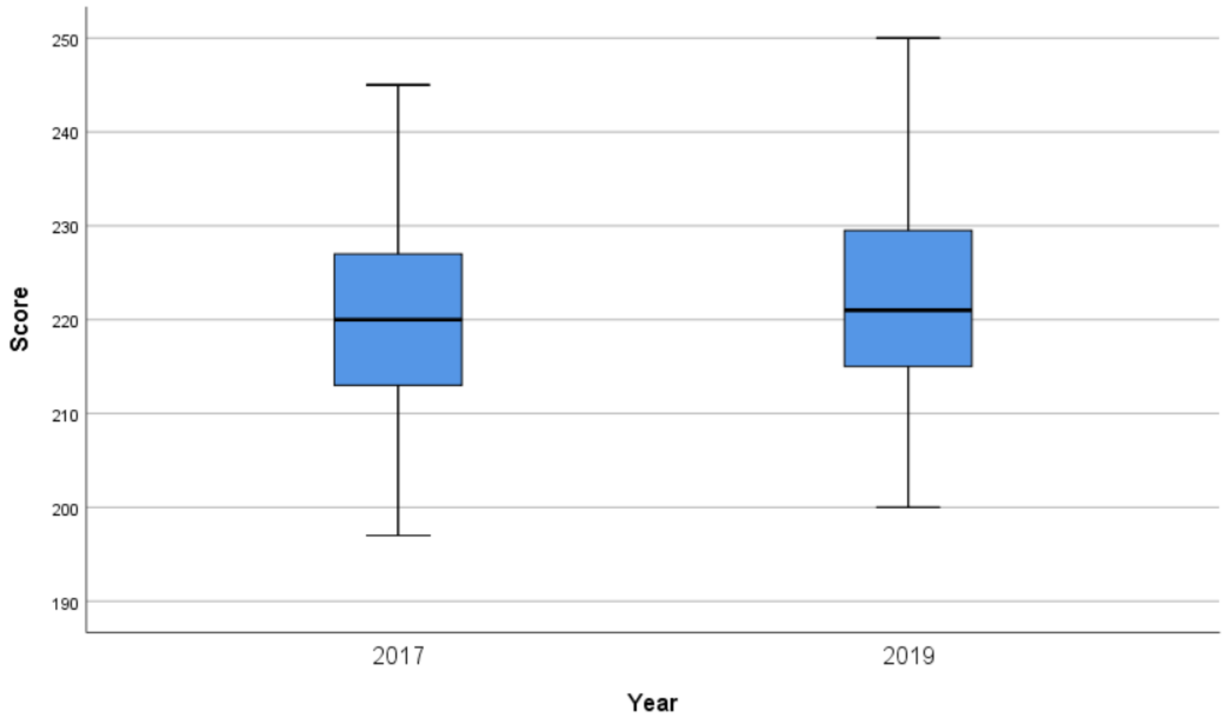

Figure 1. Box and whisker plot for NWEA data.

Histograms were used to ensure the data was normally distributed. The researcher determined the data were normally distributed after visual inspection of the histograms and began analysis of the data (see Figure 2).

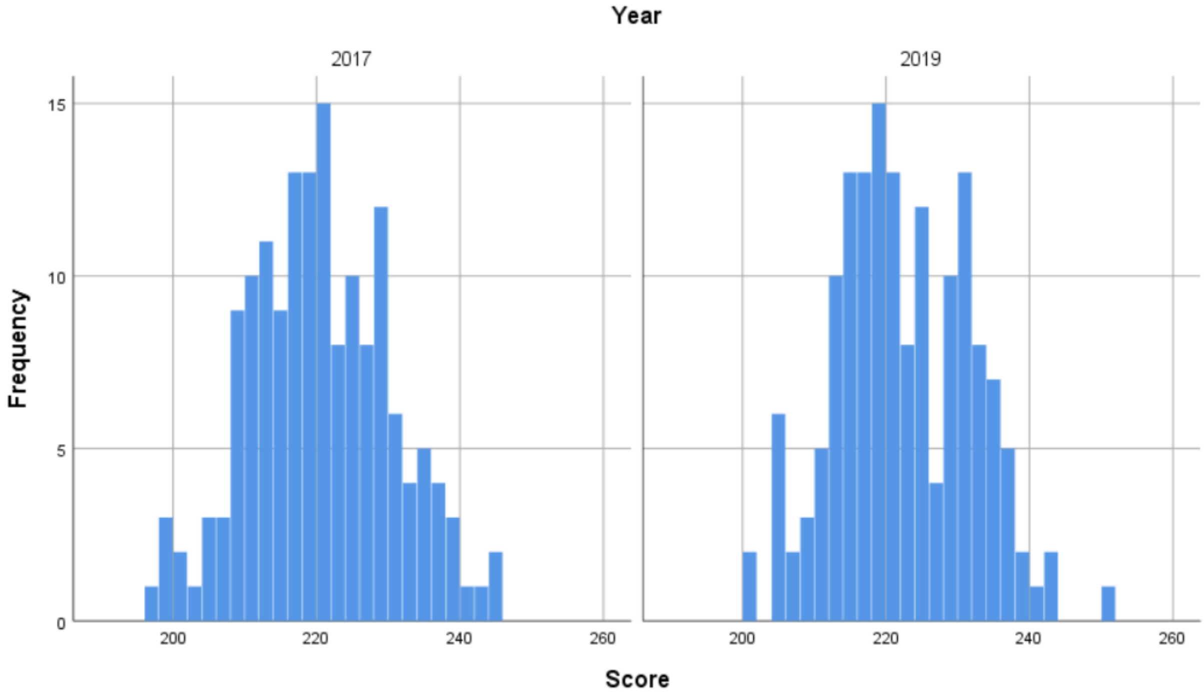

Figure 2. Histograms for NWEA scores.

According to Warner (2013), "when the degrees of freedom (*df*) are greater than 100, and when we set α=.05, two-tailed, a *t* ratio greater than 1.96 in absolute value is considered large enough to be statistically significant" (p. 188). The *t* ratio (see Table 6) for this hypothesis was 1.615. For this study, the degrees of freedom were 310. Based on the *t* ratio being less than 1.96, and a P-value greater than .05, there was no statistically significant difference between the science scores of students who participated in the NGSS aligned curriculum and of those who did not. Therefore, these findings fail to reject the null hypothesis.

Table 6

NWEA Independent Samples t-test

		F	Sig.	t	df
Scores	Equal Variances Assumed	.050	.107	1.615	310

Hypothesis Two

The second null hypothesis was: There is no statistically significant difference between attitude toward science of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards as measured by the MATS survey. An independent samples *t*-test was also used to determine if there is a statistically significant difference in students' attitudes towards science before and after implementation of the NGSS aligned curriculum. Data screening was conducted prior to conducting the *t*-test. A box and whisker plot was used to analyze the data for any outliers in the MATS survey data (see Figure 2). Two outliers were found in the MATS survey data and were also not considered severe enough to be removed from the data set.

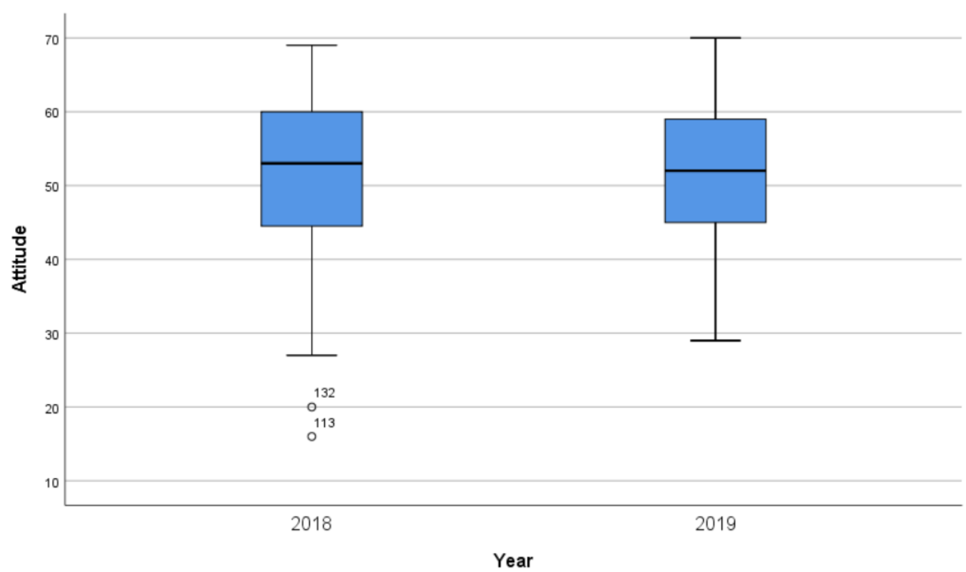

Figure 3. Box and whisker plot for MATS survey data.

Histograms were used to ensure the data in each set was normally distributed. The researcher determined the data was normally distributed after visual inspection of the histograms and began analysis of the data (see Figure 4).

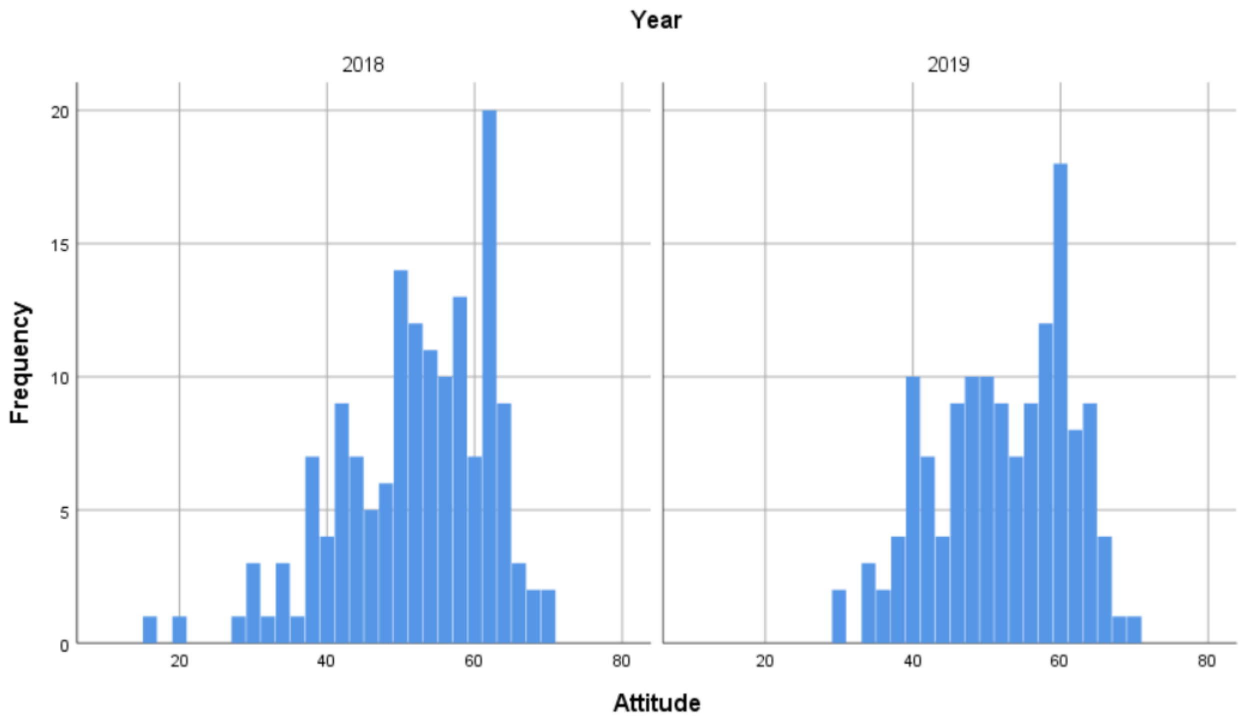

Figure 4. Histogram for MATS survey scores.

The *t* ratio (see Table 7) for this hypothesis was .214. For this study, the degrees of freedom were 289. Based on the *t* ratio being less than 1.96, and a P-value greater than .05, there was no statistically significant difference in the attitude toward science of students who participated in the NGSS aligned curriculum and of those who did not. Therefore, these findings fail to reject the null hypothesis.

Table 7

MATS Survey Independent Samples t-test

		F	Sig.	t	df
Attitude	Equal Variances Assumed	.696	.405	.214	289

CHAPTER FIVE: CONCLUSIONS

Overview

This chapter discusses the results of this study in comparison to the related literature. The researcher will discuss the purpose of this study, which was to investigate if a Next Generation Science Standards aligned curriculum has an impact on students' science scores or attitude toward science, and the results of this study compared to results of other studies previously reviewed. The implications of this study as well as the limitations within the study will be presented. Finally, this chapter will discuss recommendations for future research on this topic.

Discussion

The purpose of this causal-comparative study was to compare student test scores and attitude toward science before and after the implementation of a curriculum aligned to the Next Generation Science Standards. The study focused on two research questions:

RQ1: Is there a difference between science scores of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards?

RQ2: Is there a difference between attitude towards science of middle school students who participate in TCI's Next Generation Science Standards aligned curriculum as compared to those who used curriculum aligned to a northeastern state's standards?

The results of this study showed that there was no statistically significant difference between the mean science scores after implementation of the Next Generation Science Standards aligned curriculum when compared to the mean scores before implementation. Therefore, these findings failed to reject null hypothesis one. While the mean science scores for students who had received NGSS aligned curriculum was slightly higher (M = 221.83) than students who had received curriculum aligned to the state standards (M = 220.04), the difference between these scores was not enough to be significant.

With the increase in the overall mean scores for the NWEA MAP assessment, the results of this study do show parallels with the research that has been conducted on the topics of inquiry-based learning and authentic learning experiences and their impact on academic achievement in science (Chen, et al., 2013; McConney, Oliver, Woods-McConney, Schibeci, & Maor, 2014; Quigley, 2013). In each of these studies, the research analyzed science achievement in which the students were given the ability to experience real-life scenarios and problem-solving situations. This method of instruction is similar to the Framework of the NGSS and the basis for the curriculum that was used with the participants in this study. These results show that providing students with scenarios that enable them to experience science as professionals in this area do in the workplace increases achievement scores.

A goal of the Next Generation Science Standards is to create science literacy in schools across the nation. Science literacy can be measured using nationally normed achievement tests, such as the NWEA MAP assessment. This study used data collected from this assessment as an indicator of science achievement. The results of this study show that, while participants' scores did not increase a significant amount from before implementation of the NGSS aligned curriculum to after implementation, the participants scores are above the national average for their grade levels. According to NWEA (2018), the national mean for a seventh-grade student in the spring is 210.9 and the mean for an eighth-grade student in the spring is 213.5. The seventh- and eighth-grade participants in this study had a mean score of 220.04 before implementation and 221.83 after implementation of the NGSS aligned curriculum. It is important to take this into consideration as students who begin an assessment with a higher score have a more difficult time increasing that score as they are often already beyond the content of their current grade level.

One of the areas of concern with inquiry-based learning is the teacher's ability to relinquish their responsibility as the disseminator of information and pass that responsibility over to the students (Dorier & Garcia, 2013; Woods-McConney, et al., 2016). When teachers are able to surrender their traditional duty in the classroom, inquiry-based learning has the ability to increase student achievement and engagement in the science classroom (McConney, 2014; Pedaste, et al., 2015; Woods-McConney, et al., 2016). The results of this study show a slight improvement in achievement scores, but the results are insignificant. It is possible, although an interview would need to be completed with the teacher to be sure, that the teacher may not have been properly trained in the strategies used with NGSS teaching such as allowing students to become the leaders in their learning instead of the teacher.

The results of this study also showed that there was no statistically significant difference between the mean attitude toward science scores from the MATS survey before and after implementation of the Next Generation Science Standards aligned curriculum. While the mean attitude scores for students after implementation of the NGSS aligned curriculum were higher (M = 51.69) than for students before implementation of the NGSS aligned curriculum (M = 51.45), the difference between the two mean scores was found to be statistically insignificant by the independent *t*-test.

While the results were not significant, the mean scores for participants' attitude toward science did increase, which shows parallels to other studies that compared the use of experiential learning, authentic learning experiences, and inquiry-based learning (Dzan, Tsai, Lous, & Shih, 2015; Malone, Rickard, & Tudor, 2016; Rihtarsic, Avsec, & Kocijancic, 2016; Scogin, Kruger, Jekkals, & Steinfeldt, 2017; Swanson, 2011). Each of these studies showed that students who felt value in the material in which they were being presented or had the responsibility for their own learning had an overall better attitude toward science and were more likely to enjoy science. This reflects the results of this study in that students were presented with a curriculum that followed the Framework of the Next Generation Science Standards where lessons are student-centered and their overall attitude toward science did increase. While none of the above-mentioned studies used the My Attitude Toward Science survey, their purpose was to examine participants' attitude toward science. To date, there are no published studies available in which the research used the MATS survey to determine students' attitude toward science as the survey is still quite new.

While defining attitude has been quite difficult as there are a multitude of ideas about the composition of one's attitude, the instrument used in this study examined many of the key aspects of attitude. Many researchers have used the components of the MATS survey in order to determine participants' attitude and attitude's impact on other variables. One of these variables that has been widely researched in achievement. Many studies have investigated whether attitude has an influence on achievement (Mattern & Schau, 2002; Steinkamp & Maehr, 1983; Weinburgh, 1995; Willson, 1983. In each of these studies, the results showed that students who had a more positive attitude also received higher achievement scores in science. This parallels the results in this study as the overall mean score for attitude and the mean scores for achievement both increased.

Implications

The findings presented in this study add to the existing literature and research about the Next Generation Science Standards and the impact they have on students' science scores and attitude toward science. While the results of this study showed there wasn't a significant difference before and after implementation of a NGSS aligned curriculum, on average, the students' science scores did improve after receiving the NGSS aligned curriculum. It would be beneficial to know how much instruction the students had prior to receiving this newly aligned curriculum with the NGSS as this state did adopt the new standards two years prior to the baseline data that was collected.

The results of this study also revealed that, on average, students' attitude toward science did improve after the implementation of the NGSS aligned curriculum. Although the difference between the before and after means was not significant, the scores do show an improvement in attitude. It is important to note that these middle school students were asked to take this survey during the last week of school, so their general attitude toward school may have been impacted by the upcoming summer break. Taking this into consideration, having an increase in attitude at this point in the year is an important factor to take into consideration.

The Next Generation Science Standards are still relatively new, and many states are just now beginning to adopt these standards. This study adds to the newly started body of knowledge on the impact of NGSS aligned curriculum in the school systems. There are few studies that have begun analyzing information in regard to the impact NGSS is having in the classroom, and the results of this study provide information for administrators and curriculum directors looking into adopting these new standards. With more and more states adopting the Next Generation Science Standards, schools will need to begin adapting their current curriculum or searching for a NGSS aligned curriculum to adopt. This study can provide theoretical implications for any school looking at adopting TCI's NGSS aligned curriculum in their school. Of course, other schools will need to take into consideration the population of students that were involved in this study as it may not be applicable to other populations of students.

Limitations

One of the limitations of this study was using a convenience sample. Using a convenience sample could lead to "underrepresentation of many types of people" (Warner, 2013, p. 4). The population from which this sample was drawn, while representative of the area demographics, may not be representative of other areas. This use of convenience sampling may keep the researcher from being able to generalize the results to other schools within the state or country. However, because the sample used was representative of the area's demographics, the results are generalizable to the immediate region from which the sample came.

Another limitation of this study is the lack of previous research completed on this topic. While there is a plethora of research on the Next Generation Science Standards and what they are, there is little research available on the impact of using these standards in the classroom. There are many states that have yet to adopt these standards, and the few states that have adopted the standards are still in the beginning stages of implementing curriculum that is aligned. There have not been many studies conducted to determine if there is any impact of these new standards on students' academics. For the same reason, there is also a minute amount of research available on the effects of the Next Generation Science Standards on students' attitude toward science.

A final limitation in this study is the possibility of the participants' previous exposure to the Next Generation Science Standards. The seventh- and eighth-grade students in this study had a sixth-grade teacher who was part of a state program to develop teacher leaders. The goal of that program was to gather one teacher from each district in the state and train them in the Next Generation Science Standards. This teacher was then responsible for disseminating information to the other teachers within the district and train those teachers in the implementation of the NGSS science and engineering practices. Due to the participants having this trained teacher in previous years, it is possible they had exposure to the teaching strategies used in NGSS which may have impacted their scores prior to exposure to the NGSS aligned curriculum they received in the 2018-2019 school year.

Recommendations for Future Research

The results of this study show there are many possibilities for future research in the area of the impact of Next Generation Science Standards aligned curriculum and students' science scores and attitude toward science. In order to add to the limited body of knowledge on this topic, the researcher recommends the following:

1. Replicating this study with a similar population of students who have not had any exposure to the Next Generation Science Standards would confirm the results obtained in this study.
2. Collecting and analyzing data from a different population of students (demographic) would add to the information presented in this study and allow for a deeper comparison of findings.
3. Using a random sampling of participants would ensure a more accurate representation of the population of the area in which the study takes place.
4. An experimental research design, perhaps a pretest-posttest or quasi-experimental design, would allow the researcher to administer the new curriculum and compare their scores before and after implementation.

5. Narrow the study to focus on just one of the two dependent variables to home in on the impact the NGSS aligned curriculum had on students.
6. Ensure the teacher implementing the NGSS aligned curriculum has had adequate training with NGSS and inquiry-based learning.

The impact of Next Generation Science Standards on students' science scores and attitude toward science is an extremely understudied topic. Any additional studies on this topic will add to a much-needed area of research in science education today. Research that adds to this knowledge has the potential to impact students, teachers, administrators, curriculum directors, schools, districts, and even an entire state education system.

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Appendix A

IRB Application 3972: Next Generation Science Standards Aligned Curriculum's Impact on Students' Academic Scores and Attitude Toward Science

You forwarded this message on Fri 9/20/2019 5:44 PM

II

IRB, IRB
Fri 9/20/2019 4:19 PM
Priester, Jessica; Pritchard, Tracey Beno (School of Education); SOEDocReview; IRB, IRB

Priester_3972NonHumanSubj...
145 KB

Dear Jessica Priester,

The Liberty University Institutional Review Board has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study does not classify as human subjects research. This means you may begin your research with the data safeguarding methods mentioned in your IRB application.

Your study does not classify as human subjects research because it will not involve the collection of identifiable, private information.

Please note that this decision only applies to your current research application, and any changes to your protocol must be reported to the Liberty IRB for verification of continued non-human subjects research status. You may report these changes by submitting a new application to the IRB and referencing the above IRB Application number.

If you have any questions about this determination or need assistance in identifying whether possible changes to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office

LIBERTY
UNIVERSITY.

Appendix B

February 7, 2019
Dear [redacted],
I am a doctoral student at Liberty University. I am conducting a study related to the impact of three-dimensional learning through the Next Generation Science Standards on student achievement and attitude toward science. I am requesting permission to obtain archived data from your school's NWEA MAP Science assessment for grades 7 and 8 from the 2017-2018 and 2018-2019 school years. I am also requesting permission to obtain your school's archived data from the MATS surveys taken in grades 7 and 8 from the beginning and end of the 2018-2019 school year. If given permission to move forward, I will work with the principal and director of curriculum and instruction to ensure the data I receive has all student identifiers removed prior to obtaining the data. I want to assure you that neither your students nor your school will be identifiable in the study. I will use pseudonyms when referring to the school and the school's location in my study.
If this is acceptable, upon receipt of your permission to move forward, I will contact the principal of your school to request the required data for my study.
Sincerely,
Jessica Priester

From: [redacted]
Sent: Thursday, February 7, 2019 11:25 AM
To: Jessica Priester
Subject: RE: Permission to gather data

No problem at all. Please feel free to proceed.

[redacted]

Appendix C

February 7, 2019
Dear [redacted],
I am a doctoral student at Liberty University. I am conducting a study related to the impact of three-dimensional learning through the Next Generation Science Standards on student achievement and attitude toward science. I was recently provided permission by Mr. Southworth to obtain archived data from your school's NWEA MAP Science assessment for grades 7 and 8 from the 2017-2018 and 2018-2019 school years as well as your school's archived data from the MATS surveys taken in grades 7 and 8 from the beginning and end of the 2018-2019 school year. I am requesting the data be stripped of any identifiable student information prior to sending the data (student ID, name, birthdate, etc.). With the NWEA data, students' 2017-2018 and 2018-2019 data should be side-by-side to ensure accurate analysis. I wanted to assure you that neither your students nor your school will be identifiable in the study. I will use pseudonyms when referring to the school and the school's location in my study.
Thank you for your time and all that you do for your students. Please contact me if you have any questions.
Sincerely,
Jessica Priester

From: [redacted]
Sent: Thursday, February 7, 2019 12:26 PM
To: Jessica Priester
Subject: RE: Permission to gather data

Hello Jessica,
Thank you for your request. You have my permission to access the requested data.
[redacted]
Principal K-8 Academy