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Relationship Analysis of Storyline Curriculum Engagement and Academic Performance

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RELATIONSHIP ANALYSIS OF STORYLINE CURRICULUM ENGAGEMENT AND ACADEMIC PERFORMANCE

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Dedication

I want to dedicate this dissertation to my family, whose understanding, support, and encouragement have proved invaluable. Whether by blood or by choice, you all are my people.

To Mike, my husband, protector, and best friend. Your love and support have carried me through this last year. You are my better half. Thank you for keeping me motivated and focused.

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Abstract

Secondary educators are responsible for moving students from dependent learners to independent individuals who can solve problems and be productive members of society. Science education has changed since 2012 when the PISA and TIMSS results were analyzed and showed that American students perform significantly lower than other countries. In 2013, Kentucky adopted new science standards that replaced the extensive lists of facts to be memorized with a set of performance expectations. Students are now tested on their ability to apply content knowledge to solve a phenomenon. Seventh-grade science teachers in classrooms with wide ranges of academic readiness have resisted switching to inquiry-based learning that will give students practice using science and engineering practices. This study was designed to determine if the student population's academic outcomes would change significantly when switching from traditional science instruction to inquiry-based learning. The findings of this study will help teachers with highly diverse students to make informed decisions on the type of instructional methods that will increase their students' positive academic outcomes.

Keywords: science, inquiry, NGSS, middle school, instructional methods, professional development, performance expectations

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List of Abbreviations

CCC - Crosscutting Concepts

DCI - Disciplinary Core Ideas

Framework - *Framework for K-12 Science Education*

IBL - Inquiry-based Learning

KDE - Kentucky Department of Education

KSA - Kentucky Summative Assessment

MAP - Measures of Academic Progress

NCES - National Center for Educational Statistics

NGSS - Next Generation Science Standards

NRC - National Research Council

OTR - Opportunities to Respond

PE - Performance Expectations

PISA - Program for International Student Assessment

PBL - Project-based Learning

SEP - Science and Engineering Practices

3D Learning - Three-Dimensional Learning

TIMSS - Trends in International Mathematics and Science Study

Chapter I: Introduction

Context

The term *scientist* was first used in 1834 to describe philosophers working in universities (Melville et al., 2015). Whewell used the term to increase the social status of "pure scientists" over those who applied science in the workplace. During the annual British Association for the Advancement of Science meetings, science education was first divided into disciplines. Having different disciplines continues in science today. At the beginning of science education, a clear and careful distinction emphasized liberal and academic values instead of technical instruction or commercial utility. Historically, science used theories to design curricula to educate the population. Early in the development of science education the curricula knowledge depth was based on the social class of the educated individuals. The higher the social status of the individuals, the more complex the curriculum covered in their education. This was common for all curricula but was used to help elevate the status of sciences by making their study abstract and separated from real-world applications to meet the societal standards of the period (Melville, 2015).

Melville et al. (2015) stated that the professionalization of science led to it being associated with highly educated people. This allowed for access to increased funding and resources but limited access to scientific professions. However, this distinction also created a rift in the science community as seen in 1862 when Faraday told the British Parliament Public School Commissions, "If you teach scientific knowledge without honoring scientific knowledge as it is applied, and those who are there to convey it, you do more harm than good. You only discredit both the study and the parties concerned in it" (Melville et al., 2015, p. 6). The divide established to elevate the status created an education gap between science and technology which set the stage for generations of people to know scientific facts without being able to use those facts to solve problems in life. In the early 1900s, fewer students enrolled in science courses due to the gap between the general public and science disciplines. To bridge this divide, general science courses began to emphasize problem-solving methods inspired by Dewey. However, this approach changed when the *Framework for K-12 Science Education* (*Framework*) was published, emphasizing the need for new science standards to help students comprehend the phenomenon of the world (Melville, 2015).

Achieve, Inc. and Next Generation Science Standards Lead States wrote and published the Next Generation Science Standards (NGSS) in April 2013 (NGSS Lead State, 2013). The standards were based on the theories of the *Framework,* which moved away from teacher-centered instruction in classrooms. Adopting the NGSS as the guiding document of learning science in K-12 education significantly changed the science education system. Educators were required to completely change the instructional methods and assessments by adding phenomena to their lessons. *Phenomena* are situations that can be observed and investigated so students can construct an explanation from evidence or identify the cause for the event. The revitalization of science instruction came after the realization that students from the United States could not compete in the fast-growing science and technology career markets. Educators have begun to focus on student engagement in the classroom to prepare students better. The research has shown a direct relationship between student success on standardized tests and student engagement in the classroom (Pratt, 2013).

The *Framework* laid the foundation for the NGSS to be created to unite science, technology, and engineering in science education. NGSS was designed to increase student engagement through a shift in instructional methods and change the expectations for mastery for all levels of science education (Pratt, 2013). To implement three-dimensional learning, educators must use a relevant phenomenon to engage students with the science and engineering practices to figure out how the world works or to solve a problem (Melville, 2015). Methods discussed in this paper are sensemaking, inquiry-based learning (IBL), three-dimensional learning (3-D Learning), or project-based learning (PBL). The characteristics of learning with these methods include being student-led and teacher-facilitated, allowing students to experience the processes that scientists and engineers use daily to improve our world (Melville, 2015). This instructional strategy is intended to enable students to use their knowledge to create solutions for real-world issues or better understand how the world works (Pratt, 2013).

A typical lesson for 3-D Learning begins with a driving question and an interesting phenomenon to allow students to make sense of the natural world (Lowell et al., 2021). Lowell et al. stated that supporting students in this process requires classroom discussions that advance and change with the progression of student understanding of the phenomenon. The goal of this process is for the facilitator to assist students with making their thinking visible to others while deepening their understanding by building on other students' ideas. Sensemaking was defined by Lowell et al. as the process of figuring something out, a dynamic process of revising and building on explanations to determine how the world works. This process strengthens a student’s grasp of scientific and engineering practices. These aspects of the scientific processes, and the role those processes play in life, become more apparent as the students gain proficiency with the practices (Lowell et al., 2021).

To meet these criteria, Open SciEd was chosen as the curriculum in the classroom for this study. In the Science Classroom Resources (2023), the Open SciEd Model Design explains the storyline curriculum process in detail and justifies those processes. Every lesson begins with an anchoring phenomenon routine, followed by developing a Driving Question Board with the questions students generate after the introduction of the phenomenon. Next, the students complete a navigation routine to determine which question they need to investigate next. This routine is followed by an investigation routine, where students begin to collect evidence to explain part of the phenomenon. After each investigation, students come to a consensus about what they have discerned during the investigation and how that evidence can be used to explain the phenomenon. The problematizing routine then allows students to express new questions based on what they have figured out and what they still need to figure out. This is followed with another investigation routine to collect more evidence. The students again process the evidence and come to a consensus about what the investigation allowed them to figure out. The students then will acknowledge the progress they have made by answering the questions from the driving question board. The last step of this process is to use the evidence and what they have discovered to explain a new phenomenon. This process aligns with the *Framework* and allows students to begin to use the science and engineering practices to explain the world. The foundation for these changes was the performance of US students on international science tests.

Serino (2017) and Loveless (2017) summarized the results of two international tests given to fourth-grade students, eighth-grade students, and at 15 years of age. The origin of the first test began in 2000. The Program for International Student Assessment (PISA) administered the first international test for literacy in reading. Three years later, the next cycle consisted of literacy tests for reading and mathematics. Then, in 2006, PISA tested three subjects: reading, mathematics, and science literacy. Data from the 2006 PISA was the turning point for recognizing the necessity for the United States to alter its approach to science education for the country to compete in the science and technology fields. The Trends in International

Mathematics and Science Assessment (TIMSS) is a second international test. Serino (2017) concluded at the rate of change from the TIMSS, the U.S. would take 140 years to be equal to the international test score leaders. This data validated the need for change in science education and changes needed to ensure students had the necessary skills to be ready for next steps following high school graduation (Serino, 2017).

The PISA data for 2018 showed the U.S. scored above the OECD average in reading and science but below in mathematics (United States - OECD, 2019). The scores of the U.S. continued in there flatline for the 2018 testing cycle. The lack of growth is a point of concern for employers. Melville et al. (2015) stated that potential employers in the science and technology industries found that graduates were missing key skills to be successful in the workplace. The skills they lacked included critical thinking, collaborative work, application of concept knowledge, creative navigation of situations, and problem-solving abilities. According to Melville et al. (2015), students no longer consider science an appropriate career choice, even though science is respected within society.

Keeley et al. (2020) explained the necessity of all students being proficient in natural science, engineering design, and technology by addressing the needs of the growing population. The authors stated that society will not be able to meet the basic needs of humanity without utilizing engineering design and technology to skillfully provide housing, food, transportation, and clean energy. The authors also explained that modern society requires individuals to be technologically literate, meaning everyone is surrounded by technology and is expected to use those resources to solve everyday problems that arise. These expectations are the aspirational justification for all students needing a solid foundation in science and the reform to include technology and engineering in NGSS (Keeley et al., 2020). Preparing the next generation to be self-sufficient and solve everyday problems is essential to our nation's success.

Like all individuals, teachers bring their prior knowledge into the classroom, as stated in the theoretical framework of social learning theory (Voet & Wever, 2017). The general overview of the theory acknowledged that individuals learn behaviors from experiences and observations they collect during their lifetime. For this reason, teachers generally cling to the processes from their educational experiences. However, the state tests are now based on the three dimensions of NGSS, requiring students to apply their knowledge to solve a problem or explain an event instead of merely regurgitating facts (Achieve, 2018). The changes in the assessments require major changes to instructional methods. Teaching by emulating their teachers from school is no longer meeting the needs of the students or preparing students for life after graduation (Melville, 2015).

The changes in standards led the researcher to select Open SciEd curriculum for the TSI plan. The curriculum is scripted and all-inclusive, meaning the teacher manuals contain everything needed to successfully facilitate the lessons (Science Classroom Resources-Science Model Design, 2023). The instructional model (2023) explained that each lesson has an overview of the storyline, the goals for students for the lesson, and example prompts with sample student responses. These resources allow multiple teachers to implement the curriculum while tending to equity. Each lesson has a driving question related to the phenomenon that are student generated. Students navigate an inquiry investigation to collect data to explain the phenomenon. Each lesson builds on the previous lesson and uses a project tracker to allow students to articulate what they have figured out (Science Classroom Resources – Science Model Design, 2023). Teachers must navigate a new script to meet the requirements of the NGSS (Pratt, 2013). The new teacher script is characterized by facilitating learning and discussions to move sensemaking toward understanding.

Local teachers' pushback against storyline curriculum was unfamiliarity with the new teacher script and the student population's learning gaps. The school has one of the highest diversity ratings in the district with a diversity score of 0.45, as shown on the School Report Card. The population has only 23% proficient in math and 40% proficient in reading language arts. The ethnic breakdown is six percent Asian, eight percent Hispanic, six percent black, 73% white, one percent Hawaiian, and six percent two or more races. Four percent of the students are eligible for reduced lunch and 57% are eligible for free lunch. The diversification of the student population is a concern for educators as they struggle to meet the growing needs for differentiation in their classrooms.

The differentiation has become more extensive since the district provides education to the families who are resettled by The International Center of Kentucky. This program settles a maximum of 200 refugee families in the Owensboro area each calendar year. The school level program which services these families is called the Newcomer program. Students are placed in this program for one calendar year after they move to the country. These students are then exposed to immersive English for half the school day to help them to transition to a regular classroom schedule. After the year, these students are placed within the general population of students for their grade level. The data will address these concerns and provide evidence for using a storyline curriculum to enhance student academic performance.

Purpose of the Study

The purpose of science education was redefined with the introduction of NGSS (Keeley et al., 2020). In the Preface, engineering and technology are explained to be essential for all students because they are meant to develop the creative and systematic problem-solving skills that all individuals need to succeed in life. Historical deficiencies in this area have been identified and understanding these topics is imperative for our nation to meet the needs of the growing population. This study will analyze the relationship between using inquiry-based learning (IBL) through a storyline curriculum and the measured learning outcomes from the Kentucky Summative Assessment (KSA) for seventh-grade science students over two consecutive years.

The data from the first year were analyzed, and the students could not apply content knowledge to the phenomenon prompts of the KSA. The school was identified as an at-risk school based on the test scores. To move out of the Targeted Support and Improvement (TSI) category, all identified populations needed to show a decrease in novice scores by at least 10%. The school year of 2021-2022 was used for a baseline comparison with traditional science instruction. The school year of 2022-2023 the instruction was shifted to a phenomenon-based IBL. KSA scores will be analyzed to determine the relationship between student engagement in storyline curriculum and academic performance.

For this study, student engagement will be defined as students being exposed to the storyline curriculum daily in science classrooms. The students will use data and other forms of evidence to make sense of the phenomenon presented within the storyline. Students are now asked to construct explanations or pick the best answer to describe what is happening in the phenomenon. Applying the science and engineering practices is very different from the traditional measurement of knowledge, where students were only responsible for knowing the facts they were taught in the classroom (Melville, 2015). Students now must show they can use the process to give a viable answer to what is happening and provide an evidence-based argument to support their position. Right or wrong is no longer the measuring instrument but how the student used the provided evidence to support their claim.

The shift in teacher script from where the teacher was the provider of facts to the facilitator of learning is due to students' unlimited access to disciplinary knowledge (Melville et al., 2015). Melville explained that this access created a fundamental shift for science teachers, requiring them to become facilitators to support student learning instead of the sole source of content knowledge. However, science teachers feel ill-equipped to teach with the new script, specifically with including engineering design with pedagogical content knowledge (Dare et al., 2018; Dean & Gilbert, 2021). Adding the scientific and engineering practices as a dimension in the standards was to decrease the likelihood that scientific practices were limited to a single set of procedures, disprove the idea that there is one scientific method, and provide clear definitions for inquiry (Pratt, 2013). The new way of teaching recognizes the change in the relationship of science to society reversing the separation of science education to application in the real-world (Melville, 2015). The relationships analyzed during this study will provide needed data for teachers to understand the need to jump from traditional instruction to IBL or PBL investigations.

Conceptual Framework

The lack of application to everyday problems was rooted in the elevation of science in the sociocultural ranking (Melville, 2015). The foundation of science was split between application to real life, and the learning of abstract facts has created the inability of students to use scientific and engineering processes to use knowledge to solve problems or improve designs. Moving to inquiry-based instruction is requiring science education to change the goals and mindset to revolutionize education. The *Framework* uses research-based instructional methods to provide clear guidance to teachers implementing these new non-traditional instructional methods (Pratt, 2013).

The KSA test scores measure accountability in Kentucky, which dictates many of the procedures and processes of the school. When the data was released for the 2021-2022 KSA, the district recognized the need for improvements in specific schools. Targeted changes were implemented to move the school to a more favorable classification and prevent becoming a Comprehensive Support and Improvement (CSI) school. This research examines the science scores data from two consecutive years of teaching, one year of traditional instruction from 2021-2022, and the other year of storyline NGSS-aligned instruction from 2022-2023 to measure the effectiveness of phenomenon-based units to show significant growth in seventh-grade KSA science test scores. The school's administration needs a 10% growth of identified student populations to move the school out of the at-risk category. NGSS is based on a continuous improvement framework and the *Framework for K-12 Science Education*. The *Framework* will be used to increase the effectiveness of the science department within the school and district.

Research Question and Hypothesis

Students in the United States performed significantly lower on international science tests than other industrialized countries (Melville, 2015; Dare et al., 2018). Teachers and students selected for this study will be the seventh-grade science classroom students from a selected school in consecutive years. The teachers will shift from traditional reciting of facts to storyline or phenomenon-based learning and measure student academic progress compared to the student body that had traditional science instruction. The research question will give insight into the school's low performance on standardized testing. Determining the root cause for poor performance is a goal of the improvement plan, as the school is an at-risk location. The research question is as follows:

RQ: How does a shift from traditional to 3D Learning instruction affect seventh-grade science students' academic performance?

This study hypothesized that seventh-grade science students who engage with sensemaking and inquiry-based learning would perform better academically than those who engage with traditional science instruction. Student engagement was defined as exposure to the storyline curriculum within the classroom. Additionally, the researcher predicted that students' engagement with designing experiments and solving problems will be better equipped and enhance their academic performance as measured in the classroom and on accountability testing.

Significance of the Study

Many science teachers are resistant to the changes to align with NGSS because it requires a different skillset to guide students through the inquiry process than it does to teach them erroneous facts (Pratt, 2013). The importance of support was shown by the statement, "NSTA believes that for new standards to be implemented successfully, a significant emphasis must be placed on outreach and support for science educators." (Pratt, 2013, p. 27). This study is designed to provide evidence to the science departments in the district for the need to shift the teacher script from teacher-led to teacher-facilitated to align with the NGSS. The standards were adopted in 2013, but the implementation has been slow and met with great resistance. Providing local data to the teachers to provide a reason for the shift to phenomenon-based learning in every science classroom is the main goal of this research. Finding a correlation between the use of phenomenon in the classroom and increased performance on the science KSA will motivate teachers to make the changes necessary to align with the standards. Research focusing on storyline curriculum is less prevalent than inquiry-based or project-based learning and will need further investigation.

Understanding the NGSS and the three dimensions students must engage with to meet the performance expectations overwhelms most teachers (Melville, 2015). The need for using a dedicated, comprehensive curriculum is becoming a necessity. Jones and Burrell (2022) stated that public schools do not teach science in each grade level of K-12. This puts pressure on the teachers during accountability years to ensure the students know the standards for all previous grade bands. Jones and Burrell stated that the lack of equity in science education has led to a gatekeeper effect that controls who defines and solves problems in society. The lack of equitable science instruction makes the pressure to cram facts into the students very tempting for those teachers in accountability years because of these insufficiencies within the schools (Jones & Burrell, 2022). This researcher aims to show that a storyline curriculum can increase the number of standards taught and the depth of knowledge students retain because of their engagement in scientific processes. The research will clearly define the relationship between storyline curriculum and performance on KSA testing.

Definitions, Terms, Symbols, Abbreviations

Clarification Statements. A part of the NGSS, found below the performance expectation in the What is Assessed box, that provides supply examples or clarification for the performance expectations (Pratt, 2013).

Connection Box. Located under the foundation box, this box lists relates standards within NGSS and Common Core State Standards to the performance expectations listed in the What is Assessed box for that standard (Pratt, 2013).

Crosscutting Concepts (CCC). Seven practices that are not specific to a single discipline but instead are used in all educational disciplines and include patterns; cause and effect; scale; systems energy and matter; structure and function; and stability and change (Pratt, 2013).

Disciplinary Core Ideas (DCI). The four domains of science and engineering curriculum, including physical sciences; life sciences; earth and space sciences; and engineering, technology, and science applications, that are relevant to people's lives and have broad importance within and across disciplines (Pratt, 2013).

***Framework for K-12 Science Education (Framework)*.** Published in July 2011 by NRC, the *Framework* was used as the foundation to build the NGSS; this Framework provides a research-based ways that students learn science effectively by thoroughly implementing engineering and technology into science education, explains the practice's inclusion within the standards, and guides how the three dimensions should be used to deepen the understanding of core ideas in all areas of science (Pratt, 2013).

Foundation Box. Located under the What is Assessed box, this box contains three sections with each of the three dimensions Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts that were used to create the performance expectations for that standard (Pratt, 2013).

Inquiry-based learning (IBL). The process of asking questions, designing experiments, gathering data, and analyzing data to explain a phenomenon; a practice used by scientists to investigate how and why the world works (Eltanahy & Forawi, 2019).

Next Generation Science Standards (NGSS). A set of science performance expectations written by Achieve and NGSS Lead States that was based on the *Framework for K-12 Science Education* and was published in April 2013; the standards outline the performance expectations for students for each grade band for all three dimensions (Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts) as well as the four disciplinary cores (physical science; life science; earth and space science; and engineering, technology, and the application of science) of science education (Pratt, 2013; Willard, 2015).

Opportunities to Respond (OTR). An instructional strategy used to increase student engagement and assess the depth of knowledge of students by giving them more chances to contribute to classroom discussions (Whitney et al., 2022).

Performance Expectations (PE). Located within the What is Assessed box, this describes what a student should be able to do when the standard is mastered or to prove mastery after instruction (Pratt, 2013).

Project-based learning (PBL). An instructional strategy that increases intrinsic motivation in students by allowing them to learn by solving a problem; the process used by engineers to solve real-world problems (Gallagher & Gallagher, 2013).

Science and Engineering Practices (SEP). The practices in the standards that mimic the actions or processes of scientists and engineers when solving real-world problems; the eight practices used to participate in science include asking questions and defining problems; planning and carrying out investigations; analyzing and interpreting data; developing and using models; constructing explanations and designing solutions; engaging in argument from evidence; using mathematics and computational thinking; and obtaining, evaluating, and communicating information to explain the phenomenon (Pratt, 2013).

Scientific Inquiry. The sensemaking process led by students' questions to determine what is happening through designing and conducting an investigation (NCES, 2020).

Scientific Literacy. A student's ability to use scientific practices to develop an explanation of phenomena, to understand science-related life issues, and to solve problems scientifically (NCES, 2020).

Sensemaking. A learning method where students use data and other evidence to explain what is happening or why something is happening (NCES, 2020).

Three-dimensional learning (3D Learning) or Three-dimensions of NGSS. As a requirement of Next Generation Science Standards, students must engage in all three dimensions of the standards: the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts to fully master standards; an approach to science teaching that helps students build their research, communication, and analytical thinking skills (Pratt, 2013).

Summary

This introduction provides the context for examining data trends in science education and the correlation with standardized testing scores. The motivation for this study is to provide data and determine the relationships between storyline curriculum and standardized test score. The population selected to study was identified because this group of students was identified as an at-risk group needing targeted interventions. Research-based methods for instruction make it clear that the use of inquiry is necessary for students to achieve the deepest learning. The changes in pedagogy for science are significant, and many teachers lack access to resources that train them to meet the requirements of the standards. Increasing the data showing the correlation between science instruction and the ability of students to apply science in everyday situations is the main goal of this research.

Chapter II: Literature Review

Necessity of Change in Science Education

According to the National Research Council (NRC; 2012), the continual decline of the United States of America's performance in the science and engineering sector was significant enough to merit the revitalization of science education. The NRC developed *A Framework for K-12 Science Education* (*Framework*) in July 2011. The *Framework* stated that the purpose of science education should have prepared students for the future, and the approach to education had to be updated to meet the research-based methods. The Next Generation Science Standards (NGSS) was developed to increase science students' knowledge depth, bridge the classroom gap and create science literacy so students could apply science practices to real-world phenomena. According to the NRC (2012), the standards were based on the Framework for K-12 Science Education, which experts created to increase the knowledge base of our population in science and engineering practices. Kentucky was a Lead State Partner in developing the NGSS standards. Consequently, the standards were adopted in Kentucky in June 2013 and were scheduled to be implemented the following school year.

Phillips et al. (2018) acknowledged the importance of engagement to academic success, reduced behavioral issues, and a precursor necessary for deep learning. The researcher employed the sociocultural theory in the study and examined the active learning results through phenomena. The theory recognized the need for a learning community where individuals could practice skills and solve problems. Data was collected by quantifying the depth of learning and each participant's data analysis involvement. The results were as expected. Those individuals who collected and analyzed data reported a deeper understanding of the project than those who only collected data. These results confirmed the need to reform science education in the U.S. to develop student engagement related to real-world experiences to increase the depth of learning (Phillips et al., 2018).

Adams (2022) related the decline in the United States of America's performance in science and engineering to the changes in diversity. The literature stated that the underrepresented minority are dually disadvantaged. The article cited that the households do not value further education as other families, so the youth do not prioritize education. Adams (2022) continued that graduates cannot use scientific processes to solve real-world problems, which resulted in unpreparedness for careers in science or engineering. The evidence cited for this acknowledgment came as results from a global test administered every three years to test for science literacy. The article explained that the National Center for Educational Statistics (NCES) administered a global reading literacy, mathematics literacy, and science literacy assessment called the Program for International Student Assessment (PISA) to all 15-year-olds. Adams (2022) explained that the assessment required students to perform various tasks to solve real-world science and technology issues. The data from the assessment proved that the U.S. is behind in science and engineering education (Adams, 2022; Loveless, 2017).

The NCES (2020) defined science literacy as a student's ability to explain phenomena to understand science-related life issues from a scientific perspective. Chen and Terada (2020) outlined the essential scientific practices as asking questions; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations; engaging arguments from evidence; and obtaining, evaluating, and communicating information. Adams (2022) described the essential scientific practices in the two areas. The first of the areas was the ability to evaluate and design scientific inquiry. The second area was the ability to interpret data and use evidence to solve real-world problems. Loveless (2017) also analyzed the results of the PISA and the Trends in International Mathematics and Science Study (TIMSS) from 1995 to 2015. The author described the change in the science scores as statistically significant from 1995 to 2015 but far behind where they need to be for the U.S. to become competitive in the marketplace. NCES (2020) reported the U.S. results from the 2018 assessment, which revealed that only nine percent of fifteen-year-olds performed at or above proficiency level 5, while nineteen percent were low performers meaning they scored below proficiency level 2. Compared with the results from 2006, the United States had an overall increase of thirteen points for the average score (NCES, 2020). After the study of the data, the literature concluded that the data was significant enough to call for the reform of science education in the U.S. (Loveless, 2017).

Standard Development for Science

According to NGSS Lead States (2013), the standards were developed to provide students with experience using science and engineering practices to solve problems. The literature continued that in addition to stakeholders, industry leaders, and science educators, the standards were compared with those used in countries leading the scientific community at the time of development. Furthermore, the article stated that the standards were developed using current science education research to increase the career readiness of graduates or ensure they were prepared for post-secondary education. NGSS Lead States continued to explain that the standards were written to provide educators with a comprehensive and complete understanding of the performance expectations of student mastery. This new approach to teaching science was grounded in research and recommendations from industry professionals and the *Framework*. The revisions of the NGSS were published in April 2013 (NGSS Lead State, 2013).

NGSS Lead State (2013) contained Appendices A-M, which provided details, background information, and implementation models. Included in the standards were three dimensions built into a coherent learning progression from kindergarten through 12th grade. NRC (2013) and NGSS Lead States (2013) noted that the standards referenced connected mathematics and English Language Arts standards meant to assist educators in providing a more coherent and meaningful approach to education. These articles made the distinction that the standards were not curricula but were written to provide the foundation students needed to succeed in their future. The literature also explained the structure of the standards, which included performance expectations, vertical progressions, and boundaries for each standard which was created to provide a more cohesive approach to mastering the science and engineering practices needed to solve problems. At the same time, NGSS maintained clear boundaries for science assessments at each grade band (NGSS Lead State, 2013).

Traditional Instruction in Science Education

Voet and Wever (2017) provided a general overview of the theoretical framework of social learning theory. They stated that individuals learn behaviors from the experiences and observations they collect during their lifetime. Traditional instructional methods included passive receiving of information, active manipulation, constructive self-construction, and interactive dialogue according to Chen and Techawitthayachinda (2021). Various articles stated that the teacher-led instruction was merely the memorization of numerous facts without the ability to apply the knowledge to real-world situations (Holthuis et al., 2018; Chen & Tarada, 2020). A traditional science standard included a large list of facts to be memorized by students and regurgitated on an assessment to prove the facts were learned (Holthuis et al., 2018). In this form of thought, student engagement was defined as completing a task or listening during a class lecture (Phillips et al., 2018). Pinnick (2023) identified the lack of literature and research to assist educators with the shift from how and what they taught to the new inquiry-based model for learning on which the new standards were based.

Three-Dimensional Learning

Holthuis et al. (2018) described the purpose of NGSS as replacing the memorization of numerous facts to fluently complete investigations of the natural world to explain phenomenon or solve problems. Morris (2020) recounted the shortcomings of the educational system by looking at the PISA results. The article stated that the results highlighted the inability of the student population to collaborate, think critically, communicate effectively, and employ creativity in future roles. The author bolstered that increased cognitive learning was identified as the significant shift to produce prepared graduates. Morris (2020) also identified the need to address the depth of learned skills for high-risk students who were disengaged from school and did not pursue further education. The article explained that blended learning was utilized to create lessons relevant to student life. These new instructional strategies provided new pathways to increase student interest, which led to student engagement becoming a critical skill for all educators (Morris, 2020).

In the study by Gale et al. (2022), phenomenon-based units led students through a progression of lessons that created inquiry investigations and developed models to construct an explanation of what was happening. The authors explained that educators found that facilitating the modules increased their pedagogical content knowledge fluency by sparking inquiry investigations and requiring them to develop questions to ask their students. When the teachers reflected on the implementation of the modules in the study, they described student reactions instead of how they facilitated. The positive perspective of the teacher shifted the teaching dynamic (Gale et al., 2022).

Holthuis et al. (2018) described the changed standards and the needed shift in teacher support due to the movement from memorization of a lengthy list of facts to the sensemaking inquiry investigation needed to have proficiency in applied science and engineering practices. Furthermore, the integrated dimensions of the NGSS were designed to mimic the process of scientists and engineers who investigate real-world problems. Additionally, the more refined focus of the standards was coined as Disciplinary Core Ideas, which replaced the list of facts from previous standards. Similarly, the standards also connected various disciplines identified with the verbiage Crosscutting Concepts. Holthuis et al. (2018) continued and explained that the revitalization moved students to ask questions about how and why things occurred, which led to a deeper understanding of concepts from multiple disciplines.

Science instruction reform changed the learning activities and choices teachers provided for their students (Schmidt et al., 2018). According to Schmidt et al. (2018), the varied levels of motivation to learn have always been a challenge for educators because it depended on the past experiences of the individual students. The study continued and explained that NGSS required learning activities rooted in scientific practices. The author noted that educators must consider the audience when selecting instructional strategies. The topic must be relevant to the student body to meet the engagement level required by NGSS. Schmidt et al. (2018) stated that the varied motivation to learn stems from the student’s experience, and this factor is expected to always be present in the classroom. Furthermore, the author addressed that the instructional techniques must be grounded in scientific practices to meet the criterion of the NGSS. According to the author, educators are challenged to provide choices for the students to increase intrinsic motivation to learn and perform at a higher level. Another factor in implementing choice, confirmed by Schmidt et al. (2018), was that teachers must remain mindful of the context and value placed on the choice by the students. The effectiveness of providing choice was likely connected to the outcome because of the choice's value to the student (Schmidt et al., 2018).

Changes to Standardized Testing in Science Education

According to Munter and Haines (2019), in 2015, the U.S. Department of Education determined that students were being over-tested. The article noted that the U.S. Department of Education acknowledged that changes needed to include smarter forms of assessments to decrease the number of tests students must take. The article also stated that new assessments should be created to provide timely and actionable feedback to guide the instruction of the school curriculum. According to Shepard (2019), the goal of state testing for schools should be to evaluate the adequacy of the curriculum instead of using them to develop intervention plans for individual students or groups of students. Analyzed data used to identify and correct programmatic weaknesses while leveraging the strengths would strengthen the overall education system (Shepard, 2019). Achieve (2018) provided the alignment criterion for state summative assessments. The literature stated that the assessments required elements of design, three-dimensional performance, phenomena, scope, cognitive complexity, technical quality, and reports for each prompt. Furthermore, Achieve (2018) stated that all assessments were based on the *Framework* and were comprehensive.

NGSS Components

The purpose of the NGSS was to move from memorization of seemingly unconnected facts to include engineering practices to increase the depth of knowledge of students and increase the interest in science and engineering (NRC, 2012; NGSS Lead State, 2013; Dare et al., 2018;

Achieve, 2018). Schmidt et al. (2017) identified three dimensions of engagement and coined them the framework of momentary engagement. In the framework, behavioral engagement was identified as critical for academic achievement since participation in scientific activities was deemed essential to mastery. The second part of the framework was cognitive engagement which highlighted the requirement of student perceived value for the academic activity. The third dimension of the framework was affective engagement which focused on the individuals' feelings toward the teacher, peers, activity, and school in general. Schmidt et al. (2017) observed the importance of the person-oriented approach in the science classroom. The article noted the value of actively engaged learners who recognized the relevance and importance of the process. Learners also needed opportunities to respond (OTR) for these learning outcomes to be met, according to Whitney et al. (2022). The planned interaction allowed the teacher to provide immediate feedback for responses to the teacher-provided academic prompt (Whitney et al., 2022).

Requirements of NGSS Components

The NRC (2012) explained that one of the foundational concepts of the NGSS was the requirement for students to be engaged in science to meet performance expectations. Researchers agreed that student engagement is essential to increase learning outcomes, but very few studies focused on the domain of science (Schmidt et al., 2018). The existing research pointed out the decrease in engagement throughout the educational career in science classrooms. This was a significant change from the previous standards, which outlined knowledge the students should have attained during each level of instruction. The NRC (2012) emphasized the relevance of science to daily life; this was a basis for requiring students to engage on a high level to meet the performance expectations outlined in the standards. The shift in the standards also led to changes in the state standardized testing.

A comprehensive document by Achieve (2018) outlined the framework for summative state science assessments. The assessment design required students to use the science and engineering model to solve problems of the phenomena. The scenarios should have been relevant to the students while they were balanced in the three dimensions of the NGSS standards. The assessment must have age-appropriate cognitive complexity for the desired grade band. Interestingly, the requirements for these assessments were to be equitable in writing. The assessment was written so that all students could complete the task successfully. The assessment should provide information about the student's progression in their science knowledge and the science processes. Assessments are required to have been shaped by the NGSS standards and how they are meant to be taught. The article stated that the standards were formed with applied knowledge as the main goal. The article continued to explain the new assessment format would measure the student's ability to apply scientific concepts to phenomenon. Students should be able to use the information and data they are provided to construct an explanation for the phenomenon in the prompt (Achieve, 2018).

Focus Shift for NGSS Components

Dare et al. (2018) noted the correlation between implementing the standards to the teacher's content knowledge and their ability to explicitly and meaningfully connect various disciplines addressed by the standards. The literature explained that teachers must connect mathematics, engineering, and science for students to meet performance expectations effectively. Tas (2016) highlighted the need to ensure the students are engaged with relevant phenomena. The article explained that the learning environment must be equitable and cohesive, with a positive environment to implement the NGSS. The research stated that students experienced more growth when classroom norms included friendly peers, a safe space to ask questions, community culture, and when they were interested in the stimulus. The article also discussed how prior knowledge was used to activate the learning process and move students toward solving the problem outlined in the phenomenon. Motivation and a positive learning environment are essential in a student-led classroom (Tas, 2016). According to Li et al. (2022), the science standard reform has increased the need for school-level professional development for science teachers. The article noted the essentiality of an appropriate classroom climate to foster inquiry-based learning (IBL) and the push to increase science literacy. Research stated that students are more successful in a good classroom environment (Tas, 2016; Dare et al., 2018; Li et al., 2022).

Implementation Challenges with NGSS Components

Fischer et al. (2018) stated that curriculum reforms were difficult due to the altered content and teaching method. The author described the shift in the curriculum as a move from broad content exposure with clearly defined problem-solving procedures to a curriculum based on the scientific practices of inquiry, critical thinking, and engagement in scientific processes. Fischer et al. (2018) described the change as a movement from teacher-centered instruction to student-led teacher-facilitated learning as the critical point of the difficult transition. Furthermore, the new standards no longer provided a list of knowledge the student should have attained but instead provided methods to ensure students engaged in science inquiry investigations and increased skills needed to approach real-world challenges in science and technology. Dare et al. (2018) found that the teachers needed help when they taught science and engineering together. The article explained that science teachers have historically been responsible for teaching science content, but the new standards added another aspect that challenged the educators. Dare et al. (2018) identified one challenge to educators as creating a lesson to not only introduce the phenomenon but also to set up the project while keeping the students' focused on the problem from the phenomenon.

Dean and Gilbert (2021) described the implementation of scientific practices in a classroom as complex. The article reflected on the implementation challenges with a focus on the teacher's perspective. The authors stated that the teachers recognized the needed adjustments of students for the inquiry-based approach to science instruction. The researcher described the shift in the elementary school level as the teacher created wonder that enticed students to engage with the phenomenon being investigated. Furthermore, the practice of wonder led the students to formulate questions, which led them to analyze data and make sense of the world. Researchers noted that the inconsistency of implementing scientific practices in various classrooms needed further investigation to determine if it impacts equipped students to understand the many approaches available to solve scientific and engineering problems (Dean & Gilbert, 2021).

Dare et al. (2018) described a study that followed several teachers as they attempted to implement a science, technology, engineering, and mathematics (STEM) lesson for the first time. The authors found that the teachers struggled to implement the curriculum while ensuring the students made the necessary connections and facilitating the student-led inquiry. The aspect of NGSS, the teachers, struggled with most was dedicating the appropriate amount of time to the engineering process during this research project. Another study by Zhao et al. (2018) noted the need for knowledge diversification within student groups to attain optimal group performance. Researchers noted that mixed knowledge altered how the group solved and approached problems or tasks. According to the article, optimal groupings also exhibited higher behavioral, emotional, and social engagement than those in the low-prior knowledge or less diversified groups. In another study, Gallagher and Gallagher (2013) found that project-based learning (PBL) increased the performance of low-income, high-achieving elementary and middle school students by tending to equity in the classroom.

Curriculum for NGSS Components

Zvock et al. (2009) noted that moving to a student-centered instruction method increased student learning outcomes and prepared them for their future. They continued that student-centered instruction approached scientific concepts by guiding learners through inquiry, so they learned to develop questions, design investigations, and formulate probable explanations throughout the process. According to the research, IBL promoted a deeper understanding of concepts than the traditional learning of facts. Price et al. (2019) explained the scientific tool of interactive science simulations (SIMS) could be used to teach science practices, explore content, and increase student motivation. Researchers explained that one of the more popular variations was the PhET SIMS, which allowed students to explore otherwise difficult-to-see concepts and change variables to gain a complete understanding of how variables interact. The SIMS allowed students to interact with and visualize otherwise invisible interactions between forces of nature, according to the article. The researchers stated that teachers who used the PhET SIMS added various activities to the exchange database, which increased collaboration among educators. Another benefit noted by the authors was leveraging the SIMS to engage students in science and allowing them to engage in sensemaking activities that are phenomenon-based and aligned perfectly with the NGSS (Price et al., 2019).

Tofel-Grehl et al. (2021) also addressed the benefits of simulations and STEM during lessons on content like electric potential. The researchers recognized that educators were challenged to find ways to turn uninteresting topics into an engaging, inquiry investigation for students. A teacher from the study worked with industry leaders and developed a scaffolded model to assist educators with the concept and procedure that made the project come to life in the classroom. The study outlined the lesson. First, the students created paper circuits to get a basis for energy, electricity, and circuits. After the students initially understood the content, they designed a bracelet that lit up when they wore it but would not when it was laid flat on the table. Students were allowed to use microprocessors and code to make the bracelet blink. Finally, the students used their knowledge and created a temperature-sensing lunch box. Students were challenged and learned five standards through inquiry and sensemaking to solve the problem. The unit taught many of the standards in a way that engaged students with all three dimensions of learning (Tofel-Grehl et al., 2021).

Professional Development for NGSS Components

Professional development for NGSS needed to focus on content, be continual, and provided coaching and direct feedback through collaboration (Achieve, 2018; Yang et al., 2019; Chen & Terada, 2020; Nutt, 2021). Chen and Terada (2020) and Chen and Techawitthayachinda (2021) outlined the need for a more comprehensive model that included pedagogical practices, which led to increased student learning. State et al. (2019) noted that professional development without the necessary continued support was insufficient to create a sustainable implementation of the IBL. Shepard (2019) characterized effective professional development as one that deepened the teachers' content knowledge and pedagogical content knowledge and an increased understanding of how students learned the specific content. The article continued to explain that the reform efforts expanded professional development to include the connections between curriculum, assessments, and standards. Yang et al. (2019) described teachers as the conduit that connected educational reform and student learning.

Student Engagement with NGSS

Phillips et al. (2018) described student engagement as completing a task or paying attention during class. The authors acknowledged the importance of engagement to academic success, reduced behavioral issues, and as a necessary precursor to learning. Employing the sociocultural theory, the study examined the results of active learning through phenomenon. The theory recognized the need for learning within a community where individuals can practice skills and solve problems. Interviews were used to quantify the level of learning and how involved the individuals were in the project's data analysis. As expected, those who had an active role in data collection and analysis reported higher levels of learning than those who only collected data. These results showed the need to reform science education in the U.S. and provide additional support to increase student engagement by solving real-world problems relevant within the students' community and how this would increase their depth of knowledge (Phillips et al., 2018).

Student engagement was researched from various lenses by an extensive number of researchers. As a highly complex issue, it was essential to adopt a definition of student engagement which was defined in the *Handbook of Research on Student Engagement* as a multidimensional construct of behavioral, cognitive, and affective subtypes that drove learning through the use of student investment in understanding meaningful academic outcomes (Schmidt et al., 2018). The literature advised that previous research looked at student engagement based on instruction in a traditional classroom. Furthermore, the authors noted that very little traditional instruction is conducted in an NGSS classroom because they used PBL, simulations, inquiry, and sensemaking activities to guide students' understanding. PBL taught students how to problem solve, the rules of argumentation, experimental methods, collaboration, peer tutoring metacognition, and teaching content knowledge (Gallagher & Gallagher, 2013). The researchers explained that when content was approached from the PBL lens, students were more engaged because they found the problem intriguing, which led them to be more motivated to learn. The studies also noted that performance-approach goals increased students' intrinsic motivation because they desired to demonstrate their abilities (Tas, 2016).

Engagement was described as a malleable term open to construal in various ways depending on the person completing the interpretation (Godec et al., 2018). This literature considered engagement in science education from the Bourdieusian lens. From this perspective, little research had been done to consider how support for engagement for one student could decrease engagement for another student. In the study, the researchers concluded that educators could increase student engagement by broadening the field of knowledge past the typical science knowledge needed to be successful in the project. The authors acknowledged that more research needed to be completed before attempting this in the classroom since there is a potential for decreased engagement by those learners who successfully navigate science content within the traditional parameters. Kiran et al. (2018) investigated the relationship between engagement in science to teacher and student motivation. The results showed that teacher motivation was a poor predictor of student engagement. However, the research showed favorable student success and motivation progression when task difficulty increased over time. The authors noted that when students were allowed to experience success in the early stages of learning, it led to higher academic self-efficacy (Kiran et al., 2018).

Nutt (2021) defined student engagement as a combination of explicit instruction and many OTRs. This study determined ways to increase student engagement in a co-taught classroom. The researcher stated that using OTR increased the pace of instruction, kept students on task, and improved academic success. Research provided ranges of OTR for each grade band, but increasing the number led to higher student engagement and academic achievements. The literature cited research-based techniques for increasing student engagement in this model: eliciting responses, effective questioning, monitoring responses, feedback, and pace of instruction (Nutt, 2021).

In a study of student engagement when employing simulation activities in science, the students reported high levels of engagement, confidence, and satisfaction (Almasri, 2022). For this study, Almasri (2022) defined student engagement as the energy and effort students devoted while interacting in the learning process. The same study also noted that male engagement depended more on students' self-confidence than their female counterparts. Almasri (2022) also found that visual, auditory, and kinesthetic learners all reported higher levels of engagement when simulation-supported activities were utilized in the classroom. The learning style, gender, and self-confidence of the student was a good indicator of student engagement and satisfaction in a science classroom (Almasri, 2022). Allen et al. (2018) also found a consistent link between psychosocial factors (PSF) in middle school as a predictor for later educational outcomes. These studies showed the importance of student academic success in middle school to their overall educational outcome in their lifetime (Allen et al., 2018; Almasri, 2022).

Tas (2016) looked at student engagement and addressed self-efficacy in the science classroom concerned with student's goal orientation. The article stated that traditionally female and high-achieving academic students had a higher level of engagement than males and lower-level achievers. The second domain of the study was that student engagement was studied from the perspective of the science classroom. For this, the researchers used the self-determination theory, which stated that the learning environment could discourage or encourage the development and performance of students. The researcher found the students' academic outcomes were higher when the students perceived there was support from the teacher and peers. This perception led to students being more invested in learning and increased student engagement. The researchers concluded that supporting student autonomy and maintaining a safe, positive learning environment would increase the motivation of the student to master the content. The authors stated that providing students with choices, feedback, praise, and opportunities for inquiry would increase student learning outcomes (Tas, 2016).

In education, engagement became a buzzword when it was shown to have a correlational relationship with positive learning outcomes (Sinatra et al., 2015). The study outlined the various viewpoints of numerous researchers on student engagement. The researcher suggested that as a predictor of positive learning outcomes, engagement should be studied from the vantage of individuals or groups of learners to predict the learning outcomes more accurately. The authors acknowledged that engagement is more complex in the science classroom because of the many misconceptions during the inquiry process. The study noted that the misconceptions required a shift in conceptual thinking for the individual to overcome the misunderstanding. For this reason, Sinatra et al. (2015) suggested that using a continuum to measure the level of engagement in the science classroom would account for the various aspects of engagement that needed to be monitored to gauge the level of interaction in science practices.

Academic Achievement for Middle School Students with NGSS

Geary (2018) synthesized the development of middle school students and the relationship to academic success. They used the theory of Piaget, Vygotsky, and Erikson to explain the intellectual development of the students. Teachers have leveraged knowledge development to increase the student’s learning outcomes in the study. The literature stated that educators had used this development knowledge to create developmentally appropriate yet challenging lessons. The researchers described middle school as the transitional phase of development, and students became capable of hypothetical deductive thinking and reasoning, which made them capable of solving complex problems. In the study, the students reflected on the process and analyzed the data to draw various conclusions based on their different perspectives. The researcher stated that middle school students changed their demeanor, attitude, and thought processes during the transitional phase of development. The study concluded that academic achievement was more successful when the student had a particular social, emotional, and relational group. The foundational needs in Maslow's hierarchy had to be met before the student could succeed academically (Geary, 2018).

Duong et al. (2021) described another study that stated that diversification was considered when examining academic achievement and learning gaps in society. The literature indicated that identifying the various contributing factors to achievement gaps has traditionally examined the black-and-white approach to inequity. Duong et al. (2021) examined other minorities concerning academic outcomes and found that peer-group context was a good predictor for academic performance. The article identified a correlation between the individual's social group and engagement behaviors that led to various academic performances. The research also showed that middle school students became more closely connected with the behaviors of their social group. The literature was limited in the correlation between social groups and academic norms; however, the author stated that females tended to be more academically successful, but there was no significant variation in standardized test scores. The research indicated that injunctive norms had a more substantial influence on female adolescents than on males. These norms gave the group more control over the behavior and academic outcomes of the group members (Duong et al., 2021).

Achievement goals were also used to predict students' academic performance in science class. Hidiroglu et al. (2015) outlined the four-factor model of achievement goals: mastery approach goals, performance-approach goals, mastery avoidance goals, and performance-avoidance goals. The mastery and performance goals focused on outperforming others, while the avoidance goals focused on not being the worst academically or behaviorally. Those students who set performance-approach goals would have strived for excellence and are highly engaged in coursework. There are mixed results in understanding the motivation and goals of the students who had avoidance goals. The cognitive engagement was predicted by the individual student's mastery approach or avoidance goals. The student showed a positive correlation between focusing on learning, understanding, and improvement. In this study, the seventh-grade science students possessed higher performance-approach goals than avoidance goals for science class (Hidiroglu et al., 2015).

Gifted and talented students have increased in the sciences. Teachers needed to create cross-curricular and exciting lessons for the student population to fully engage these students and stretch their thinking to meet their potential (Mark et al., 2021). Integrating science, technology, engineering, art, and mathematics (STEAM) into inquiry-based lessons would have allowed the students to continue to grow and flourish academically. Including multiple disciplines permitted the students to learn how science could be related to many aspects of life and careers. Tasking these students with a problem to solve and allowing them to collaboratively move through the science and engineering process to find a solution was an effective strategy to ensure students engaged in a way to increase academic outcomes in science (Mark et al., 2015). A greater depth of learning was possible when community leaders were included in the projects so the students could see firsthand the localization and relevance to everyday life. Tapping into the foundational cross-curricular problem-solving methods would have allowed students to experience critical thinking, problem-solving, and inquiry investigation while mastering the NGSS standards. The best practice would have posed a problem to the group and allowed them to research, design, and engineer a solution (Mark et al., 2015).

Theories and Theorists in NGSS

Moving students from IBL to understanding the basis for the problem was complex (Achieve, 2018). Students needed self-efficacy to succeed in the new science domains, while science self-efficacy could be used to predict science learning outcomes (Yang et al., 2020; Scogin et al., 2017). Zvock et al. (2019) completed a meta-analysis review of the 37 studies that calculated one-half of a standard deviation that favored the students who participated in inquiry-based instruction. The students who participated in student-centered instruction had a more profound understanding than those who participated in teacher-centered instruction (Zvock et al., 2019). Students from the study by Scogin et al. described a better understanding of the importance and relevance of the standards they were learning in all subjects and how those skills led them to successfully solve problems. Ke et al. (2016) completed a study analyzing the theory and data behind the game-based learning movement. The literature and case study data synthesis provided the groundwork for future theories to model game-based learning (Ke et al., 2016).

When measuring the successes of student learning, it was impossible not to ignore the importance of the engagement theory, self-efficacy theory, and value-expectancy theory. These three theories complemented each other in the science classroom. The Committee on Development in the Science of Learning (2018) explained that the beliefs and values of learners were essential in the learning outcomes of individuals. The individual's perception of belonging, competence, and capabilities directly influenced the learners' academic achievements, making the self-efficacy theory essential to this study. At the same time, the expectancy-value theory was addressed in the science curriculum by connecting the phenomenon to the experiences and lives of the learners. The relevancy of the scenario would have increased student motivation by sparking curiosity in learners' minds. Ensuring the connection between learners and the problem added value to the inquiry process, which led to improved learning outcomes and a better understanding of students' motivations (Committee on Development in the Science of Learning, 2018).

Science education aimed to produce scientifically literate graduates (NGSS Lead State, 2013; Achieve, 2018; Jones & Burrell, 2022). Literature utilized these theories to increase the intrinsic and extrinsic motivation of the learners in science classrooms, which allowed learners to achieve greater learning outcomes (Committee on Development in the Science of Learning, 2018). Creating challenges supporting autonomy within the classroom increased the students' motivation to learn, led to greater growth, and reduced learning gaps within the student population, as noted by the research. The monitored growth of the learners was quantified by analyzing their test scores and engagement, which led to a better understanding of how different curriculums influenced standardized test scores in science (Committee on Development in the Science of Learning, 2018).

Student Performance with NGSS

Student engagement with the science and engineering practices was required to demonstrate mastery (NGSS Leading States, 2013). Chen and Terada (2021) developed and validated an observation-based protocol (OBP) to measure student engagement in the classroom with the eight scientific practices outlined in the NGSS. Teachers from the study noted that the use of the eight practices are inherently interconnected because each key element could not be used in isolation. The literature explained that the eight practices were divided into three categories based on the knowledge development phase: investigating, sensemaking, and evaluating and communicating. The investigation category included *asking questions, planning, and carrying out investigations,* and *using mathematical and computational thinking*; the sensemaking category was comprised of *developing and using models, analyzing and interpreting data,* and *constructing explanations*; lastly, evaluating and communicating included *engaging in argument from evidence* and *obtaining, evaluating, and communicating information*. The OBP aimed to measure students' movement from passively receiving information to engaging in science and honed the skills necessary to compete for employment in the science and engineering marketplace.

Standardized Testing for NGSS

Munter and Haines (2019) investigated the effects of leader rationale on student performance for standardized tests. The literature had mixed results as to the value of the standardized test results. One such perspective saw the learners as data-producing machines with little regard for the assessment's effects on the tested individuals. Still, others argued that the feedback from the assessments was essential to meeting the needs of the students by identifying strengths and learning gaps. Another viewpoint was that the students would strive for success to be placed in advanced placement classes. The authors identified that the school's results could remove or place labels on the school for needing to improve or for excelling. These labels seemed to cause significant stress, so teachers strived to move students farther with innovative lessons that increased student motivation and reduced learning gaps. There was significant evidence for each of these viewpoints, according to Munter and Haines (2019). In the article, the goal of education was to prepare students for their future, so the standardized test scores measured performance, but did they measure our students' full range of abilities? The literature was not straightforward, but it answered this question and answered that educators understood the various reasons for standardized tests and would continue to strive for success through meaningful instruction (Munter & Haines, 2019).

Overall, the literature showed increased student learning outcomes when the teachers had the support and professional development to implement PBL or IBL instructional strategies at a high and consistent level for an extended time (Capraro et al., 2016). Students who engaged in a curriculum of inquiry-based instruction performed better on science achievement tests than students taught with other methods (Zvock et al., 2019). One characteristic that predicted student performance was their academic self-concept (Sutton-Davis, 2018). Whether the academic self-concept was the reason for the better performance, or a result of the high performance was still being determined. Sutton-Davis (2018) suggested that students with high test anxiety might have put more effort into the assessment and obtained higher test scores.

Since adopting the NGSS Standards, science teachers have been tasked with creating and maintaining high innovation in teaching the standards. Educators and students felt the pressures of standardized testing in every school. This pressure often influenced the types of instruction teachers were willing to implement in the classroom. Scogin et al. (2017) recognized the hesitation of educators to implement experimental learning opportunities within the classrooms for fear of negative performance on state assessments. Considering the requirements of the science standards and the new approach to science assessments, educators abandoned their traditional methods of instruction to increase science literacy (Scogin et al., 2017). After

COVID-19, test scores plummeted in many districts. Recovering from the learning deficit has pushed educators to move to more innovative approaches to increase growth in the student knowledge base. Moving forward, science educators embraced the need to implement cross-curricular projects to decrease the learning gaps. Research supported collaborative learning to move the students to a higher level of understanding. The components of many lessons missed in the science classroom connected the curriculum to everyday lives and careers. Increased collaboration and the utilization of the nontraditional PBL or IBL showed consistent increases in test scores except for reading (Scogin et al., 2017).

Behavioral Performance with NGSS

Madkins and McKinney de Royston (2019) analyzed the culturally relevant pedagogy in science classrooms after the reform of standards. Described in the research was the movement to approach science education as doing science to increase science literacy does not directly address the issue of equity and diversity. However, the article noted that educators are mindful of these issues when creating lessons. Examples of the process included many of the units created had sidenotes on attending to equity and diversity in the classroom. The article noted a rebuttal that science education was that the teachers taught students how to solve problems and think critically, which would have helped them overcome any inequities in the real world. The authors stated the goal of students to make connections across curriculums, which gave them skills that would be invaluable in their careers or post-secondary education. Documentation of using culturally relevant pedagogy in the science classroom to tend to equity needs to be studied in more depth to determine the effectiveness of implementing NGSS (Madkins & McKinney de Royston, 2019).

Academic Performance with NGSS

A study of IBL in Dubai was conducted to determine if the students learning from a textbook were experiencing IBL in the science classroom (Eltanahy & Forawi, 2019). The study was conducted as part of a national movement for the country to become one of the top 20 countries in PISA. Before the study, the classrooms were provided with a new course curriculum and textbooks to assist with implementing inquiry in the science classrooms. The study found that using IBL in science classrooms significantly increased the learning outcomes of students and the perception of the concept by teachers and students. The trifecta of forces used to complete the IBL experience was the instructional strategies of the teacher, the implementation by the students, and the textbook as the guiding curriculum (Eltanahy & Forawi, 2019). The textbook followed the “5 Es” theory which contained all the theories, concepts, and experiments as a standalone curriculum. Teachers then utilized inquiry for the students to learn to become scientifically literate, increasing their problem-solving ability.

Capraro et al. (2016) had six focus groups that implemented various levels of PBL. The focus noted that a significant challenge to implementing the PBL was that the student learning gaps in mathematics were difficult to overcome. A major constraint was the limitations on time to complete the projects. Otherwise, when implemented, using PBL led to student growth and achievements in standardized testing (Capraro et al., 2016). These were considerations that teachers looked at when they decided what instructional strategies to use during the school year. Facilitated change in the science classroom was less complicated than sustaining the shifts in teaching practices. A study by Gale et al. (2022), looked at the variation in implementation when participating in a research-practice partnership. Professional development for module implementation was expected to increase inquiry levels past that of the sample modules (Gale et al., 2022). Based on these studies, effective professional development positively influenced teacher instructional methods that met the requirements of the reformed standards.

Gale et al. (2022) highlighted the redesigned instruction for science provided teachers with opportunities to increase collaboration and support for the reform. The authors reported that the sustainability of the reformed practices was overly challenging for teachers without professional support to assist with 3D units. According to the research, adapting the standards into a curriculum was complex and highly time-consuming. The literature stated that adjusting instructional methods required new skill sets that teachers were not as confident as in traditional teaching methods. The researchers noted that teachers in the study demonstrated their ability to modify the curriculum to meet the needs of the students within their classrooms and made the lessons more equitable by adapting them to the culture of their room. Authors stated the professional development needed to be redesigned to account for the skills required of the teachers.

Gale et al. (2022) collected data from a study where a technology institute partnered with the local public school district to create a science curriculum for the predominantly low-income student population. In the study, professional development was provided during the summer to assist the educators with utilizing inquiry-based lessons in the curriculum for the following school year. The multiyear study then documented the changes the teachers reported in their instructional methods based on having these modules. The study found that teachers continued replicating successful module activities with their student populations and modified the existing curricula to align with the reformed standards (Gale et al., 2022).

Application of Scientific Practices with NGSS

Whitney et al. (2022) researched the various instructional strategies associated with NGSS and the tendency to increase academic engagement and achievement while it prevented problem behaviors. The authors noted opportunities to respond, when planned, was ideal for NGSS because it allowed for immediate teacher feedback and is a research-based instructional strategy. Shepard (2019) identified the main categories of skills for students to engage with scientific practices as cognitive, intrapersonal, and interpersonal. The research named four learning goals for all students to successfully navigate the workforce after graduation. These four learning goals were sensemaking of phenomena, generating and evaluating scientific evidence and explanations, understanding the nature and development of scientific knowledge, and participating productively in scientific practices as the needed skills to enter the science or engineering competitive workforces. Shepard (2019) explained the importance of coherence to support sensemaking and assist educators with determining what students know.

Nutt (2021) elaborated on the use of OTR. In the study, educators saw the most success when students had the opportunities for various ways to respond. These responses were the product of effective questioning by the teacher and included individual, pair, small-group, and whole-class discussions. Chen and Terada (2020) developed the OBP to measure the eight classroom scientific practices. These researchers understood the requirements of the NGSS for students to develop and apply the practices of science instead of repeating presented knowledge. The article noted the essential component of assessing student progress and proficiency in implementing scientific practices. Yang et al. (2019) stated that the new pedagogy needed to promote a student's development of their ability to apply scientific knowledge to everyday content, while demonstrating their development and understanding of science and engineering practices.

Teacher Performance with NGSS

Bernhard (2022) stated that the NGSS is clear on the endpoint for student learning in the classroom but is less clear about how this should look from a facilitator's perspective. The article also noted that educators have a consensus on student learning but different approaches to the overall learning process. The author identified three dimensions through the use of the framework of adaptive expertise. Bernhard (2022) suggested cross-institutional collaboration for teachers to increase their knowledge base and develop collaborative pedagogy methods to teach NGSS. The *theory of teacher change* had previously measured teacher effectiveness and relied on the assumption that more skilled teachers led to higher knowledge transfer to students (Chen & Terada, 2021). Research of the eight practices in NGSS science and engineering showed that teachers favored hands-on activities over engaging students in sensemaking discussions (Cherbow et al., 2020). To help correct this deficiency, Fischer et al. (2018) suggested the mathematics and science teachers participated in professional development that was content focused. Research showed that the best results occurred when the training was ongoing with frequent exposure from other teachers or specialists who modeled inquiry instructional strategies to increase student performance significantly. This study measured advanced placement students' success after tests were shifted from traditional materials to phenomena-based questions, which relied heavily on scientific practices to succeed. The literature outlined this type of professional development that led to changes in instructional methods, especially when coupled with opportunities for collaboration that allowed educators to connect the content with localized context (Fischer et al., 2018).

According to Yang et al. (2020) and Voet and Wever (2017), classroom norms and procedures have provided the foundation for learning in a classroom. Improved teacher practices in the classroom positively affected the student's learning outcomes. The researchers found that the provided professional development for teachers with immersive IBL prepared the educators for classroom implementation. Yang et al. (2020) stated that classroom practices provided the interconnectivity between teaching and learning. The authors stated that effective professional development was using modeling for teachers, which ensured they understood both the teacher and student roles in learning. The article described one major advancement in the standards: the switch to learner mastery was evaluated on the connections made across disciplines as the student worked toward a solution. For IBL to be successful, the teacher was required to have an increased pedagogical content knowledge than teachers from the traditional classroom (Yang et al., 2020).

Professional Development for NGSS Instruction

Tofel-Grehl et al. (2021) developed a unit through collaboration with other professional learners in a 25-hour professional development workshop. In the professional development workshop, participants designed and learned to facilitate the lesson. Over the course of four days, the teachers became ready to move the module to the classroom for a test in implementation. Researchers found this magnitude of support was essential for the full vision of NGSS to come to fruition. The authors determined these types of collaboration were necessary to fully implement the NGSS standards in the classrooms daily. Another example of this type of professional development was a three-year project, where Capraro et al. (2016) established sustained professional development for three urban schools and implemented PBL. The authors noted the quality of the professional development as highly important to its outcome on teaching practices and student outcomes.

The most effective professional development for reform was intensive and sustained, including active learning, coherence and focus on content (Capraro et al., 2016; Achieve, 2018; State et al., 2019; Shepard, 2019; Chen & Terada, 2020; Nutt, 2021). The authors agreed that the changes in science called for intensive professional development, teachers needed the support of a professional learning community to assist them with the implementation task. Capraro et al. (2016) stated PBL and IBL were more effective when teachers had a cohort of professionals to share ideas and with whom to collaborate. They elaborated that those teachers used different pedagogical techniques, and that the availability of others more fluent in the instructional method proved invaluable. The data from the three-year study showed a significant increase in test scores for those students in the highest implementation group. The data also identified that students from the low implementation group showed little change in performance (Capraro et al., 2016).

Overall Effectiveness of NGSS

There are many variables to instruction in the science classroom that could increase the effectiveness of the curriculum. One of these critical variables was using different opportunities for student response during instruction (Whitney et al., 2022). The level of engagement with content through effective instruction led to fewer behavioral challenges in the classroom. Whitney et al. identified three OTR responses teachers could use to increase engagement in content-related instruction, verbal, non-verbal, and partner responses. The most important factor was initially thought to be the frequency of the OTR. However, varied response types were recently identified as a crucial variable to maintain classroom engagement. The study expanded the types of OTR to six categories: verbal, choral, response cards, gestural, peer discussion, or manipulatives.

McGrath and Hughes (2018) addressed the use of IBL in inclusive science classrooms. This study is of interest because the purpose of the study was to use the previous year's testing data to improve student outcomes for students with learning disabilities. Interestingly during the study those identified students fell into one of two scenarios when faced with a more complex thinking model, they either fell behind or relied on peers to facilitate their learning. The literature gap in this area left the researcher unsure if the students with learning disabilities could make the necessary connection between the inquiry task and the scientific practices and concepts needed to be successful with this instructional model. The researcher explained that traditionally students with learning disabilities have significant learning gaps and were struggling to meet the performance expectations of the NGSS. As the students became confused by vocabulary during the lesson, they would disengage from the lesson. McGrath and Hughes were surprised to find that these same students performed at a proficiency-level on the unit assessments. This study also pointed out the difficulties teachers face when trying to meet the requirements of IBL curriculum. Adding students with learning disabilities to a room where the teacher is already struggling adds an unprecedented complication. The results from the study support the conclusion that those teachers did tend to equity within the science classroom even though the students reported a need to understand the scientific processes during group activities (McGrath & Hughes, 2018).

Pros and Cons of New Instructional Methods

When analyzing the results from Capraro et al. (2016), the research led the individuals to state the positive effects of PBL. The article stated PBL increased student engagement and collaboration growth, drawing on a broader knowledge range than traditional teaching. The shift from teacher-led instruction to teacher-facilitated learning required practice and skill. Teachers from this study were given an hour extra per day to collaborate with a professional learning community which helped them implement these new ideas within their classrooms. This study stated the teachers used traditional instruction and PBL to increase student outcomes because the student learning gaps were too significant to effectively shift away from all traditional instruction (Capraro et al., 2016).

Evans and Dolin (2018) completed a study to increase the effectiveness of teaching scientific literacy goals using IBM and self-efficacy. The work argues that the goals of scientific literacy may be outside the scope of many educators. However, Evans and Dolin developed a professional development to increase the effectiveness of teachers that had contextual merits from Denmark, Scotland, and other European countries. One of the significant aspects of the professional development was that the students had constructed new knowledge based on their questions and realizations. The authors drew on the relationship between self-efficacy and scientific process including persistence, risk-taking, and student-centered teaching. These statements were grounded in the Theory of Self-Efficacy outlined by Bandura. Two tools were recommended for transforming all standard lessons into inquiry investigations and increasing familiarity with the science literacy statements. Evans and Dolin based the inquiry investigations on the NRC outlined for inquiry activities was also recommended. Another helpful tool for those who used a storyline curriculum would have determined the goals from the Concept Networks of National Standards. Although these are very different from traditional curriculum objectives, the literature stated the potential usefulness of the information was worth the time spent to decode the aspects of importance in scientific knowledge. According to Evans and Dolin (2018), networked concepts were particularly helpful and allowed students to develop cross-curricular concepts when building inquiry investigations.

Jones and Burrell (2022) stated that quality science instruction was characterized by not only cognitively engaging IBL experiences but also the students must design the investigations and go through the scientific processes which are found in discussion-based classrooms. The researchers stated the true test for quality science instruction was if the students could use their knowledge to solve pressing societal issues, leading to students becoming community advocates (Jones & Burrell, 2022). The idea of equitable science instruction can be measured by the level of engagement and interest of all demographic groups within the classroom (Adams, 2020; Jones & Burrell, 2022). The effects of science inequities reach farther than in the classroom (Jones & Burrell, 2022). In our society, science is embedded in everyday life. Jones and Burrell, stated solutions to community problems rely on the proficiency of individuals to utilize the science and engineering practices. However, these solutions depend on a small sample of the population because many individuals lack the skillset needed to apply these principles to life due to the inequities in science education (Jones & Burrell, 2022).

Jerrim et al. (2022) used the 1996 National Science Education Standard definition of inquiry as follows:

> Develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments.

The study found there was no statistical significance to the difference in the performance on the General Certificate of Secondary Education (GCSE) examination in England and the PISA. The data was analyzed several different ways, one of which looked at the progress of the students over a five-year period from the end of primary school to the end of secondary school. Jerrim et al. stated the inquiry-based teaching likely had more impact on real-world science skills. The authors also concluded students likely benefit more from guided inquiry-based instruction. Jerrim et al. (2022) recommended future research to measure the level of inquiry-based instruction for a longitudinal research study.

Summary

Chapter II synthesized the literature, both historical and current, to provide the basis for the study presented in this dissertation. The revolutionary changes to science education have produced anxiety and pushbacks from the educators charged with delivering the content. These educators are ill-equipped and not as confident in the instructional methods needed to meet the needs of the Next Generation Science Standards (NGSS). The lack of quality professional development and support for the educators to make the shift has slowed the progress for implementation. From the inception of science education, the separation of application and theories has created great disparagement in the content knowledge needed to be productive in a science-embedded society. The best way to ensure equity in the science classroom and to correct the marginalization is by engaging all students in IBL with diverse groups to complete the investigations (Jones & Burrell, 2022). There is a gap in the data with using storyline curriculum to decrease the percentage of novice-level students on standardized testing in Kentucky. This study will address this gap in the literature.

Chapter III: Research Design

Chapter III outlines the methodology for this study. As a quantitative study, statistical analysis was employed to complete the study, complete data analysis, and clearly define research questions, variables, participants, sampling methods, and the justification for the selected methods. In addition, a description of the instruments used to complete the study, data security methods, and a description of the risks are included in Chapter III. The works of Ravid (2018) and Yockey (2020) were the sources for the statistical analysis of the data for this study. The independent *t* test and Pearson's r were used to determine the statistical significance of the relationship between the selected variables per the reasons presented in the prior mentioned works by Ravid and Yockey.

Research Design

Chapter II thoroughly examined the history and revitalization of scientific education, which included the need to move to performance expectations instead of traditional academic standards (NRC, 2012; NGSS Lead States, 2013; Achieve, 2018). There was significant research on why the standards were shifted and supported the instructional changes required to meet the standards. However, after ten years, not all science classrooms have shifted to new instructional methods to ensure students successfully meet the performance expectations. Therefore, this research provided important data and insight into the correlation between shifting instruction to a storyline curriculum and students' performance on standardized science tests.

When examining the Kentucky Summative Assessment (KSA) data from the previous academic year, the scores were significantly below the acceptable threshold both in the district and the state. Many students performed far below grade level on the state assessment. In order to better prepare students for their future, the administration tasked the departments to create a plan to increase the students' abilities to apply their content knowledge. The goal for each content area was to reduce the novice-level responses by 10% for the current academic year. Understanding the use of traditional instruction in previous years, the seventh-grade science team implemented the OpenSciEd curriculum in the classrooms. The teachers chose to monitor academic progress by administering the science Measure of Academic Progress (MAP) testing in the winter and spring. The data from these assessments were used to drive instruction and select remediation topics for the student body. This study used the results from the Kentucky Summative Assessment (KSA) for seventh-grade science to measure the long-term academic progress of the changes to the instructional methods. The student population was diverse and similar to the consecutive seventh-grade student populations.

Purpose of the Study

The purpose of the realignment of science standards was to better prepare students for life after graduation (Pratt, 2013; Jones & Burrell, 2022). The study aimed to provide the district with local data for implemented inquiry-based learning (IBL) into daily instruction to determine if there was a correlation with standardized test scores in seventh-grade science. This study provided a baseline from the 2021-2022 year of KSA science test scores in seventh-grade science, where traditional instruction was utilized to teach science. The study investigated the relationship between the OpenSciEd curriculum and KSA science scores. The data provided through this study was provided to the science educators and curriculum personnel and provided data for the use of storyline curriculum with diverse populations in seventh-grade.

Group A – KSA scores from seventh-grade students with traditional instruction in science for the school year 2021-2022.

Group B – KSA scores from seventh-grade students with OpenSciEd storyline sensemaking curriculum in science for the school year 2022-2023.

After the 2021-2022 KSA scores were published, the school was identified as an at-risk school which needed a targeted strategic intervention (TSI) plan. This study provided local data to establish if the use of storyline curriculum in the seventh-grade science classrooms is related to the students' performance on the science KSA. OpenSciEd curriculum was chosen and approved by the district as the curriculum based on the units being listed as 'quality' by the peer review panel of Next Generation Science Standards (NGSS). Within the year, the district agreed to fully fund the classrooms after the curriculum received a green rating from EdReports for the middle school curriculum.

Research Question and Hypotheses

Changes to science education were rooted in research-based methods to decrease performance gaps in science and engineering (Melville et al., 2015). This research began with the initial goal of increasing seventh-grade science KSA scores in the school. Data will be analyzed from two different populations of students for the KSA science testing scores in a specific middle school. The first population completed the state testing after a year of traditional science education. The second population completed MAP science test in the winter, MAP science test in the spring, and the KSA science test after a semester of storyline inquiry-based learning (IBL) education to measure continuous growth. The research question was developed based on the available data and gaps discovered during the literature review. The question was as follows:

RQ. How does a shift from traditional to three-dimensional learning instruction affect seventh-grade science student academic performance?

H_0: There is no relationship between seventh-grade science student engagement and sensemaking curriculum. The mean scores on science standardized tests are equal for both groups.

H_1: A relationship exists between seventh-grade science student engagement and sensemaking curriculum. The mean scores on science standardized tests are unequal for both groups.

This question aimed to determine if there was a relationship between the seventh-grade science student engagement and sensemaking curriculum through the analysis of the difference in the mean scores for the two different student populations on the KSA. The question also determined if there was a statistical significance between the means of the KSA scores. Examining school performance on the science KSA for seventh-grade science allowed the researcher to draw conclusions about the implemented OpenSciEd storyline sensemaking curriculum.

Description of Population

The quantitative study focused on one secondary public school in Kentucky that was identified as an at-risk school by the 2021-2022 KSA data results. Data was collected on all students in a particular school with a strategic growth plan to determine if there was an increase in students' academic performance on the KSA after the curriculum and instructional methods were altered. The researcher used the school report cards published by the Kentucky Department of Education (KDE) science tests for the 2021-2022 and 2022-2023 school year. The demographics for the school's seventh-grade students are as follows:

Table 1

Demographics and Socioeconomic Information Table

Academic year	2021-2022		2022-2023	
	n	%	n	%
Gender				
Female	129	52	115	45
Male	121	48	140	55
Racial and Ethnic Identity				
African American	15	6	13	5.3
American Indian or Alaska Native	0	0	0	0
Asian	13	5.2	27	10.5
Hispanic or Latino	21	8.4	29	11.3
Native Hawaiian or Pacific Islander	0	0	3	1.1
Two or More Races	18	7.2	19	7.4
White (Non-Hispanic)	183	73.2	165	64.4
Socioeconomic Status				
Economically Disadvantaged	156	62.4	152	60
Students with Disabilities (IEP)	29	11.6	35	14
English Learner	15	6	15	6
Foster Care	5	2	0	0
Gifted and Talented	3	1.2	1	0.4
Homeless	1	0.4	1	0.4
Migrant	2	0.8	3	1.2
Military Dependent	0	0	0	0

Note. N = 250 for the 2021-2022 academic year. Participants were science seventh-grade students. N = 255 for the 2022-2023 academic year. Participants were science seventh-grade students.

Sampling Procedures, Confidentiality, and Anonymity

The researcher emailed the Kentucky School Principal and requested their participation in the study. The email included the following information: an explanation of the study, the practical application of the study, the assurance of confidentiality, and the assurance that there were no known risks to participation in the study. The KDE School Report Card provided data for the 2021-2022 and 2022-2023 school years, and the KSA reports for both school years were made available to the researcher. All data was stored on the district server. Raw scores were made available to allow for a more thorough statistical analysis. No identifying information was extracted. The principal of the school made the data available and was in full support of the research. Only the scores and the school report card were used to determine the level of performance of the school, with no knowledge of the student identities.

Description of Instruments

In addition to the reports, the researcher confirmed the use of traditional instruction in the science classrooms with the school's curriculum specialist for the year 2021-2022. The researcher confirmed the use of OpenSciEd in seventh-grade science classrooms during the year 2022-2023 by reviewing the lesson plans for the teachers. All data was available from standardized testing and did not require any additional instruments for collection.

Variable in the Study

The variables in the study were the instructional methods used during the school year to teach science in the seventh-grade and the school's performance on the science portion of the KSA. The group of students who received traditional classroom instruction were labeled as Group A and the school year of 2021-2022. The group of students who engaged in the OpenSciEd curriculum were labeled as Group B and was the group of students from the 2022-

2023 school year. Group B participated in the MAP and KSA tests to measure short-term and long-term academic performance. Only the KSA data was used for this study.

Data Preparation

The researcher organized the data in Excel to complete statistical analysis to determine the relationship and statistical significance of the data. The following steps were used to complete the analysis:

- Group A data was transferred to Excel column A. Group B data was transferred to Excel column B.
- The Data Analysis tool for *t* test: Two-Sample Assuming Unequal Variances was used with Group A as Variable 1, Group B as Variable 2, and Alpha: 0.05.
- The table was produced with the mean, variance, observations, hypothesized mean difference, degrees of freedom, t stat, *p* value for one-tail, t critical for one-tail, *p* value for two-tail, and the *t* critical for two-tail.
- Interpreted the data using the *p* value for the two-tail analysis.
- If the p value < 0.05 then the null hypothesis was rejected. If the p value > 0.05 then the null hypothesis was not rejected and there was no statistical significance in the two means.

Description of Data Analysis Method

The independent variable *t* test for unequal variances was used to determine if there was a relationship between the variables. Group A and Group B had different sample sizes and variances so the independent variable *t* test for unequal variances was chosen to complete the statistical analysis. A *t* test provided widely understood and accepted data by educators (Ravid, 2020). The test was completed using Microsoft Excel. The *t* test for independent samples was used to determine if the differences between the groups were statistically significant or if the results could have occurred by chance (Ravid, 2020). The *t* test allowed for comparing the two groups by comparing the means of the groups.

The *t* test for independent samples was to determine if the differences between the groups were statistically significant or if the results occurred by chance (Ravid, 2020). This was used because it is based on the *t* distribution theory and is regularly used to compare the means of two groups to determine if the difference is statistically significant. When the research questions were considered, the two different methods of science instruction and determined if the changes were statistically significant. According to Ravid (2020), the *t* test was one of education's most widely used statistical analysis tools. Yockey (2018) stated that the assumptions for the independent-sample *t* test were that the samples are normally distributed, the standard deviation of both populations are unequal and unknown, and the sample was sufficiently large.

The steps for data analysis were from the text by Yockey (2018). The first step in data analysis was to import the raw data into Excel to identify patterns in the data. Then the mean scores for the KSA science tests were determined for Group A and Group B. Next, an F-test was used to confirm the variance between the two groups. Once confirmed, an independent *t* test for unequal variances was calculated. The analysis was used to determine the mean KSA science scores for the school for Group A and Group B to determine if the difference in the means was statistically significant. The null hypothesis was true if the variances were close to 1.0. However, if the F ratio was large, then the variation among the group means was statistically significant.

After confirming the large variance, the independent *t* test for unequal variances was calculated. From this data, the *p* value was checked for equality of the means. If $p \leq .05$, the null hypothesis was rejected, and the results indicated the nature of the difference between the groups was stated. If $p \geq .05$, the null hypothesis was not rejected, and there was a notation that the differences in the means of the groups were not statistically significant.

Summary

Chapter III provided the basis for the analysis of the study. The F-test was used to determine if there were unequal variances. Then an independent *t* test for unequal variances was used to determine if differences in the groups were statistically significant and verified a relationship between the variables. Yockey (2018) and Ravid (2022) guided the researcher through the data analysis process using Microsoft Excel. Justification for methodology was discussed in detail for this study.

Chapter IV: Findings and Analysis

Overview

This study aimed to examine the effects of instructional methods on the academic outcomes of seventh-grade science students. Investigating the relationship of three-dimensional instruction with the academic outcomes for a rural school district with a high level of diversification. The changes to science education were introduced to undo the separation of science education and the application of scientific processes. The effects of poor science education have been felt throughout the U.S. for the past decade with individuals struggling to compete for science and engineering positions in the workplace. These effects could impact the wellbeing of society if the education system is not capable of using science and engineering to continue to provide for the growing population of the world.

The implications of this study were to provide data for the diverse population and the academic outcomes of the students within the district when addressing knowledge gaps with new instructional methods. Accounting for the gaps in science education in the country, the results for academic success while aligning with the Next Generation Science Standards (NGSS) will provide local data demonstrating the importance of application to solve real-world problems and to better understand how the world works. When analyzing the data, the use of an independent *t* test for unequal variances assumes the sample were normally distributed, the standard deviation was known for both populations but were unequal, and the sample set was sufficiently large. The analysis allowed for the data set with different sample sizes and levels of variances to be compared. The hypothesis was as follows:

H_0: $\mu_1 = \mu_2$

H_A: $\mu_1 \neq \mu_2$

Where μ_1 was the mean from Group A and μ_2 was the mean from Group B. The results of the data were addressed in the following sections.

Data Collection

The results of the Kentucky Summative Assessment (KSA) are published annually on the school report card by the Kentucky Department of Education to allow the community to see the overall performance of the schools within their community. This measurement of academic performance was an accountability measurement for the school but was also a way for educators to determine the weaknesses within their curriculum. By analyzing the data of the KSA, educators can determine how well the students were able to meet the performance expectations for the standards of that grade band. In the case of the science KSA for seventh-grade, the educators are looking for proficiency for science standards of fifth through seventh-grade. The data published gives the demographics, percentages of academic performance for all subjects tested, and the economic status of the tested population. This data was provided to the schools each fall for the students who tested the previous spring.

Raw data was provided to the schools, along with the school report cards which show the overall performance of the students in the schools and the district. Schools are rated based on the student population's performance in various subjects depending on the grade level of the student. All seventh-grade students in Kentucky are tested in reading, math, and science. The science scores are used to drive instructional methods to decrease the learning gaps by addressing the deficiencies of the previous group with the students currently in the grade. Interestingly, the state measures the improvements of the schools based on the performance of the student population compared with the results from the previous school year. There is no comparison of how the student population had grown from year to year but instead compares them with a different group of students. The KSA tests science students in fourth, seventh, and eleventh grade.

Quantitative Data Analysis

As referenced in the literature review, Group A was the seventh-grade science student for the academic year 2021-2022. Group B was the seventh-grade science students for the 2022-2023 academic year. The Kentucky Department of Education (KDE) collects the data annually to rate the schools through a matrix of test scores, the school climate survey, demographics, discipline, and changes in scores from the previous year. The school is then given a ranking of overall performance based on these various variables. Schools receive individual reports for each student who was part of the accountability testing for the school. The data is used to determine if schools need additional support to provide students with an equitable education.

The raw scores are numerical data, while the published data includes only the percentages of novice, apprentice, proficient, and distinguished scores of the student population for the school, district, and state. The cut scores for the science KSA for the seventh-grade are 400-491 novice, 492-509 apprentice, 510-528 proficient, and 529-600 distinguished. The percentages of each performance level were calculated, and graphs were produced to represent the analysis for both academic years visually.

Statistical Findings

An independent *t* test for two samples assuming unequal variances was used to analyze the raw data. The mean for Group A was 496, with a variance of 1,202. The mean for Group B was 498, with a variance of 158. Group A had 233 observations, while Group B had 218. When the *t* test was performed, the degrees of freedom was 296 to account for the difference in variances between the two groups. The hypothesized mean difference for the *t* test of Group A and Group B was stated to be zero for the test. The *p* value was calculated as 0.37 which was greater than alpha of 0.05, so the null hypothesis could not be rejected and there is no significant difference in the means of the samples.

Table 2

Results of Independent t test Assuming Unequal Variances

Source	n	m	SD	t(296)	p	Cohen's d
2021-2022	233	496	35	-1.41	0.372	0.133
2022-2023	218	498	13	-1.41	0.372	0.133

Note. The independent *t* test assuming unequal variance was calculated and used *df* = 296. The *p* value was greater than the alpha of 0.05, so the null hypothesis could not be rejected, and no statistical significance was found between the academic performance of the two groups. Cohen's d was calculated, and the effect size was small because it was less than 0.20. Those who received the inquiry-based instruction performed equally to those who received the traditional science instruction.

The literature review found many sources which stated a shift in instructional methods of this magnitude would require support and continual professional development to sustain. The data collected showed the academic outcomes did not decrease when the instructional methods were switched to the three-dimensional units. Educators who were resistant to the implementation of inquiry-based instruction expected the results of the populations to decrease significantly. Instead, the data showed the performance of the populations were consistent.

The consistency of the data from 20221-2022 to 2022-2023 prompted the analysis of the various academic outcomes as percentages of novice, apprentice, proficient, and distinguished. The data for these were as follows:

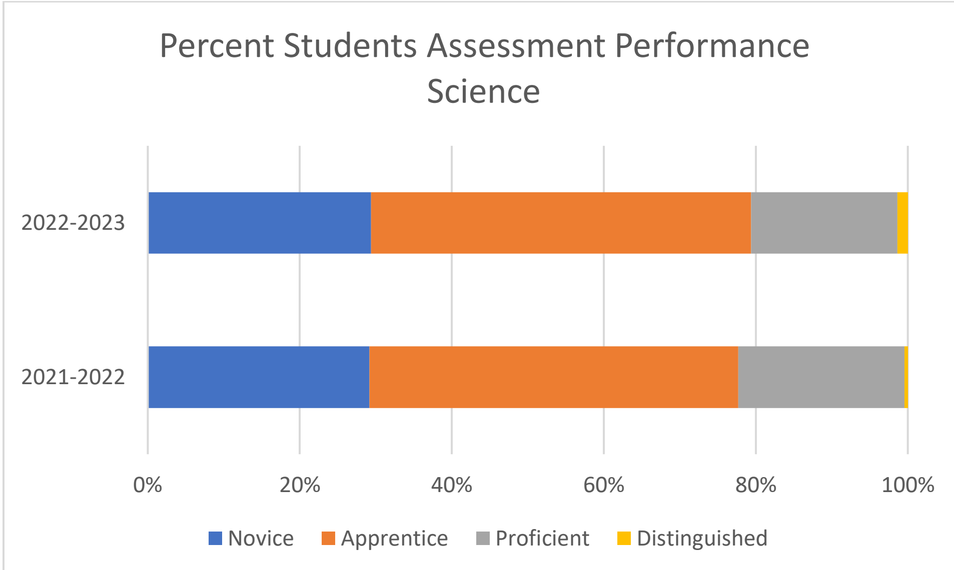
Table 3

Percent Academic Performance

Source	Novice	Apprentice	Proficient	Distinguished
2021-2022	29.2%	48.5%	21.9%	0.4%
2022-2023	29.4%	50.0%	19.3%	1.4%

Note. The data is for seventh-grade science students who participated in the KSA for the years 2021-2022 (Group A) and 2022-2023 (Group B). Percentages were calculated using the number of participants that were scored in each category. The total populations for Group A were n = 233 for 2021-2022, and the total population for Group B was n = 219 for 2022-2023.

Figure 1



Note. This figure demonstrates the percentages of academic performance for the two groups represented in the data. There was no statistical significance to the difference in the performance of the two groups based on the results of the independent *t* test assuming unequal variances.

Research Question

RQ: How does a shift from traditional to three-dimensional learning instruction affect seventh-grade science students' academic performance?

According to the data collected, there was no statistical significance to the seventh-grade science students' academic outcomes with a shift from traditional to 3D Learning instruction. The academic outcomes of the students were consistent with the performance of the student population who experienced traditional instruction. The null hypothesis was not rejected based on the *p* value. Student outcomes were consistent with previous years of traditional science instruction. This data provided to the educators will support the use of inquiry-based instruction for all science classrooms. This was consistent with the literature review in that the educators require time and support to improve academic performance outcomes with inquiry-based instruction. The lack of decrease in performance supports the shift in instruction with the population with diverse economic, ethnic, and readiness levels.

The analysis of the percentage of student outcomes was used to compare the academic outcomes for each performance level. This data showed similar percentages for each of the four outcome levels. Analysis only looked at the level of academic performance and did not analyze the student performances which were close to moving to a higher level. The school found that 60% of students performed as expected on the KSA in comparison with the MAP testing. There is no historical MAP data for science at this school. The school administered the science MAP test in the winter and spring before the KSA was administered in May of 2023.

Summary

Chapter IV presented the purpose of the study and established the correlation between the information collected in Chapter II to the current study. The data collected was used to fill the gap in the literature for the use of three-dimensional instruction in a school with a highly diverse population. The diversity score of the school was 0.45, which was above the state average of 0.44 (Public School Review, 2023). The data from the current study indicated steady results for the KSA during a shift in instructional methods. Based on the information in the literature review, academic performance should increase with subsequent years of instructional consistency.

Chapter V: Conclusions and Discussion

Summary of Study

The historical separation of science education and the application of scientific practices has plagued our society since the inception of science education. However, the U.S. began to realize the severity of the separation when the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMMS) results for science showed the variances between the performance of American students and those students in other countries. These results prompted the creation of the *Framework for K-12 Science Education* (*Framework)* to change the course of science education. Once the *Framework* was completed, the Next Generation Science Standards (NGSS) was written and adopted by various institutions to change the science standards to performance expectations. The shift to performance expectations required students to be proficient in applying scientific and engineering practices to real-world phenomena.

The adoption of the NGSS did not lead to immediate changes in the classrooms. Ten years after the call for implementation, many classrooms still rely on the traditional instructional methods for science. This study was designed to provide data for the implementation of inquiry-based instruction in schools with high levels of diversity where more than 50% of students were not proficient in science at the seventh-grade level. The lack of proficiency at this level is evidence of the requirement for change.

Conclusions

This study provided insight into inquiry-based learning with a diverse student population in a middle school science classroom. KSA science results from the 2021-2022 and 2022-2023 academic years were compared to determine if there was a statistical significance to the type of science instruction used in the classroom. The data analysis showed no statistical significance in the difference between students' performance for the two different years.

The study used the KSA science test because all students participated in this assessment during their seventh-grade school year in the state. This test is used to rate the effectiveness of the school on a school report card. When the state adopted NGSS in 2013, it updated its assessment type to better reflect the standards' intent. Since the state uses this assessment to determine the effectiveness of the learning and the school needs to decrease the percentage of novice scores, the KSA was chosen as the instrument to collect student outcomes data.

The data collected showed that the results of the KSA were similar for the two academic years.

Relationship of Conclusions to Other Research

These results are consistent with the longitudinal study of Jerrim et al. (2022). The longitudinal study found that inquiry-based learning did not significantly increase student performance. Instead, Jerrim et al. (2022) stated that students need guided inquiry-based learning to increase their understanding and help them grow. Pinnick (2023) addressed the need for more research on how to switch from traditional instruction to inquiry-based learning (IBL). When looking at the results of this study, one new question emerges. Did the inexperience of the teachers with the curriculum affect the student outcomes? After the year, the teachers were sent to professional development to gain the skills to teach the curriculum with more effectiveness. Analyzing the 2023-2024 school year data could provide insight into how professional development and experience changed student outcomes.

As Keeley (2020) stated, graduates must be proficient in the science and engineering practice. The data from this study shows that seventh-grade science students have deficits in science. This was not shocking news based on prior KSA data and Adams (2022) and Loveless

(2017) research. Students today still suffer from the inability to apply their knowledge because of the inherent separation of content and application implemented at the beginning of science education (Serino, 2017). The National Research Council (2012) created the performance standards for science and engineering to decrease the gap in performance between the U.S. and other countries worldwide. This study, however, showed no statistically significant change when implementing three-dimensional learning (3D learning) in science classrooms for one academic year.

Dare et al. (2018) noted a correlation between implementing the standards to the teacher's content knowledge and their ability to connect mathematics, science, and engineering in their instruction through relevant phenomena for the students. Science teachers need content-specific professional development to increase their effectiveness with new instructional methods (Li et al., 2022). However, this new professional development must also include consistent, ongoing support for the full effect to be seen in student outcomes (Dare et al., 2018). Zvock et al. (2009) stated that student-centered instruction better prepared them for the future. Gallagher and Gallagher (2013) reported that PBL increases performance for diverse student populations by tending to classroom equity. This leads to the conclusion that teachers need targeted professional development to increase students' learning within the classroom.

Student engagement does not have a single definition in education today. Sinatra et al. (2015) identified engagement as a buzzword in the educational system, which is used to identify a correlational relationship with positive learning outcomes. The author indicated that engagement in the science classroom differs from other classrooms. When misconceptions are identified during the inquiry process, there has to be a shift in conceptual thinking to correct the fallacy. The authors encouraged using a continuum to measure the level of engagement for various aspects of instruction to monitor the interaction with science and engineering practices (Sinatra et al., 2015). IBL meets the requirements of the lessons described by Geary (2018) by developing knowledge to create developmentally appropriate yet challenging lessons for the specific population of students within the classroom.

Discussion

The idea that disadvantaged students cannot be successful with IBL is what started this study. Educators resist changing the curriculum because the student population has significant learning gaps. Pinnick (2023) addressed the issue of disadvantaged students being far below reading level and lacking the knowledge to participate actively in the complex inquiry-based learning process. However, this study showed no statistically significant change in students' performance between traditional instruction and the use of IBL. The population's demographics show that many of the students fall within the category of disadvantaged. When analyzing the data, it would be interesting to see if there was growth for these individual students. Measuring the development of these students during the year of instruction would provide needed insight into the use of IBL to decrease the learning gaps of individual students. Leading students through a progression of lessons where they create, complete, collect, and analyze data through investigations and then constructing explanations based on that evidence should lead to a deeper understanding of scientific and engineering practices (Gale et al., 2022).

The other challenge to measuring student outcomes could call into question the lack of data for these students. Students in Kentucky are tested in science three times during their education experience: the fourth, seventh, and eleventh grades. The accountability testing measures each group of students against the performance of the previous student population. While this is a good indicator of changes made in the curriculum to fill the holes in the lessons, it does not give insight into the growth of that student (Shepard, 2019). Chen and Tarada (2020) defined traditional learning as passively receiving information through active manipulation, constructive self-construction, and interactive dialogue. Increasing the fluency of graduates so they can utilize science and engineering practices to solve real-world problems will increase the opportunities for Americans in competitive employment markets (Adams, 2022; Loveless, 2017).

Another idea is to set individual learning goals with all students. Tas (2016) noted performance goals increase the students' intrinsic motivation because they desire to demonstrate their abilities. Creating a tool to allow students and teachers to communicate about performance and performance-approach goals effectively could be critical to student success in the classroom. These goals would need to start more accessible and increase in difficulty as the year progressed (Kiran et al., 2018). Making a rubric-type design where the student could score their performance and compare it to the feedback from the teacher is an area worth pursuing in the future.

Practical Significance

The results from this study give data to show there is not a statistically different change in the scores for KSA science testing when using the inquiry-based learning compared with traditional instruction. The ideas from the results of the study of content/instructional methods professional development, creating performance-approach goals, and increasing the student populations' data could all improve science education's monitoring and effectiveness in America. Moving forward, this researcher will implement the results of this study within the classroom and monitor the performance of the student population. The notion that diverse students would not be able to navigate the IBL successfully was shown to be inaccurate. The students in this study were socioeconomically, ethnically, and culturally diverse.

The study gives excellent insight into implementing 3D Learning in the classroom. Tas (2016) found increased academic outcomes when students have perceived teacher and peer support. Using 3D Learning to provide collaborative learning with a collection of classroom norms sets the fundamental elements for student success. The longitudinal study of Jerrim et al. (2022) identified some weaknesses within this research project. Using this information to guide future studies will increase the effectiveness of science teachers throughout the world.

P-20 Implications

The student learning outcomes of innovation, implementation, diversity, and leadership were all addressed within this project. The study was the first step in shifting science education in the school. For a significant change to occur, new instructional methods and a new curriculum were introduced. The study aimed to provide altered classroom instruction methods to improve student's educational outcomes and prepare them to be competitive in the employment market after graduation. KSA scores were analyzed, and one major deficit area was inquiry questions. To address the inability of students to answer inquiry questions, a shift in instructional methods was implemented to provide students with experience in applying science and engineering practices to real problems. Open SciEd curriculum provided the three-dimensional instruction and incorporated skills from science, engineering, mathematics, and English language arts into daily lessons.

The curriculum addressed issues such as tending to equity and diversity in daily instruction. Student groups were chosen to provide diversification in content knowledge and experiences. All the components led to commiserate performance on the KSA after the implementation of the new curriculum. The school is the Newcomer program's home school; therefore, the teachers also educate several students who speak limited or no English. The families are brought into the community; many of these students have never attended any educational facility. Creating and implementing classroom lessons has brought a new dynamic to the school's diversity. All of these aspects have added to the fullness of this research study.

The impact of the research project on the leadership abilities of the researcher was also noted. Beginning the study marked a new point in life. Diving into the research and development of this study led to new roles in teaching and within the school. The data collected for this study was presented to the district to improve science education within the district. Developing the research study, analyzing the data, and concluding was invaluable to the researcher's professional development. The data was used to implement changes to the instructional methods to improve student outcomes. The impact of the changes is being monitored closely using formative, summative, and accountability testing to determine if these processes need to be implemented throughout the district. Teachers are continually observing the practices of these classrooms to understand how the instructional methods can be implemented to meet the needs of the students better.

The implications of this research to seventh-grade science classrooms will impact countless lives. The school aims to decrease the novice performance for minority students by 10% for the current academic year. These students are dually disadvantaged because most of them are racially and socioeconomically disadvantaged. Creating meaningful lessons that students can relate to while using guided IBL will allow students to decrease their deficits and increase their academic success. Providing all seventh-grade science students with an educational experience that will help them implement science and engineering practices in real life will profoundly affect their lives. All of the results will be used to move the student population toward a clear understanding of how to solve problems and create innovative solutions for the betterment of the world.

One of the main takeaways from this study was realizing the need for a cross-institutional professional learning community for the successful implementation of IBL. With other instructional methods, practice makes perfect, but with IBL, the more collaboration and support a teacher has the better the students' academic outcomes. Teachers in the district of study from the various middle schools do not routinely collaborate. Therefore, a cultural change in the district will need to occur for this dynamic shift in planning and instruction to be successfully implemented on a larger scale. For now, the classroom teachers from this study collaborate with professionals nationwide through email and sharing of resources to gain the needed PLC community to implement the curriculum.

The classrooms used for this research study are now the model classrooms for other teachers who are considering Open SciEd for their science instructional curriculum. Open SciEd has recently released the curricula for high schools, and several peer educators have observed the IBL teaching in these classrooms. New science teachers are brought to observe the curricula in the model classrooms during their first year of teaching. One such teacher was a chemistry teacher that commented her students had spent a month on a concept taught in 90 minutes through this instructional method. Since the teacher shared this information with others in her building, more educators have been in the classrooms to see how IBL could impact their students. Changing to this instructional method takes a significant amount of preparation. The fruits of the labor are not seen immediately, but the changes are manageable through experience, collaboration, and professional development.

Model classrooms use phenomenon-based strategies daily. Moving through these processes in an immersive setting would allow the educators to see the curriculum in action. Providing this experience for educators allows for the deeper understanding outlined in the literature review. The researcher will continue to collect and analyze data to advance education in the current classroom to extend the research further. The researcher plans to complete the various studies outlined in this future research section in the coming years. The results of those studies will add to existing research and allow for the effectiveness of the various instructional methods to be measured in the same classroom environments.

Limitations of the Study

This study did not examine the long-term effects of the shift in instruction, only the initial year when the shift began. The study only includes a single academic year for each population, which is a weakness of this study. Analyzing the results of a longer academic period would provide more reliable data. Many other factors were not considered in this study. There were significant changes to the science teachers during the school year of 2022-2023. Both of the positions for seventh-grade science teachers were vacated shortly after the start of the academic year. One position was filled by a teacher in the building. The second position required the use of long-term substitutes to provide instruction during the vacancy. A permanent teacher was moved into the position on November 7, 2022.

The new science teachers began implementing the new instructional methods in January of 2023. The effects of this time in the classroom could not be measured. The students only received five months and four units of inquiry-based instruction before completing the KSA. When considering the effects of the curriculum, it is important to analyze the curriculum for the complete academic year. The teachers fully implemented the Open SciEd curriculum for the

2023-2024 academic year. The students for the 2023-2024 academic year will have nine phenomenon units before the accountability testing.

The level of inquiry-based instruction may have been less effective due to a lack of experience by the teaching team. Although the teachers are seasoned, inquiry-based instruction takes time and support to become effective. The teachers attended professional development over the summer following this study to increase their curriculum implementation. A new curriculum is difficult to navigate independently of other factors, but this situation had the added complexity of the shift in instructional methods, which increased the challenge significantly. The movement from teacher-centered instruction to teacher-facilitated and student-led inquiry required time and skill development for mastery of implementation. The professional development was specific to the content and units taught by those teachers. Connections with other educators who used the same units or storyline curriculum were retained for PLC contacts. These additional resources are an invaluable asset for all parties to develop inquiry-based learning in seventh-grade science classrooms effectively.

Recommendations for Future Research

There are several analytical aspects that would be excellent topics for future research. The first is the correlation between the KSA and Measure of Academic Progress (MAP) testing results for science. One of the interesting issues with the MAP and KSA science is that the science test uses the sixth to eighth-grade NGSS grade band standards while the KSA is given to seventh-grade science students. There are case studies on the NWEA site supporting the use of MAP testing for predicting performance on the KSA. Comparing the performance of the student body on the two tests would provide educators with assessment and growth data to better understand the performance of the student body.

Another area for future research would be to study the academic performance of seventh-grade science students who engage in guided IBL versus IBL. The idea for measuring guided inquiry-based learning was from the study of Jerrim et al. (2022). Measuring students' performance based on these two instructional methods could provide insight into the best practices for teaching science with diverse student populations. Data from the United States pushes educators to move from traditional instructional methods to IBL. There are different types of IBL, so studying the student outcomes for two of those practices could provide much-needed evidence for improving science education. Analyzing the future data could also provide insight into the effectiveness of the teacher and their experience with teaching a specific curriculum using IBL instructional methods.

Future research could also analyze the performance of different demographic and socioeconomic groups when IBL is the instructional method. Analysis of the academic outcomes of these subpopulations would provide insight into the relevance of the phenomena used in the classroom and the suitability of those scenarios for the various student groups. The best practice for accountability testing was to determine the strengths and weaknesses of the curriculum. A thorough understanding of what was seen as a relevant phenomenon to the population within the district would help create more meaningful instruction and, therefore, increase the academic outcomes of the population.

The most obvious pathway to future research would be to expand the current study by analyzing the data for another academic year of IBL instruction with the current demographics. This research would allow the education community to have a clearer understanding of the types of support required for teachers to implement three-dimensional instruction in the classroom effectively. As science teachers struggle to implement the NGSS within the education system, a relevant data set could increase motivation to support classroom changes. Having the data to support these changes will increase the support the teachers will receive to make the shifts within their classrooms. They are analyzing future data to see the changes in students' performances as the teachers continue implementing the OpenSciEd curriculum with a diverse population.

The plan is to implement Response to Intervention (RTI) work into all units for the 2024-2025 academic school year. No research specifically looks at the use of RTI with the IBL instructional method. Analyzing the academic outcomes for a diverse population when combining the instructional intervention of RTI at Work by Solution Tree with the IBL of Open SciEd curriculum would be very interesting. The straightforward approach to this future research would be to compare the means of the 2024-2025 KSA to those of the 2023-2024 academic years. Shifting to this intervention model would require the teachers to identify five essential standards and ten necessary standards for the academic year. The teachers would work closely to quickly provide interventions to various groups that did not perform at a mastery level for that particular assessment or for extensions for those who have already mastered the current standards. This model has been successfully implemented in districts with diverse student populations nationwide. Measuring the academic outcomes compared with those students from the 2023-2024 academic year will provide data for using RTI with IBL.

Continued research with the current student demographics will increase the data available to other educators with similar student populations. A longitudinal study for IBL within the US will be created by strategically investigating a different variable each academic year. The longitudinal study will allow researchers to identify the strengths and weaknesses of the instructional method. The study will also provide educators with data for best practices and strategic interventions to reach various subpopulations. Analyzing the data based on various demographics, socioeconomic statuses, and readiness levels will provide insight into increasing the academic outcomes of those populations.

A culminating study would conclude after five consecutive years of data are collected. Groups would be designed as follows: Group A had traditional science instruction in 2021-2022. Group B experienced low implementation of IBL during the academic year of 2022-2023. Group C experienced high implementation of IBL during the academic year of 2023-2024. Group D experienced high implementation of IBL and RTI during the academic year of 2024-2025. Group E experienced high implementation of IBL and RTI during the academic year 2025-2026. Group E was a repeat of the parameters of Group D to provide data for the use of RTI with IBL. No literature was found to match this combination of instructional methods. Two different analyses of the data would be needed to understand the impact of the research fully.

First, an analysis of Group D and Group E would be completed separately to determine if there was a relationship between the level of instructional competencies that would affect the academic outcomes of the student population. Both of these instructional methods have been recommended for use with diverse learner populations. Combining the methods adds a different complexity level, which needs further research. The second data analysis would look at the changes in the mean test scores for the various groups to determine the most effective instructional method for the diverse student population. A researcher could determine which instructional methods are most effective for the different subpopulations by looking at the various demographics and the different instructional methods. A study of this magnitude would be complex, but the results have the potential to change science education fundamentally.

Inquiry questioning is also used in Kentucky's accountability testing for social studies. The student population from Group B will participate in the social studies accountability testing this year. Analyzing the students' performance on the social studies test would provide insight into the ability of the students to apply the inquiry concepts to other content subjects. Comparing the results with those from the 2022-2023 social studies KSA and 2023-2024 would provide data for the effects of inquiry-based learning on the cross-curricular application of the guiding concepts. Group A would be the students taking social studies KSA in 2022-2023. Group A had no IBL science instruction. Group B would be the students taking social studies KSA in 2023-2024. This population had five months of IBL science instruction. Analyzing the data would provide data to understand the relationship between science instructional methods and the performance of inquiry questions in other content areas.

The last recommendation for future research is to analyze the performance of each demographic on the various KSA inquiry responses. Collect data on the students for science and social studies testing for the KSA for the 2024-2025 and 2025-2026 academic years. Compare the means for each test for the respective populations. Group A would be the student population who took the science KSA in 2021-2022 and the social studies KSA in 2022-2023. Group B would be the student population that took the science KSA in 2022-2023 and the social studies KSA in 2023-2024. Group C would be the student population who took the science KSA in 2023-2024 and the social studies KSA in 2024-2025. Comparing the means to determine if the differences were statistically significant would provide a better understanding to the full effects of the curriculum shift in the science classroom.

Summary

Chapter V is a synthesis of the results of the study, the relationship to the literature presented in Chapter II, and the study's implications. This research aimed to determine if there was a statistically significant difference in the academic outcomes of a diverse student population receiving traditional science instruction from those who engage in 3D Learning. Upon analysis of the data, there was no statistical significance between the performance of the two student populations. The shift from learning facts to IBL occurred in 2013 for science education in Kentucky. However, many classrooms have not shifted their instruction to align with the true purpose of the new performance expectations. This research investigated the use of IBL with a highly diverse group of learners. Ideas for future research were outlined with the reasoning for those recommendations. The discussion of the results and outcomes from the study was addressed to include insights from the various literature. The implications for P-20 were discussed at length, as this research is meant to address the gap in the literature, specifically if IBL can be successfully used as the instructional method with highly diverse learners. While science teachers struggle to move students to mastery of the NGSS performance expectations, the intent of this research is to provide clear and concise data to promote change in instruction for the learners in the classrooms today.

References

Achieve. (2018). *Criteria for procuring and evaluating high-quality and aligned summative science assessments*. Next Generation Science Standards. https://nextgenscience.org/resources/criteria-procuring-and-evaluating-high-quality-and-aligned-summative-science-assessments

Adams, S. (2022). *The impact of socioeconomic status on the development of STEM identity, choice, and persistence* [Doctoral dissertation, Murray State University]. Murray State Theses and Dissertations. 265. https://digitalcommons.murraystate.educ/etd/265

Allen, J., Way, J. D., & Casillas, A. (2018). Relating school context to measures of psychosocial factors for students in grades 6 through 9. *Personality and Individual Differences*. *136*, 96-106. https://doi.org/10.1016/j.paid.2018.01.041

Almasri, F. (2022). Simulations to teach science subject: Connections among students' engagement, self-confidence, satisfaction, and learning styles. *Education and Information Technologies*. *27*, 7161-7181. https://doi.org/10.1007/s10639-022-10940-w

Bernhard, T. (2022). Science teacher educators' visions and evaluations of expertise in NGSS-aligned instruction across institutions. *Journal of Science Teacher Education*, *34*(4), 369-390. https://doi.org/10.1080/1046560X.2022.2105706

Capraro, R. M., Capraro, M. M., Scheurich, J. J., Jones, M., Morgan, J., Huggins, K. S., Corlu, M. S., Younes, R., & Han, S. (2016). Impact of sustained professional development in STEM on outcome measures in a diverse urban district. *The Journal of Educational Research*, *109*(2), 181-196. http://doi.org/10.1080/00220671.2014.936997

Chen, Y.-C., & Techawitthayachinda, R. (2021). Developing deep learning in science classrooms: Tactics to manage epistemic uncertainty during whole-class discussion. *Journal of Research in Science Teaching*, 1–34. https://doi.org/10.1002/tea.21693

Chen, Y., & Terada, T. (2021). Development and validation of an observation-based protocol to measure the eight scientific practices of the next generation science standards in K-12 science classrooms. *Journal of Research in Science Teaching*. *58*(10), 1489-1526. https://doi.org/10.1002/tea.21716

Cherbow, K., McKinley, M. T., McNeill, K. L., & Lowenhaupt, R. (2020). An analysis of science instruction for the science practices: Examining coherence across system levels and components in current systems of science education in K-8 schools. *Science Education*, *104*(3), 446-478. https://doi.org/10.1002/sce.21573

Committee on Developments in the Science of Learning (2018). *How people learn II: Learners, contexts, and cultures*. Washington, D.C.: National Academy of Sciences.

Dare, E. A., Ellis, J. A., & Roehrig, G. H. (2018, April). Understanding science teachers' implementation of integrated stem curricular units through a phenomenological multiple case study. *International Journal of STEM Education*, *5*(1). https://doi.org/10.1186/s40594-018-0101-z

Dean, S. N., & Gilbert, A. (2021). What scientists do: Engaging in science practices through a wonder-framed nature study. *Interdisciplinary Journal of Environmental and Science Education*, *17*(4-In Progress), e2255. https://doi.org/10.21601/ijese/11136

Duong, M. T., Badaly, D., Ross, A. C., & Schwartz, D. (2021). Longitudinal associations between academic descriptive and injunctive norms and adolescent achievement. *Merrill-Palmer Quarterly*, *67*(2), 149-174.

Eltanahy, M., & Forawi, S. (2019). Science teachers' and students' perceptions of implementing inquiry-based learning instruction in a middle school in Dubai. *Journal of Education, 199*(1), 13-23. https://doi.org/10/1177/0022057419835791

Evan, R., & Dolins, J. (2018). Taking advantage of the synergy between scientific literacy goals, inquiry-based methods and self-efficacy to change science teaching. *Professional Development for Inquiry-Based Science Teaching and Learning*. (5). 105-120. https://doi.org/10.1007/978-3-319-91406-0

Fischer, C., Fishman, B., Dede, C., Eisenkraft, A., Frumin, K., Foster, B., Lawrenz, F., Levy, A. J., & McCoy, A. (2018). Investigating relationships between school context, teacher professional development, teaching practices, and student achievement in response to a nationwide science reform. *Teaching and Teacher Education*, *72*, 107–121.

F T burns middle school (2023-24 ranking)-Owensboro, KY. Publicschoolreview.com (n.d.). https://www.publicschoolreview.com/f-t-burns-middle-school-profile

Gale, J., Koval, J., Alemdar, M., Grossman, S., & Usselman, M. (2022). Sustaining shifts in science teaching through a research-practice partnership. *School Science and Mathematics Association*. *122*, 298-310. https://doi.org/10.1111/ssm.12545

Gallagher, S. A., & Gallagher, J. J. (2013). Using problem-based learning to explore unseen academic potential. *Interdisciplinary Journal of Problem-based Learning*, *7*(1). https://doi.org/10.7771/1541-5015.1322

Geary, K. (2018). *Factors of academic achievement for middle school students* [Research Project]. Integrated Studies. *93*. https://digitalcommons.murraystate.edu/bis437

Godec, S., King, H., Archer, L., Dawson, E., & Seakins, A. (2018). Examining student engagement with science through a bourdieusian notion of field. *Science & Education*. *27*, 501-521. https://doi.org/10.1007/s11191-018-9988-5

Hidiroglu, M., & Sungur, S. (2015). Predicting seventh grade students' engagement in science by their achievement goals. *Asia-Pacific Forum on Science Learning and Teaching*. *16*(2), 1-18.

Holthuis, N., Deutscher, R., Schultz, S. E., & Jamshidi, A. (2018). The new NGSS classroom: A curriculum framework for project-based science learning. *American Educators*. *42*(2), 23-27.

Jerrim, J., Oliver, M., & Sims, S. (2022). The relationship between inquiry-based teaching and students' achievement. New evidence from a longitudinal PISA study in England. *Learning and Instruction*, *80*. https://doi.org/10.1016/j.learninstruc.2020.101310

Jones, T. R., & Burrell, S. (2022). Present in class yet absent in science: The individual and societal impact of inequitable science instruction and challenge to improve science instruction. *Science Education*, *106*, 1032-1053. https://doi.org/10.1002/sce.21728

Ke, F., Xie, K., & Xie, Y. (2016). Game-based learning engagement: A theory-and data-driven exploration. *British Journal of Educational Technology*, *47*(6), 1183-1201. https://doi.org/10/1111/bjet.12314

Keeley, P., Sneider, C. I., & Ravel, M. (2021). *Uncovering student ideas about engineering and technology: 32 new formative assessment probes*. Hawker Brownlow Education.

Kentucky Department of Education. (2022, October 18). Kentucky school report card. https://kyschoolreportcard.com/organization/20?year=2022

Kentucky Department of Education. (2023, October 31). Kentucky school report card. https://kyschoolreportcard.com/organization/20?year=2023

Kiran, D., Sungur, S., & Yerdelen, S. (2019). Predicting science engagement with motivation and teacher characteristics: A multilevel investigation. *Int J of Sci and Math Educ*. *17*, 67-88. https://doi.org/10.1007/s10763-018-9882-2

Li, S., Liu, X., Yang, Y., & Tripp, J. (2021). Effects of teacher professional development and science classroom learning environment on students' science achievement. *Research in Science Education*, 1–23. https://doi. org/10.1007/s11165-020-09979-x

Loveless, T. (2017, March). *How well are American students learning*. The 2017 Brown Center Report on American Education. https://www.bookings.edu/wp-content/uploads/2018/06/2018-Brown-Center-Report-on-American-Education_FINAL1.pdf

Lowell, B.R., Cherbow, K., & NcNeill, K. L. (2021). Considering discussion types to support collective sensemaking during a storyline unit. *Journal of Research in Science Teaching*. *59*(2), 195-222. https://soi.org/10.1002/tea.21725

Madkins, T. C., & McKinney de Royston, M. (2019). Illuminating political clarity in culturally relevant science instruction. *Science Education*, *103*(6), 1319-1346. https://doi.org.10.1002/sce.21542

Mark, S., Lee, C. W. J., & Azmani, P. A. (2021). Growing capacity in gifted and talented education through science, technology, engineering, arts, and mathematics (STEAM). *Kentucky Teacher Education Journal: The Journal of the Teacher Education Division of the Kentucky Council for Exceptional Children*. *8*(1). https://digitalcommons.murraystate.edu/ktej/vol8/iss1/3

McGrath, A. R., & Hughes, M. T. (2018). Students with learning disabilities in inquiry-based science classrooms: A cross-case analysis. *Learning Disabilities Quarterly, 41*(3), 131-142. https://doi.org/10/1177/0731948717736007

Melville, W., Jones, D., & Campbell, T. (2015). *Reimagining the science department*. Arlington, VA: NSTA press.

Morris, A. (2020). *Personalized learning: An engagement strategy for at-risk student population* [Doctoral dissertation]. *Murray State Theses and Dissertations*. *172*. https://digitalcommons.murraystate.edu/etd/172

Munter, C., & Haines, C. (2019). Students get what flows downward: District leaders' rationalizations of the standardized testing of children. *The Educational Forum*, *83*, 160-180. http://doi.org/10.1080/00131725.2019.1567891

National Center for Educational Statistics (2020). Program for international student assessment 2018 science literacy results. nces.ed.gov/surveys/pisa/pisa2018/#/science/achievement

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13165

NGSS Lead States. (2013). Next generation science standards: For states, by states. Washington, DC: The National Academies Press.

Nutt, J. E. (2021). Co-teaching strategies: Improving student engagement by increasing opportunities to respond. *Kentucky Teacher Education Journal: The Journal of the Teacher Education Division of the Kentucky Council for Exceptional Children*. *8*(2). https://digitalcommons.murraystate.edu/ktej/vol8/iss2/3

Phillips, T. B., Ballard, H. L., & Lewenstein, B. V. (2019). Engagement in science through citizen science: Moving beyond data collection. *Science Learning in Everyday Life*, *103*, 665-690. http://doi.org/10.1002/sce.21501

Pinnick, B. S. (2023, May). *Examining elementary teacher perceptions and experiences of transitioning from knowledge-based to inquiry-based social studies standards*. *Murray State Thesis and Dissertation*. *280*. https://digitialcommons.murraystate.edu/etd/280

Pratt, H. (2013). *The NSTA reader's guide to a framework for K-12 science education: Practices, crosscutting concepts, and core ideas* (2nd ed.). NSTA press.

Price, A., Wieman, C., & Perkins, K. (2019). Teaching with simulations: Teachers use simulations for student motivation, content learning, and engagement in science practices. *The Science Teacher (National Science Teachers Association)*, *86*(7), 46-52.

Ravid, R. (2020). *Practical statistics for educators*, (6th ed.) Lanham MD: Rowman & Littlefield.

Science Classroom Resources – Science Model Design. OpenSciEd. (2023, May 8). https://www.openscied.org/openscied.org/openscied-instructional-model/

Schmidt, J. A., Rosenberg, J. M., & Beymer, P. N. (2018). A person-in-context approach to student engagement in science: Examining learning activities and choice. *Journal of Research in Science Teaching*. *55*(1), 19-43. https://doi.org/10.1002/tea.21409

Scogin, S. C., Kruger, C. J., Jekkals, R. E., & Stenfeldt, C. (2017). Learning by experience in a standardized testing culture: Investigation of a middle school experiential learning program. *Journal of Experiential Education*, *40*(1), 39-57. https://doi.org/10.1177/1053825916685737

Serino, L. (2017, April 7). *What international test scores reveal about American education*. The Brookings Institution. https://www.brookings.edu/articles/what-international-test-scores-reveal-about-american-education/

Shepard, L. A. (2019). Classroom assessment to support teaching and learning. *The Annals Academy of Political and Social Science*, 683. https://doi.org/10.2307/26732346

Sinatra, G. M., Heddy, B. C., & Lombardi, D. (2015). The challenges of defining and measuring student engagement in science. *Educational Psychologist*. *50*(1), 1-13. https://doi.org/10.1080/00461520.2014.1002924

State, T. M., Simonsen, B., Hirn, R. G., & Wills, H. (2019). Bridging the research-to-practice gap through effective professional development for teachers working with students with emotional and behavioral disorders. *Behavioral Disorders*, *44*(2), 107-116. https://www.jstor.org/stable/10.2307/26660780

Sutton-Davis, K. (2018). *Testing performance as it relates to academic self-concept and test anxiety in students with and without ADHD*. *Murray State Theses and Dissertation*. *74*. https://digitalcommons.murraystate.edu/etd/74

Tas, Y. (2016). The contribution of perceived classroom learning environment and motivation to student engagement in science. *European Journal of Psychology Education, 31*, 557-577. https://doi.org/10.1007/s10212-016-0303-z

Tofel-Grehl, C., Ball, D., & Searle, K., (2021). Making progress: Engaging maker education in science classrooms to develop a novel instructional metaphor for teaching electric potential. *The Journal of Educational Research*, *1114*(2), 119-129. http://doi.org/10.1080/00220671.2020.1838410

United States - OECD (2019). PISA 2018 Results. https://www.oecd.org/pisa/publications/PISA2018_CN_USA.pdf

Whitney, T., Scott, T. M., & Cooper, J. T. (2022). An examination of response requirements associated with teachers' use of different opportunities for student response during instruction. *Kentucky Teacher Education Journal: The Journal of the Teacher Education Division of the Kentucky Council for Exceptional Children*. *9*(2). https://digitalcommons.murraystate.edu/ktej/vol9/iss2/1

Willard, T. (2015). The NSTA quick-reference guide to the NGSS: K-12. NSTA Press.

Voet, M., & De Wever, B. (2019). Effects of immersion in inquiry-based learning on student teachers' educational beliefs. *Instructional Science*, *46*(3), 383-403. https://doi.org/10.1007/s11251-017-9439-8

Yang, Y., Liu, X., & Gardella, J. A., Jr. (2020). Effects of a professional development program on science teacher knowledge and practice, and student understanding of interdisciplinary science concepts. *Journal of Research in Science Teaching*, *57*(7), 1028–1057.

Yockey, R. (2018). *SPSS demystified: A simple guide and reference*. New York, NY: Routledge.

Zhao, J., Lin, L., Sun, J., Zheng, X., & Yin, J. (2018). Students' engagement in a science classroom: Does knowledge diversity matter?. *The Journal of Educational Research*. *111*(6), 756-763. https://doi.org/10.1080/00220671.2018.1427036

Zvock, K., Holveck, S., & Porter, L. (2019). Teaching for conceptual change in a density unit provided to seventh graders: A comparison of teacher- and student-centered approaches. *Research in Science Education*, *51*(5), 1395-1421. https://doi.org/10.1007/s11165-019-09907-8

Appendix A: IRB Approval

MURRAY STATE
UNIVERSITY

Institutional Review Board

328 Wells Hall
Murray, KY 42071-3318
270-809-2916• msu.irb@murraystate.edu

TO: Stephanie Sullivan, College of Education and Human Services

FROM: Reigh Kemp, IRB Coordinator and Gary ZeRuth IRB Member RK

DATE: 11/20/2023

RE: Human Subjects Protocol I.D. – IRB # 24-112

The IRB has completed its review of your student's Exempt from further review protocol Relationship Analysis of Storyline Curriculum Engagement and Acadmeic Performance
After review and consideration, the IRB has determined that the
research, as described inthe protocol form, will be conducted in compliance with Murray State University guidelines for the protection of human participants.

The forms and materials that have been approved for use in this research study are attached to the email containing this letter. These are the forms and materials that must be presented to the subjects. Use of any process or forms other than those approved by the IRB will be considered misconduct in research as stated in the MSU IRB Procedures and Guidelines section 20.3.

Your stated data collection period is from 11/20/2023 to 11/20/2024

If data collection extends beyond this period, please submit an Amendment to an Approved

Protocol form detailing the new data collection period and the reason for the change.

This Exempt from Futher Review **approval is valid until 11/19/2024.**

If data collection and analysis extends beyond this date, the research project must be reviewed as a continuation project by the IRB prior to the end of the approval period, 11/19/2024. You must reapply for IRB approval by submitting a Project Update and Closure form (available at murraystate.edu/irb). You must allow ample time for IRB processing and decision prior to your expiration date, or your research must stop until such time that IRB approval is received. If the research project is completed by the end of the approval period, then a Project Update and Closure form must be submitted for IRB review so that your protocol may be closed. It is your responsibility to submit the appropriate paperwork in a timely manner.

The protocol is approved. You may begin data collection now.

Opportunity *afforded*

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