THE USE OF ELEMENTARY AND MIDDLE SCHOOL SCIENCE LEAD TEACHERS FOR THE PURPOSE OF DELIVERING EFFECTIVE PROFESSIONAL DEVELOPMENT DURING THE TRANSITION TO NEW STANDARDS

A Record of Study

by

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ABSTRACT

The State of Tennessee transitioned to new science standards. Previous methods for delivering professional development were unable to support teachers in pedagogy, content knowledge, or sustainability during this paradigm shift. As such, a lead teacher model was thoughtfully and intentionally implemented, and delivered professional development for three-dimensional learning and the Tennessee Academic Standards for Science. The lead teacher model provided for one middle school science lead teacher per grade level (6-8) per middle school, and one K-2 and one 3-5 STEM lead teacher per elementary school. The lead teachers participated in monthly professional learning communities, and then re-delivered that information to their schools and grade levels. Using a mixed methods design, the researcher examined the relationship between the effectiveness of lead teacher re-delivery sessions and student achievement of the group, self-efficacy, and how the current lead teacher model impacted self-reported science teaching practices. Research findings showed that as effectiveness scores of a lead teacher re-delivery session increased, so did student achievement. Analysis from a variety of qualitative instruments suggested the lead teacher model did impact teacher's self confidence in science knowledge and science teaching. Historical data provided unique themes for how the district's current lead teacher model impacted science teaching practices, and indicated suggestions for how to support teachers in the areas of science curriculum, assessment, and future professional development. Results from the research will provide district personnel with recommendations for how to enhance the lead teacher model during the continued transition to new science standards.

DEDICATION

"A leader is one that knows the way, goes the way, and shows the way."

-John C. Maxwell

Dedicated to Betty Jean Cottar, who completed her Doctor of Education degree and graduated from Texas A&M University in 1998. Thank you for always showing the way mom.

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Eleanor Roosevelt once said, “People grow through experience if they meet life honestly and courageously. This is how character is built.” As a military spouse, I have been fortunate to work in several states with a variety of talented and dedicated educators. It is those educators and my experiences in each location that have shaped the professional I am today. I would like to extend a heartfelt thanks to my colleagues at Lamar and David Elementary- Conroe Independent School District, TX; Abrams Elementary- Fountain Fort Carson School District, CO; Sango Elementary- Clarksville Montgomery County School System, TN; Anchorage Public School and District- Louisville, KY; STARBASE DOD Program- Savannah, GA; and the entire school system for where this research took place. I have grown personally and professionally thanks to the experiences I have shared with teammates, administrators, parents, and students of each school and community.

Finally, I would like to thank my family. My parents instilled in me a love for learning at a young age, and they provided me with a first class education. This set the

foundation for me to continue my education. My husband, Reggie, has been my rock. He has helped me stay the course by reminding me of the goals I have set. Whenever I felt academic fatigue, he helped me refocus. Our children, Walter and Addie, have been resilient teenagers throughout this process. The greatest reward is seeing them thrive in their own education and finding solace in the fact that by leading by example, my husband and I may have had something to do with that. My family's support and encouragement have given me the courage to see this program to fruition, and I am proud to share this accomplishment with them.

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CHAPTER 1: LEADERSHIP CONTEXT AND PURPOSE OF THE ACTION

Educators in Tennessee want to create opportunities for students to be college and career ready by increasing the rigor in the classroom and teaching to higher standards. To promote this, the State of Tennessee has written and adopted new science standards developed from the *K-12 Framework for Science Education* that will require a pedagogical shift for how we teach science. Science teachers will need professional development delivered in an effective manner where they will have access to collaboration and support.

Defining the Problem

Crockett City School System (CCSS) is comprised of 7 high schools, 7 middle schools, and 23 elementary schools. As the STEM / Science Curriculum Consulting Teacher, K-8 for the Crockett City School System, the researcher's responsibilities include interpreting state standards and content, working with administrators, academic coaches, teachers, and community members, modeling best practices for science teachers, and acting as a liaison between the district and state. With approximately 400 science teachers in grades K-8, capacity issues cause a significant disconnect between the science teachers and the school district. As a result, teachers do not receive timely and effective communication from the district, there is a lack of rigorous science teaching and best practices, and science teachers do not have a method for exercising their voice in decision-making. Furthermore, the state has adopted new standards that will be implemented in 2018-2019, and there is work to do to interpret and deconstruct them, build a repository of resources, and write assessment items. The school district is in need of professional learning communities (PLCs) designed to concentrate on these issues science teachers are facing. The Crockett City School System is interested in changing how professional development is delivered from central office to teachers through the use of science lead teachers and PLCs. It is the researcher's desire that by using science lead teachers to deliver district-wide professional development (PD) through monthly PLCs, the necessary support will be provided for science teachers to make the pedagogical shift in science teaching required by the new standards.

Science Lead Teachers as a Solution

There is a need to increase rigor in the elementary and middle school science classroom. The State of Tennessee is transitioning to new science standards and previous methods for delivering professional development from the district will not support teachers in pedagogy, content knowledge, or sustainability during this transition. In order to support teachers throughout the implementation of three-dimensional learning and the new science standards, thoughtful and intentional professional development will need to be implemented over the next three years. Due to the size of our school district, capacity is an issue when delivering effective professional development. Therefore, it is the vision of the Crockett City School System to implement a new method for delivering professional development to all stakeholders with the use of science lead teachers.

Each of the seven middle schools will select one lead teacher from each 6^{th}, 7^{th}, and 8^{th} grade science team to represent their school for a total of 21 middle school science lead teachers in CCSS. Additionally, each of the seven middle schools will select one lead teacher from each 6^{th}, 7^{th}, and 8^{th} grade math team to represent their school for a total of 21 middle school math lead teachers in CCSS. Each of the 23 elementary schools will select one lead teacher to represent grades K-2 and one lead teacher for grades 3-5 for a total of 48 elementary lead teachers in CCSS. Elementary lead teachers are not only responsible for science, but math integration as well, and therefore are referred to as elementary STEM lead teachers. For the purpose of this study, the researcher focused only on middle school science lead teachers and elementary STEM lead teachers.

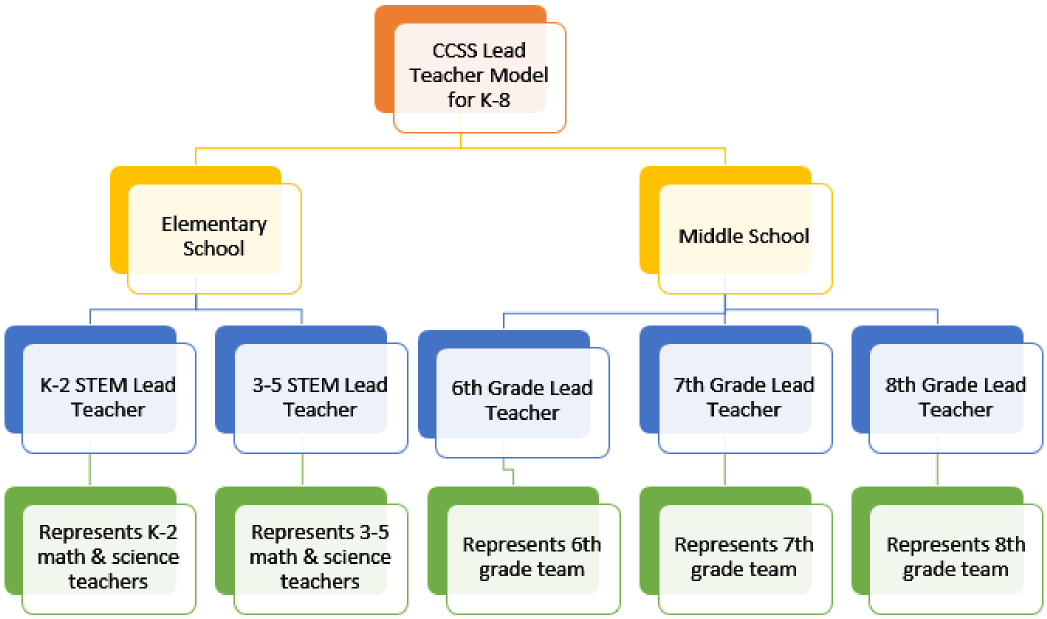
The lead teachers will participate in a monthly professional learning community led by the content specialist for the school district, and then re-deliver that information to their grade level. This structure is designed in an effort that teachers will receive more timely and effective communication and professional development centered on topics of their interest. Professional development through lead teachers will develop teacher leadership capacity amongst teachers in their buildings and since teacher leaders serve as a liaison between district and schools, teachers across the district will have more voice in the decision making process.

Development of a Lead Teacher Program

In 2017, the assessment and accountability team for the Crockett City School System secured a grant from The Department of Defense Education Activity (DoDEA) that focused on the implementation of a College and Career Coordinator (C^3), and supported initiatives to ensure all students graduating from CCSS high schools were college and career ready. A component of this grant included funding for the implementation of a lead teacher program to support increasing rigor in the science and math classrooms. The first year of implementation for the C^3 initiatives began in 2017-2018. We are entering the second year of implementation of the lead teacher model, and for the purpose of this research this study focuses on the 2018-2019 school year.

Provisions from the grant state that each of the seven middle schools will select one lead teacher from each 6^{th}, 7^{th}, and 8^{th} grade science team to represent their school for a total of 21 middle school science lead teachers in CCSS. Additionally, each of the seven middle schools will select one lead teacher from each 6^{th}, 7^{th}, and 8^{th} grade math team to represent their school for a total of 21 middle school math lead teachers in CCSS. Each of the 23 elementary schools will select one lead teacher to represent grades K-2 and one lead teacher for grades 3-5 for a total of 46 elementary lead teachers in CCSS. Elementary lead teachers are responsible for science and math integration, and therefore are referred to as elementary STEM lead teachers. For the purpose of this study, the researcher focused only on middle school science lead teachers and elementary STEM lead teachers.

Figure 1. Lead Teacher Model for Math and Science Teachers, Grades K-8



District Directors of Curriculum and Instruction define the purpose of Crockett City School System's lead teacher program is to provide input and conduct professional learning related to the direction and implementation of district wide, content area initiatives through collaboration with colleagues. These positions are designed to improve student achievement by increasing teacher content knowledge through an expanded blend of rigorous instructional strategies, using both traditional and digital resources.

In the spring, building administrators submit nominations of lead teachers from their school to the district's Directors of Curriculum and Instruction. Once the lead teachers are approved by the district, each lead teacher will review and sign a Memorandum of Understanding.

District officials further shaped the lead teacher model by emphasizing the following requirements. First, the lead teacher commitment lasts for one school year running August to May. Lead teachers are required to meet over the course of the year eight times. Lead teachers meet during school three times on pull out days, their substitutes are funded from the C^3 Program, and they will receive training hours on their professional development record for their participation. Five times over the course of the school year lead teachers will attend after school sessions that last 1.5 hours. A $600.00 stipend paid to the teacher from the C^3 Program will compensate the lead teacher for their time and work. Under the requirements of the C^3 Program, lead teachers are required to document information regarding how they re-deliver to their schools information from the after school PLCs.

Lead teacher collaboration sessions may focus on curriculum, implementation of strategies, or the developing pedagogy. Lead teachers exploring curriculum work may focus on exploring or piloting new curricular resources and strategies, creating resource repositories, revising scope and sequencing documents, and communicating curricular changes to building stakeholders. Professional learning is an opportunity for teachers to dive deeper into their content knowledge, particularly topics in science that are new to the teacher or require a greater depth of knowledge due to the transition to new standards. The table below is an overview of the 2018-2019 sessions for Middle School Science Lead Teachers.

Table 1

Middle School Science Lead Teacher Overview

Middle School Science Lead Teachers 2018-2019 Agenda					
Dates	**Focus Strategy**	**PLC Big Ideas**	**Redelivery Notes**	**Input and Feedback**	**Next Steps**
August 15th After School PLC 3:00-4:30 p	Understanding and evaluating Science Performance Tasks	Click here for clear targets and PPT	It is suggested that re-delivery occur with all 6th, 7th, and 8th grade science teachers present. A greater number of teachers for this exercise creates a more rich conversation about what constitutes an effective science task.	Re-Delivery Spreadsheet Documentation from Middle School Lead Teachers	Encourage grade levels to begin writing their own tasks. Academic coaches should receive the same PLC to be able to provide support for teachers analyzing assessments for three-dimensions.
September 19th Full Day PD 8:00 a.m.-3:30 pm	Strengthening Science Pedagogy	Click here for clear targets and PPT	No formal re-delivery is required. However, teachers are encouraged to share the consensus from PLC regarding the deconstruction of upcoming standards, resources, and task.	Survey to Teachers for Full Day Pull Out Session	Create a science hub where teachers can access resources
October 17th After School PLC 3:00-4:30 pm	Writing Two and Three-Dimensional Clear Targets	Click here for clear targets and PPT	Re-delivery PPT is provided for lead teachers to use when re-delivering to grade level teams.	Re-Delivery Spreadsheet Documentation from Middle School Lead Teachers	There is disconnect for how to deconstruct standards. Work with all contents to streamline this process and create a flow chart that is science specific.
November 28th Full Day PD 8:00 a.m.-3:30 pm	Strengthening Science Pedagogy	Click here for clear targets and PPT	After content dive with professors and a tour of the APSU facilities, teachers spent the afternoon deconstructing the matching standards and planning resources for units after Christmas.	Survey to Teachers for Full Day Pull Out Session	Discuss the creation of a model blended unit of instruction encompassing digital and traditional resources.
January 16th After School PLC 3:00-4:30 pm	Using Observable Features with Science and Engineering Practices (SEPs)	Click here for clear targets and PPT	It is recommended with this re-delivery all 6-8 science teachers are present together as more participants will increase conversation around observable features	Re-Delivery Spreadsheet Documentation from Middle School Lead Teachers	Share observable features with administrators and academic coaches so there is support during planning sessions utilizing this tool for instruction and assessment.
February 13th Full Day PD 8:00 a.m.-3:30 pm	Deconstructing New Standards and Implementation of the Blended Units	Click here for clear targets and PPT	No formal re-delivery is required. However, teachers are encouraged to share the blended units from PLC and the curriculum work from the morning session will be made available for all teachers on the science hub.	Survey to Teachers for Full Day Pull Out Session	Encourage middle school lead teachers to apply as state content facilitators for the summer trainings and to participate on item review. These opportunities should arise in the next month.
March 13th After School PLC 3:00-4:30 pm	Discussing Cluster Items in Assessment and Phenomenon	Click here for clear targets and PPT	Lead teachers will provide time for grade level members to solicit input for recommendations on the order and time for standards on next year's pacing guide. A google link is provided for consensus from each grade level to be recorded	Re-Delivery Spreadsheet Documentation from Middle School Lead Teachers	Attend re-delivery sessions to support the feedback process for the pacing guides.
April 17th After School PLC 3:00-4:30 pm	2019-2020 Pacing Guides	Click here for clear targets and PPT	Teachers will re-deliver final drafts of 19-20 pacing guides on the morning of April 23rd at the district wide science professional development.	Re-Delivery Spreadsheet Documentation from Middle School Lead Teachers	Conduct final edits of pacing guide, present to administrators and academic coaches and post on the curriculum hubs.

Personal Context and Researcher's Roles

As the STEM / Science Curriculum Consulting Teacher, K-8 for the Crockett City School System, the researcher's responsibilities include interpreting state standards and content, collaborating with administrators, academic coaches, teachers, and community members, modeling best practices for science teachers, and acting as a liaison between the district and state.

The Tennessee Academic Standards for Science were adopted in 2016 and the 2018-2019 school year has been designated as the first year of implementation. The Tennessee Department of Education (TDOE) has strategically designed a three year implementation process for the new science standards with explicit goals for each year, and our district is adopting the same process. The three goals for year one of implementation are:

1. Teachers know and teach every science standard.
2. Students are appropriately engaged in all of the science and engineering practices throughout the school year.
3. Teachers would start to see how the crosscutting concepts (CCCs) are manifested in what they teach.

As a science educator employed in Kentucky from 2012-2015 during the transition to Next Generation Science Standards (NGSS), the researcher is familiar with the *Framework for K-12 Science Education* and the shift to 3-Dimensional Science Instruction. This personal experience helps significantly when thinking about strategies for implementing Tennessee's new science standards. From this experience, areas the researcher has identified where teachers will need support in year one include: (a) an understanding of the components of each of the three dimensions of science and what it looks like in context; (b) a process for how to deconstruct science standards utilizing the resources available; (c) curating and sharing resources; (d) writing two-dimensional lessons; (e) deepening content knowledge; and (f) assessing student learning appropriately.

In this role, it is the researcher's responsibility is to create a timeline for year one implementation of the new standards for the district, and adequately prepare an agenda for science lead teachers that will support students, teachers, and administrators during the transition. As the researcher shapes the agenda for each month's lead teacher session, she will consider feedback obtained from academic coaches, administrators, grade level planning meetings, utilize feedback surveys from lead teachers to identify areas of need, access instructional technology coaches for support, and provide directors of curriculum and instruction with an outline of big ideas and clear targets for feedback.

Key components to a successful lead teacher program include organization, clear expectations, and open communication. Once the researcher receives a list of all STEM (elementary) and science (middle school) lead teachers, the researcher will organize the lead teachers utilizing a Google classroom that houses rosters, schedules, agendas, a survey link to document redelivery information, and all of the collaboration throughout the year. The researcher plans to communicate to lead teachers through the Google classroom, an email list serve, and calendar invites from Outlook. Preparation also includes establishing a professional development course through the school district's platform that will document lead teachers' training hours, stipend hours, and attendance for school district and grant compliance.

Finally, to ensure lead teachers return to their colleagues and provide re-deliveries with fidelity, informal school visits and observations occur throughout the course of the year. As the researcher watches these re-deliveries and documents observations, it is the goal of the curriculum and instruction team to glean information that will aid in identifying the needs of the district during the transition to new science standards.

Research Questions

The purpose of this study is to investigate the use of elementary and middle school science lead teachers for the purpose of delivering effective professional development during the transition to new standards. Even though the Crockett City School System Lead Teacher Model includes lead teachers for math and science, the study will focus only in the area of science. Three research questions will guide this mixed methods study.

Question 1: What was the relationship between effectiveness of the lead teacher re-delivery sessions and student achievement of the group?

Question 2: What was the relationship between the district's lead teacher model and teacher self-efficacy?

Question 3: How did the district's current lead teacher model impact self-reported science teaching practices?

Definitions

3-Dimensional Science Instruction- Science instruction that encompasses disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). The integration of all three-dimensions connects standards across disciplines and demands a deeper dive into content.

C3 Program- A College and Career Coordinator (C^3), oversees the grant funded by DoDEA which provides for the implementation of the lead teacher program. Soon after the grant was received, CCSS coined the nickname "C^3 Program" for all initiatives under the umbrella of the grant.

Framework for K-12 Science Education- In 2012 the National Research Council published the *Framework for K-12 Science Education*. From the framework, the Next Generation Science Standards (NGSS) were written. Tennessee did not adopt the NGSS. However, four years later, Tennessee did write their own standards utilizing the principles from the *Framework for K-12 Science Education*. Therefore, the NGSS and the Tennessee Academic Standards for Science can be considered "sister standards."

Professional Development- Process of improving and increasing capabilities of persons through access to education and training opportunities in the workplace, through outside organization, or through watching others perform on the job. Professional development helps build and maintain morale of staff members, and is thought to attract higher quality staff to an organization.

Professional Learning Communities (PLCs)- A method to foster collaborative learning among colleagues within a particular work environment or field. Schools often use PLCs as a way to organize teachers into working groups of practice-based professional learning.

Self-Efficacy- A person's belief about his or her ability and capacity to accomplish a task or to deal with the challenges of life.

College and Career Readiness

Closing Thoughts

The curriculum and instruction team for the district has emphasized that the delivery of professional development through lead teachers will be crucial during the first year implementation of new science standards. Trygstad, Smith, Banilower, and Nelson (2013), concluded in their study referencing the 2012 National Survey of Science and Mathematics Education (NSSME), schools and districts are not prepared to transition to three-dimensional learning. The Crockett City School System will need to take thoughtful and purposeful action to plan professional learning sessions with our science lead teachers that support them in the areas of understanding the three-dimensions of science instruction in context, deconstructing standards, curating resources, and deepening their content knowledge. Roles of the lead teacher include collaborating across schools, modeling best practices, acting as a liaison between their school and district, and becoming reflective of their practice all while building capacity and reducing variability across the district. All of these roles work together for the benefit of student achievement and will be especially critical during the transition to new science standards.

CHAPTER 2: REVIEW OF SUPPORTING SCHOLARSHIP

Introduction

Developing science literate students for the future requires a pedagogical shift in science instruction. To support teachers in the transition of new standards and more rigorous science instruction, intentional decision-making will be required for selecting the most appropriate method for delivering effective professional development. In large school districts where variability is a concern and the method for delivering professional development is considered, the use of professional learning communities may be an equitable solution. Furthermore, utilizing science lead teachers in professional learning communities will not only allow for the effective and timely delivery of professional development to schools and grade-level teams, but also for science teachers across the district to have a voice in the district's decision-making process.

The Need to Teach for Rigor

As educators prepare to teach students in the 21st Century classroom and ready our youth for their future, there is a growing demand to increase rigor in the classroom. On December 10, 2015, the Every Student Succeeds Act (ESSA) was signed into effect, and reauthorized the 50-year old Elementary and Secondary Education Act (ESEA) which was the Nation's education law and commitment to equal opportunity for all students. The Every Student Succeeds Act's provisions ensure success for students and schools, to include the teaching of high academic standards that will prepare students to succeed in college and careers (Congressional Digest, 2017).

Many states, to include Tennessee, have developed standards to ensure all students will meet college and career requirements. A major focus of these standards is to increase higher-order thinking skills and the ability to solve complex problems (Marzano & Toth, 2014). It is essential graduating seniors have these skills when entering the workforce or continuing their education post-high school. Marzano and Toth (2014) remind us that higher-order learning is the foundation for the concept of rigor, and a critical shift in instruction is needed to achieve that rigor.

An example of this critical shift in science instruction across the country is the transition to new science standards. In October 2016, the State of Tennessee adopted the Tennessee Academic Standards for Science, which utilized the principles of three-dimensional learning from *The Framework for K-12 Science Education.* Tennessee's new standards call for a paradigm shift in the way we teach science, and when implemented promise to improve the coherence of content from grade to grade and promote equity and diversity of science and engineering education for all learners.

The question therein lies, are our science teachers ready for that pedagogical shift in science instruction? Trygstad, Smith, Banilower, and Nelson (2013), concluded in their study referencing the 2012 National Survey of Science and Mathematics Education (NSSME) that schools and districts are not prepared to transition to three-dimensional learning. The greatest concern was evidence that elementary science is noticeably inadequate with an average of 20 minutes of instruction per day. Furthermore, data indicated that elementary teacher's perceptions of their ability to teach science as compared to reading language arts and math is significantly lower. For example, teachers in grades 3-5 ranked themselves 33% “Very Well Prepared” to teach science as compared to 76% for math and 74% for reading language arts. Additionally, the study indicated only 5% of elementary teachers had college coursework in engineering. This was reflective in their perceptions of preparedness as grades 3-5 teachers ranked themselves as 5% “Fairly Well Prepared” to teach engineering as compared to 48% life science, 48% earth science and 39% physical science (Trygstad, Smith, Banilower, & Nelson, 2013).

Teachers, especially those in the elementary classroom that are responsible for more than one content area and all four science disciplines, will need considerable support in the transition to new standards. Serious considerations should be given to how professional development will support this transition in terms of time, structure, and delivery method. Marzano and Toth (2014, p.15) echo this concern from their research and explain, “Standards experts agree that the major challenge for new standards has been getting teachers the aligned training to help them refine and adjust their instructional techniques.”

The timely passing of ESSA and its expectations for students to achieve rigor through higher-order thinking skills and the ability to solve complex problems, coupled with the pedagogical shift for teaching new standards, requires forward thinking in regards to delivering effective professional development.

Why New Science Standards?

Science education is at a pivotal point in the United States and to be globally competitive in the future there has been a call to invest in science reform. The National

Research Council established The Committee on a Conceptual Framework for the New K-12 Science Education Standards to undertake a study and make recommendations for reform. The 18 member committee was composed of members from the National Academy of Science or the National Academy of Engineering as well as educational researchers and policymakers. They were charged with developing a conceptual framework that would encompass core ideas supported by crosscutting concepts and practices. In 2011, the National Research Committee released a report that provided a vision for K-12 science education (Keller & Pearson, 2012). This report was published in 2012 as *A Framework for K-12 Science Education* which serves as the foundation for many states in the development of new science standards. After opting out as a lead state in the Next Generation Science Standards, Tennessee developed a committee and commissioned them to write new state science standards using the *Framework* as its foundation. In 2016 Tennessee adopted the Tennessee Academic Standards for Science which incorporated the pedagogy from *A Framework for K-12 Science Education*. Tennessee's transition to new science standards took instruction from teaching Grade Level Expectations (GLEs) and Checks for Understandings (CFUs) in a simplistic one-dimensional style, to three-dimensional instruction incorporating the science and engineering practices, crosscutting concepts and disciplinary core ideas. This paradigm shift in science education has entered its first year of implementation in Tennessee. The state of Tennessee recognized this paradigm shift in science education would be a process and identified three goals for year one of implementation. First, teachers know and teach every science standard. Second, students are appropriately engaged in all of the science and engineering practices throughout the school year. Finally, teachers would start to see how the crosscutting concepts (CCCs) are manifested in what they teach. The state will release its second-year goals in early spring of 2019.

Science and Engineering Practices (SEPs). Science and engineering practices are the first of three dimensions. A significant component of the science and engineering practices is that they are not designed solely to address science but apply to engineering and technology education as well. *A Framework for K-12 Science Education* (National Research Council, 2012), explicitly defines for each science and engineering practice how it is interpreted when used for science instruction as compared to engineering. Natural grade level progressions in the *Framework* assist teachers in identifying the appropriateness of each science and engineering practice. Feedback received during the early reviews of the *Framework* suggested that teachers would feel unprepared to teach engineering practices since they aren't engineers by trade. However, Keller and Pearson (2012) suggest that teachers do not need to be the sole deliverer of this content and can receive support from in-house experts such as engineering and technology teachers. The eight science and engineering practices from *A Framework for K-12 Science Education* (NRC, 2012, p. 3) include:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking

6. Constructing explanations (for science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

The science and engineering practices offer a more compelling way of doing and engaging in science rather than just reading or knowing about science (Huff, 2016). Science lessons can be inquiry-based, but do not necessarily meet the intent of the *Framework*. For example, students can follow a procedure to investigate whether or not certain light affects how plants grow. Students can even identify the variables and analyze the data collected during the investigation. However, if the student is not the one that has planned and carried out the investigation, teachers are not meeting the full intent of the science and engineering practice. The gradual release of science and engineering practices from teacher-led to student-led takes time, and student engagement with the practices should be scaffolded and supported throughout the year. Additionally, the above activity falls short of students building scientific knowledge and consensus and explaining the scientific phenomena to one another (Duncan & Cavera 2015). In a study conducted by Reiser, Michaels, Moon, Bell, Dyer, Edwards, McGill, Novak, and Park (2017), teachers found that a necessary prerequisite for helping students to understand the practices was to engage in the practices themselves. One teacher noted the increased significance in learning when having to develop the model themselves instead of being told how to do so.

Science and engineering practices are integrated throughout disciplines. Analyzing and interpreting data and using mathematical and computational skills are two science and engineering practices that overlap math practices in the state of Tennessee. Additionally, engaging in an argument for evidence and obtaining, evaluating and communicating information are explicitly a part of the Tennessee Reading and Language Arts Standards. Utilizing such strategies such as Socratic Circles and Claim, Evidence, and Reasoning (CER) while interpreting scientific texts allows teachers to strategically integrate both disciplines simultaneously.

Science and engineering practices create a student-centered classroom, where phenomena is explored and the students are building consensus. The practices are interdisciplinary and require a significant amount of support and professional development for teachers to feel confident in teaching with fidelity this new dimension.

Crosscutting Concepts (CCCs). Crosscutting concepts is the second dimension in the *Framework* and bridge science and engineering across disciplines. Fick (2016) suggests thinking of crosscutting concepts as lenses used to analyze the scientific phenomena, and depending on which theory is examined depends on which lens one would use. The seven crosscutting concepts from *A Framework for K-12 Science Education* (NRC, 2012, p. 3) include:

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function

7. Stability and change

Patterns, as an example, are a form of "organization and classification and prompt questions about relationships and the factors that influence them" (NRC, 2012, p. 84). One example is the patterns of day and night in the discipline of Earth and space sciences. Students collecting data on the hours of daylight compared to nighttime can examine the patterns to explain phenomena. Once students understand the principles of utilizing patterns, it is applicable across disciplines such as patterns of waves (physical science) or patterns of DNA (life science).

In Fick's (2016) research, the author suggests three goals for incorporating the crosscutting concepts. Students should use the components of the crosscutting concepts to deepen their understanding about a topic, to clarify any confusion presented regarding a topic, and to apply the crosscutting concepts across science topics to increase their knowledge of new concepts. Duncan and Cavera (2015) concur explaining that crosscutting concepts can be used as tools to explore the world and should not be taught as stand-alone ideas.

Crosscutting concepts is the most unfamiliar dimension to teachers in the paradigm shift of science education. Just as the implementation of new standards is a process, so is fully understanding the variety of methods for how crosscutting concepts are utilized.

Disciplinary Core Ideas (DCIs). Disciplinary core ideas are the third-dimension in the *Framework* and include physical science, Earth and space sciences, life science, and engineering, technology and applications of science. The four DCIs are made up of 13 core ideas and 44 component ideas. The disciplinary core ideas from *A Framework for K-12 Science Education* (NRC, 2012, p. 3) include:

Physical Sciences

PS1: Matter and its interactions

PS2: Motion and stability: Forces and interactions

PS3: Energy

PS4: Waves and their applications in technologies for information transfer

Life Sciences

LS1: From molecules to organisms: Structures and processes

LS2: Ecosystems: Interactions, energy, and dynamics

LS3: Heredity: Inheritance and variation of traits

LS4: Biological evolution: Unity and diversity

Earth and Space Sciences

ESS1: Earth's place in the universe

ESS2: Earth's systems

ESS3: Earth and human activity

Engineering, Technology, and Applications of Science

ETS1: Engineering Design

ETS2: Links among engineering, technology, science, and society

The intertwining of three-dimensional instruction means disciplinary core ideas no longer have to be taught in isolation. The science and engineering practices and crosscutting concepts allow for the process of photosynthesis, which is a life science disciplinary core idea, to be taught concurrently with the Law of Conservation of Mass, which is a physical science disciplinary core idea. Furthermore, the *Framework* published grade band endpoints for second, fifth, eighth, and twelfth grades, so teachers can invest time into understanding what is required for mastery of the disciplinary core idea at their grade level and thus support effective vertical alignment. Keller and Pearson (2012) urge educators when using grade-band endpoints to remember that they are descriptors and not the standards, and the *Framework* should serve as the base for the development of standards.

While the disciplinary core ideas reflect a concerted effort to consolidate all of the scientific topics students should know, there are fewer to teach because each is more complex (Duncan & Cavera, 2015). It is important to note that to reach a deeper understanding of a scientific topic does not necessarily mean teaching more details. Too many details can "obscure the big picture and leave students with fragmented and often incorrect understanding" (Duncan & Cavera, 2015, p. 52).

Whether a state is a leader in Next Generation Science Standards or has used the *Framework* as the foundation for writing their standards, the disciplinary core ideas remain constant. For example, in the Next Generation Science Standards, PS.1: Matter and Its Interactions may be taught at a certain depth in middle school whereas the state of Tennessee placed it in fifth grade. Therefore, educators may view different state standards written from the same *Framework* as sibling standards. They incorporate the same language but may choose different grade bands for delivery.

Implementation. To begin incorporating three-dimensional instruction, teachers should look for engaging phenomena to hook students' curiosity. Krajcik (2015) discusses potential sources for phenomena that are aligned with disciplinary core ideas include the local environment, personal hobbies, current challenges facing the environment, readings from the internet, journals, and magazines, and fellow science colleagues. Incorporating phenomena brings back the "How might?" and the "I wonder?" that has been absent from the science classroom.

When implementing three-dimensional instruction, Keller and Pearson (2012) offer recommendations and next steps for teachers and administrators when collaborating. First, it is recommended teachers collaborate with each other, especially those from different content areas, to coordinate instruction regarding common vocabulary terms and concepts. Second, it is advised teachers connect learning models with the science and engineering practices and disciplinary core ideas. This allows for the teachings of more complex concepts necessary for solving engineering problems. Next, K-12 teachers should not teach STEM in isolated ways but through a more interdisciplinary approach. Purposeful professional development and cross-collaboration will support this endeavor. Finally, the *Framework* should be a platform to launch out-of-school partnerships and learning opportunities. With the added demands of teaching science in three-dimensions, districts should reach out to partners in education and their science community members to help supplement and support the transition to new science learning.

Obstacles to implementing three-dimensional science instruction may present themselves. Huff (2016) defines two myths that serve as barriers to implementation. First, states that have adopted Common Core State Standards (CCSS) are adamant that science was included as part of their state standards. While the CCSS may have components of science in them, they should not replace meaningful science instruction that is included in three-dimensional learning. This would no doubt limit the ability for students to become science literate by engaging and doing science while incorporating the disciplinary core idea with the science and engineering practice and crosscutting concepts. Secondly, Huff (2016) shares the myth that many science teachers think they are "already doing this." While many teachers do incorporate best practices in the classrooms, careful consideration is not given to how to engage students in the practices of science. Conversations and explanations of the scientific phenomenon require a paradigm shift in how we teach science and cannot be accomplished by just utilizing best practices. A final suggestion from Duncan and Cavera (2015) is to be reluctant to utilize existing lessons. Much of the classroom instruction prior to the development of the *Framework* may have claimed to be inquiry-based, but does not engage students with the three-dimensions.

Developing science-literate students for the future requires a paradigm shift in science education. Incorporating three-dimensional science instruction, in conjunction with 21st-century skills and sufficient professional development will ensure success for Tennessee stakeholders during this transition.

Professional Learning Communities

In the transition to new standards, Tennessee science teachers will make a pedagogical shift in science teaching and learning. Teachers will be required to make a radical departure from typical approaches to teaching and learning in science classrooms and move to a more three-dimensional (3D) learning. Three-dimensional learning is the interaction of science and engineering practices, disciplinary core ideas, and crosscutting concepts. These changes in classrooms move students from learning about scientific ideas to figuring out scientific ideas that explain how and why phenomena occur. To support science educators in the transition, teachers will need to learn how to apply these ideas to their classroom.

One method for supporting teachers throughout a second order change, such as the pedagogical shift in science teaching, is through the use of professional learning communities. "Professional learning communities are an integration of two traditionally distinct concepts- professional learning and community. In this model the professional's expert knowledge and focus on student learning and needs are combined with the communities shared interest, core values, and mutual responsibility" (Mullen, 2009, p. 15). According to Mullen (2009), professional learning communities may be viewed from three different perspectives: organizational, cultural, and leadership. From an organizational perspective, the goal is to build school capacity. Professional learning communities are viewed as a model for implementing change, which is accomplished by promoting staff collaboration and reflection while keeping at the forefront the goal of improving student achievement. From a cultural perspective, all stakeholders equally share the goal of transforming schools into communities to enhance learning for students and teaching for educators. To propel this change, the school community must honor shared values, and confront and transform bias. All members regardless of ethnicity, religion, or special needs are members of the team and considered equal. From a leadership perspective, professional learning communities provide an opportunity to build leadership capacity in teachers through networks for discussing issues regarding instructional practice, acclimating new teachers, fostering cross-curricular integration, and bridging the school to the community. School leaders who fully comprehend the research behind professional learning communities will be able to accomplish goals otherwise unattainable as individuals. Mullen (2009) concludes that the three key characteristics to an effective professional learning community include:

1. Focus on learning rather than teaching.
2. Dedicate oneself to a culture of collaboration.
3. Commit to school improvement and collaboration.

Benefits of implementing professional learning communities. In a study conducted by Reiser et al. (2017), teachers in a mid-western state utilized professional learning communities (PLCs) during a three-year program concurrent with implementing three-dimensional learning. Findings indicated that teachers reported an increase in confidence in teaching in ways called for by the *Framework*, and teachers felt more prepared to implement the new standards in their classroom because professional development helped them see how engaging students in discussion and argumentation for developing scientific understanding aligned with the new standards. Reiser et al.

(2017) reported the most encouraging result from the study was the increase in sophistication of science teachers' pedagogy of the science and engineering practices.

Harris and Rosenman (2017) reflect on their participation in the Teacher Institute on Science and Sustainability (TISS) at the California Academy of Sciences. These teachers committed to a one-year intense professional development for teaching their new science standards delivered through a two-week summer institute and PLCs throughout the year. Success in their PLCs stemmed from the protocol structure they experienced as well as the trust and camaraderie they formed with their team members. Participation from this experience, evidenced by survey results and classroom observations, led to new opportunities for teachers and students. These included strategies for teaching the confidence to enact them. Additionally, teachers noted that because their confidence in teaching the Next Generation Science Standards and the Science and Engineering Practices increased, their students gained a greater understanding of the content.

Research shows a positive impact of professional learning communities on science teaching efficacy. Mintzes, Marcum, Messerschmidt-Yates, and Mark (2013) define self-efficacy as the measure of an individual's confidence in his or her ability to successfully engage in a complex task. In a research study conducted in Northern California, 116 elementary teachers representing two different schools participated in a study to determine if professional learning communities that featured demonstration laboratories, lesson study, and annual summer institutes had an effect on science teachers' self-efficacy. Fifty-five teachers from one school represented the experimental group and 61 teachers from a neighboring school represented the comparison group. This mixed methods research study utilized the Teaching Science as Inquiry (TSI) instrument for measuring self-efficacy. Mintzes, Marcum, Messerschmidt-Yates, and Mark (2013) reported the most significant findings from the study was that the experimental group, who originally demonstrated a significantly low self-efficacy in science teaching, grew substantially over a three-year period as a result of their participation in professional learning communities. The growth was not only representative in the Teaching Science as Inquiry (TSI) scores, but in reported changes in classroom teaching practices and children's behavior. Furthermore, interviews with the participants suggested that professional learning communities provided teachers with an opportunity to collaborate with colleagues in small grade level groups, try out ideas on their own students, observe undergraduate interns interacting with children, and experience outcomes of their work on children's behavior.

In a research study conducted in eastern North Carolina, 107 middle school teachers participated in a three-year study for the purpose of analyzing the overall effectiveness of professional development programs. Lakshmanan, Heath, Perimutter, and Elder (2010) concluded that by using a combination of content knowledge courses and professional learning communities over a three- year period, the standards-based professional development program was able to positively impact both teacher efficacy and teacher implementation of reformed science teaching. Furthermore, Lakshmanan, Heath, Perimutter, and Elder (2010) emphasized that the most important benefit from participation in professional learning communities was increased self-efficacy, and they believe this was possible due to the confidence gained from the repeated implementation of new instructional methods immediately following instructional training.

Obstacles for implementing effective professional learning communities. Literature suggests that many educators understand the importance of professional learning communities for school effectiveness, but nevertheless fail to implement them successfully. Mintzes, Marcum, Messerschmidt-Yates, and Mark (2013) made several suggestions for supporting the goals of professional learning communities. First, school officials need to highly consider providing teachers with the time, space, and incentives they need to take on additional professional roles. The possibility of stipends, paid substitutes for work completed during the day, or comp time is examples of this. Second, principals should be visible in the professional learning communities. Playing an active role in the professional learning community not only shows a level of support from the principal, but makes them aware of the struggles and successes the group works through. Next, online repositories should be created so that once resources are created they can be collectively shared. Finally, more in-depth research on professional learning communities can be used to improve teaching effectiveness and student learning.

Why then with four simple ingredients for successful implementation of professional learning communities do many leaders fail? Balyer, Karatas, and Alci (2015) completed a study in Instanbul, Turkey where the main purpose was to find out what the principals' role was in establishing professional learning communities and how effectively they perform this role at their school. Findings indicated that the principals in the study understood the intent behind professional learning communities and the benefits to using them, but felt they couldn't implement them successfully due to their excessive daily administrative tasks which included paperwork, filling out reports, writing letters, making phone calls, and attending meetings with parents, students and teachers. Comparatively, principals in the study conducted by Wallace, Nesbit, and Miller (1999) were required to attend the professional learning communities, but only a minority of them provided the type of participation and support desired. Those not in attendance were supportive by providing verbal accolades and arranged time for the re-deliveries to occur, but claimed other demands on their time prevented them from attending many sessions.

Professional learning communities are a proven method for delivering effective professional development when implemented with fidelity. Professional learning communities increase teacher self-efficacy and overall school effectiveness. Time and commitment are barriers that prevent school leaders from successfully implementing professional learning communities.

Science Lead Teachers in Professional Learning Communities

One effective method for delivering science professional development in a large district is through the use of the lead teachers. Teacher leaders serve their schools in many ways such as mentoring their peers, influencing policy and change, improving instruction practices, acting as a catalyst for change, and developing teacher leadership capacity. Acting as a teacher leader also gives professionals purpose and meaning in ways different than that of the classroom teacher.

Thornton (2010) reports on a study conducted in 44 middle schools across 13 rural counties. The participants were both male and female principals and teachers. Data collected from the study were analyzed using two frameworks, one of which was the Lambert's Teacher Leadership Capacity Matrix. Lambert's matrix consists of four quadrants: Quadrant I represents schools with low teacher skillfulness and low teacher leader participation. Quadrant II, schools with low teacher skillfulness and high teacher leader participation. Quadrant II, schools with high teacher skillfulness but low teacher leader participation. Quadrant IV, schools with high teacher skillfulness and high teacher leader participation. From the results of the study 14% of schools fell into Quadrant I, 18% Quadrant II, 59% Quadrant III, and 9% Quadrant IV. Data indicated that 59% of schools from Quadrant III had predominately high levels of skilled teachers, but they were not participating in leadership roles. Thornton (2010) continued to report that further data analysis revealed more schools were not falling into Quadrant IV due to time, formal leadership structures, communication and fragmentation of faculty, and principal leadership style. It is a missed opportunity to not develop teacher leader capacity within a building and reap the benefits that can occur from schools with strong teacher leadership. Thornton (2010) noted that in order to capitalize on building teacher leadership one must support change by making time (staff meetings, PLCs and collaborative planning), communicate effectively, use PLCs for teacher leadership, have a shared vision and make that vision actionable, and public recognition to teachers with incentives.

In a study conducted by Fogleman, Fishman, and Krajcik (2006), lead teachers were utilized to reform science teaching. Six inquiry based middle school science units were implemented in Detroit Middle School classrooms and sat virtually untouched for five years. For the past three years, the Center for Learning and Technology in Urban Schools (LeTUS) has utilized lead teachers to lead professional development workshops pertaining to the units so as to deepen their own understanding of the units, increase the district's capacity to sustain the units, and assist in reforming middle school science instruction. The initial criterion for selecting lead teacher candidates included proven content knowledge, ability to communicate and collaborate with others, and respected by peers. In this particular study, selection of effective lead teachers had promising outcomes. The goals of implementing and sustaining reform in the middle school science classrooms were successful in this study because of the support from the district for ongoing professional development through the implementation of lead teacher work. The professional learning communities in this study illustrate the importance of opportunities for lead teachers to share their expertise about science content culminated with their classroom experiences forming a more powerful basis for professional development.

Delivering effective professional development in large school districts through the use of science lead teachers in professional learning communities is a way to not only deliver equitable and timely professional development to the schools, but also a way to develop the leadership capacity of science teachers within their own building.

Closing Thoughts

Many school districts across the Nation are increasing rigor in the science classroom through the implementation of new science standards. To fully support this transition and the paradigm shift for how we teach science, educators will need timely, effective and meaningful professional development. In a large school district, officials may consider the use of science lead teachers for delivering effective professional development through professional learning communities. In this mutualistic relationship, not only do lead teachers bring district-wide professional development to their grade level teams, they additionally serve as a liaison between the school and district so that all stakeholders have a voice in the decision-making process. Furthermore, developing the leadership capacity of science lead teachers will impact school effectiveness thus having a positive effect on student achievement.

CHAPTER 3: SOLUTION AND METHOD

Outline of the Proposed Solution

There is a need to increase rigor in the elementary and middle school science classroom. The State of Tennessee is transitioning to new science standards and previous methods for delivering professional development from the district will not support teachers in pedagogy, content knowledge, or sustainability during this transition. In order to support teachers throughout the implementation of three-dimensional learning and the new science standards, thoughtful and intentional professional development will need to be implemented over the next three years. Due to the size of this school district, capacity is an issue when delivering effective professional development. Therefore, it is the vision of the Crockett City School System to implement a new method for delivering professional development to all stakeholders with the use of science lead teachers.

Each of the seven middle schools will select one lead teacher from each 6^{th}, 7^{th}, and 8^{th} grade science team to represent their school for a total of 21 middle school science lead teachers in CCSS. Additionally, each of the seven middle schools will select one lead teacher from each 6^{th}, 7^{th}, and 8^{th} grade math team to represent their school for a total of 21 middle school math lead teachers in CCSS. Each of the 23 elementary schools will select one lead teacher to represent grades K-2 and one lead teacher for grades 3-5 for a total of 48 elementary lead teachers in CCSS. Elementary lead teachers are not only responsible for science, but math integration as well, and therefore are referred to as elementary STEM lead teachers. For the purpose of this study, the researcher focused only on middle school science lead teachers and elementary STEM lead teachers.

The lead teachers will participate in a monthly professional learning community led by the content specialist for the school district, and then re-deliver that information to their grade level. This structure is designed in an effort that teachers will receive more timely and effective communication and professional development centered on topics of their interest. Professional development through lead teachers will develop teacher leadership capacity amongst teachers in their buildings and since teacher leaders serve as a liaison between district and schools, teachers across the district will have more voice in the decision making process.

Justification of the Proposed Solution

The mission of the Crockett City School System is to *"Educate and Empower our Students to Reach their Potential.*" The vision is *"All Students will Graduate College and Career Ready."* To support the mission and vision of CCSS four strategic goals have been identified. They are:

1. To improve student achievement.
2. Maximize employee capacity
3. Improve efficiency and effectiveness
4. Engage the public in support of student achievement.

Implementing the lead teacher model will effectively support each of the four strategic goals set in place by the board of education.

To meet the first strategic goal for improving student achievement, one area for focus is to enhance standards-based curriculum, instruction, and assessment resources. The use of lead teachers during PLCs to deconstruct standards, align curriculum and curate resources directly impacts this focus.

To meet the second strategic goal of maximizing employee capacity, one area of focus states that our district will increase individualized professional learning opportunities. By serving as a STEM or science lead teacher, as a district we are building the leadership capacity and enabling lead teachers to grow in their profession. They are deepening their learning, participating at the district level, and returning to present professional development to their staff. As a member of their school staff, lead teachers also bring ideas and innovation from their building to the district and are empowered to make suggestions for growth and change.

To meet the third strategic goal of improving efficiency and effectiveness, one of the focus areas is to improve organizational efficiency through technology. During lead teacher PLCs, a technology integration coach will pair with the curriculum consulting teacher to model ways to organize instruction through a blended approach.

The fourth strategic goal is to engage the public in support of community engagement. During the transition to new science standards, the lead teachers will need exposure to community members such as professors from the local college as well as industry leaders to help give teachers a content dive. Developing these relationships for the purpose of strengthening content knowledge and also as a community connection for field trips and STEM challenges will meet the focus areas for this goal.

The four strategic goals adopted by the school system are the responsibility of all stakeholders in the Crockett City School System community. The lead teacher model will support and provide success for achieving all four goals.

Study Context

Crockett City, Tennessee is a rural town positioned in middle Tennessee. The Crockett City School System (CCSS) is the second largest employer in Crockett City and is in the top ten largest school districts in the state of Tennessee with nearly 5,100 employees that serve over 36,000 students. There are 42 total schools that make up this diverse population of learners. Student demographics show 53.4% of students are white, 29.3% black or African American, 12.5% Hispanic, 2.7% Asian, 1.1% Native Hawaiian/Pacific Islander, and 1% American Indian/Alaskan Native. Historically, 50% of students qualify for Free or Reduced Lunch, and 30% of students are military connected. The average per pupil spending in CCSS is $9,597, as compared to the State average of $10,340, and the National average of $12,290. All high schools perform in the top 25% of high schools across the nation and the graduation rate in CCSS averages 94%. Crockett City is an excellent place to work and raise a family, and is one of the top five fastest growing cities in the nation. Large industries have recently made their home in Crockett City, and are active community members in the CCSS Education Foundation as Partners in Education (PIE). To ensure anonymity, Crockett City School System (CCSS) is a pseudonym assigned to the school district that participated in this research study.

Research Questions

The purpose of this study is to analyze the use of elementary and middle school science lead teachers for the purpose of delivering effective professional development during the transition to new standards. Even though the Crockett City School System Lead Teacher Model, grades K-8 provides for lead teachers of math and science, the study will focus only in the area of science. Three research questions will guide this mixed methods study.

Question 1: What was the relationship between effectiveness of the lead teacher re-delivery sessions and student achievement of the group?

Question 2: What was the relationship between the district's lead teacher model and teacher self-efficacy?

Question 3: How did the district's current lead teacher model impact self-reported science teaching practices?

Research design. This research study is a fixed mixed methods design. It incorporates the use of quantitative and qualitative methods which were predetermined at the start of the research process, and the instruments were implemented as planned. Of the three core mixed methods designs as established by Creswell and Plano Clark (2018), this study is an example of a convergent design. The convergent design, previously referred to as the concurrent or parallel design, is intended to bring together the qualitative and quantitative data analysis so they can be compared or combined. The intent for this is to validate one set of finding with the other and supports the idea of triangulation. Triangulation of quantitative and qualitative data ensures the breadth and depth of the study to enhance its validity.

Sampling design. Participants in this study were part of purposeful sampling as the researcher intentionally selected science teachers who have experienced the key concept being explored in this study. It was necessary to capture the perspective of many stakeholders.

Approximately 300 elementary school science teachers representing 23 elementary schools (K-5) had the opportunity to experience the Crockett City School System's lead teacher model either as a STEM lead teacher or science teacher. The elementary teachers deliver science instruction to approximately 17,700 elementary students.

Approximately 80 middle school science teachers representing seven middle schools (6-8) had the opportunity to experience the Crockett City School System's lead teacher model as either a science lead teacher or science teacher. The middle school science teachers deliver science instruction to approximately 8,699 middle school students.

Data Collection Methods

This mixed methods research design will utilize a variety of instruments for collecting qualitative and quantitative data. Historical data obtained from the Crockett City School System includes the lead teacher re-delivery observation rubric, common district assessment data, science curriculum survey, lead teacher re-delivery report, lead teacher full day reflection, and the C^3 end of year science survey. The Self-efficacy

Teaching and Knowledge Instrument for Science Teachers (SETAKIST-R) was emailed as a pre- and post-self-efficacy survey to all elementary and middle school science teachers. Consent forms preceded the survey. All instruments were included in the researcher's Institutional Review Board (IRB) which was approved by Texas A&M University concurrent with the researcher's school system in September, 2018.

Re-delivery observation rubric. This tool is used by the Crockett City School System Instruction and Curriculum Department to evaluate the quality of a re-delivery session. This observation rubric is built on five attributes that evaluate the re-delivery session's learning communities, leadership, learning designs, implementation, and outcomes. During a re-delivery session, a lead teacher will share strategies learned from district level PLCs with those they are responsible for representing as a lead teacher. The researcher, assuming the role of the curriculum consulting teacher, observes the re-delivery session and then appropriately makes comments for each attribute and assigns an overall effectiveness score for each attribute that factors in to a total score.

Common district assessment data. Elementary science teachers in 3^{rd}, 4^{th}, and 5^{th} grades administered two common science assessments over the course of the school year testing students on the new science standards. Middle school science teachers in 6^{th}, 7^{th}, and 8^{th} grades administered three common science assessments over the course of the school year testing students on the new science standards. These assessments were constructed at the district level, were intended to mirror the state assessment of the new science standards, and science teachers administered them in their classrooms at designated times throughout the school year.

Science curriculum survey. The science curriculum survey is sent out by the Instruction and Curriculum Department mid-way through the year. The district uses the data from this survey to plan for summer professional development, as well as resources and support that should be considered for the following school year. The survey utilizes a Leichardt scale as well as one open-ended question to address the three areas of science curriculum, science assessment, and future science professional development opportunities.

Lead teacher re-delivery report. The lead teacher re-delivery report is a Google survey document teachers are required to fill out after each re-delivery session they facilitate at their school. Throughout the school year, elementary and middle school lead teachers attend five after school professional development sessions. Lead teachers are supposed to re-deliver to their school within approximately one week of the PLC. Teachers self-report when and where the re-delivery occurs, who is present, what topics are presented, how the topics are re-delivered, and lastly there was an opportunity for them to pose any questions they may have for the district level staff. This is completed in compliance with the C^3 grant and usually takes the lead teachers less than three minutes to complete.

Lead teacher full day reflection. Lead teachers had two full day professional development sessions in the fall of 2018 where substitutes were provided for them to come out of the classroom for a full day of professional learning. At the conclusion of both full days, teachers were given an opportunity to respond to a Google survey that provided feedback and reflection from the day. This survey had five questions with a

Leichardt scale from one to five and two open-ended the questions. The questions asked what the teacher's favorite takeaway from the day was, and for future professional development sessions, what areas would they like to see support. This information was useful for planning future PLCs as well as providing historical context for the research.

C^3 end of year science survey. To maintain compliance with the grant that supports the CCSS lead teacher program, the assessment and accountability office administers at the end of the school year a C^3 Survey. This survey asks four questions that require a quantitative response and a fifth question that is open-ended. This survey is sent to all science educators in CCSS and is sorted by elementary, middle, and high school. Furthermore, even though there is anonymity, participants on this survey indicate whether they were a lead teacher or not.

Table 2

Crockett City School System C^3 End of Year Survey

Questions
1. At which school do you teach? 2. Which grades do you teach? 3. Are you a lead teacher for your school? 4. Overall my understanding of the science teaching practices is (Likert Scale 1-4). 5. The total number of sessions I attended this spring in which the lead teacher of my content area shared information about science teaching practices or related instructional strategies was? 6. The total number of times during the spring of 2019 in which I utilized science teaching practices or related instructional strategies shared by my lead teacher was? 7. I believe the utilization of science teaching practices improves the educational opportunities for all students (Likert Scale 1-4). 8. Please include any additional comments you wish concerning science teaching practices or related instructional strategies.

Self-efficacy Teaching and Knowledge Instrument for Science Teachers. This quantitative instrument was developed by J. Kyle Roberts from Baylor College of

Medicine, and Robin K. Hensen from the University of North Texas, and has been nicknamed the SETAKIST-R. The pre- and post-self-efficacy survey consists of 16 questions and hypothesizes that science teacher self-efficacy exists in two constructs: teaching efficacy and knowledge efficacy. In addition to the 16 questions on the post-self-efficacy survey, the researcher added two open-ended qualitative questions.

Table 3

Self-efficacy Teaching and Knowledge Instrument for Science Teachers (SETAKIST-R)

Pre- and Post-Self-Efficacy Questions
1. When teaching science I usually welcome student questions. 2. I do not feel I have the necessary skills to teach science. 3. I am typically able to answer students' science questions. 4. Given a choice, I would not invite the principal to evaluate my science teaching. 5. I feel comfortable improvising during science lab experiments. 6. Even when I try very hard, I do not teach science as well as I teach most other subjects. 7. After I have taught science once, I feel confident teaching it again. 8. I find science a difficult topic to teach. 9. I know the steps necessary to teach science concepts effectively. 10. I find it difficult to explain to students why science experiments work. 11. I am continually finding better ways to teach science. 12. I generally teach science ineffectively. 13. I understand science concepts well enough to teach science effectively. 14. I know how to make students interested in science. 15. I feel anxious when teaching science content that I have not taught before. 16. I wish I had a better understanding of the science concepts I teach.
Additional Questions on Post-Self-Efficacy Survey (added by the researcher)
Question 1: Describe how the lead teacher model affected your confidence in teaching the new science standards. Question 2: Describe how the lead teacher model impacted your instruction.

Data Analysis Strategy

The purpose of this study is to analyze the use of elementary and middle school science lead teachers for the purpose of delivering effective professional development during the transition to new standards. Three research questions are included in this study and each question includes a strand of data that will be collected, explored and analyzed.

Research question one asks, “What was the relationship between effectiveness of the lead teacher re-delivery sessions and student achievement of that group?” The qualitative stand will utilize two instruments; the overall effectiveness score from the observation rubrics from the re-delivery sessions, and the common district assessments from the 2018-2019 school year. Each observation rubric has five attributes that evaluate the re-delivery session. An overall effectiveness score for each attribute factors in to a total score. Each re-delivery observation rubric has a list of participants in the re-delivery session. Elementary science teachers in 3rd, 4th, and 5th grades administered two common science assessments over the course of the school year testing students on the new science standards. Middle school science teachers in 6th, 7th, and 8th grades administered three common science assessments over the course of the school year testing students on the new science standards. To explore the data, the researcher will compile an average of all science teacher participants in a re-delivery session and their student’s achievement scores on a common district assessment that followed that re-delivery session. An analysis utilizing a Pearson *r* will be used to run correlation between the observation rubric’s total effectiveness score from a re-delivery session, and the overall group average of student achievement on a common district assessment that followed the observation. Qualitative data from the re-delivery observations will be coded and analyzed to provide meaningful insight into the re-delivery sessions and triangulation to support the conclusions.

Research question two asks, “What was the relationship between the district’s lead teacher model and teacher self-efficacy?” This quantitative/qualitative strand utilizes the Self-efficacy Teaching and Knowledge Instrument for Science Teachers. This sixteen question pre- and post-self-efficacy survey will be administered in September, 2018 and again in April, 2019. Teachers participating in this survey received a consent form per school district and IRB regulations. The survey was anonymous, but participants utilized a personal code consisting of their birthday and zip code so that the researcher could match pre and post data. To explore the data the researcher will match the pre and post codes so that a paired sample t-test can be run to analyze the quantitative data. Additionally, this question will utilize an open-ended question that was added to the post-self-efficacy survey. The question asked, “Describe how the lead teacher model affected your confidence in teaching the new science standards.” These answers will be analyzed for thematic content and will provide triangulation to the results from the paired sample t-test.

Research question three asks, “How did the district’s current lead teacher model impact self-reported science teaching practices?” This qualitative strand will analyze responses from the end of the year C3 science survey, science curriculum survey, lead teacher re-delivery report, lead teacher full day reflection, and an open-ended question that was added to the post-self-efficacy survey. All questions on the above instruments allowed for teachers to report their understanding of the re-delivery sessions, their commitment to the lead teacher model, and provide additional comments for how the lead teacher model impacted their instruction. All teacher reported responses will be organized and coded for thematic results.

Timeline

This research study takes place over several months and data is collected during the 2018-2019 school year. Table 4 lists the timeline for this study in its entirety:

Table 4

Timeline for Study

Topic	Approximate Date of Completion
Begin the Design of the Study	October-December 2017
Begin Review of the Research for Chapter 2	October-December 2017
Submit Request for Research in School District	April 2018
Prepare Documents for Research and IRB Application (observation rubric, letter to teachers, self-efficacy survey)	April 2018
Submit the IRB Application	July 2018
Distribute Pre-Self-Efficacy Survey	September 2018
Re-Delivery Observations	October 2018-April 2019
Distribute Post Self-Efficacy Survey	April 2019
Collect Common Unit Assessment Data	May 2019
Collect Data from C3 Grant Program Evaluation	May 2019
Write Chapters 1-3	July-October 2019
Submit Chapters 1-3	October 2019
Submit Updated Chapters 1-3 Based on Chair Review	October 2019
Oral Defense of Proposal to Committee	November 2019
Begin Inferential Analysis of Data	November 2019
Submit Draft of Chapters 4 & 5 for Review by Chair	March 2020
Submit Final Copy of ROS to Committee	April 2020
Oral Defense to ROS Committee	Prior to May 1, 2020
Graduation from Program	August 2020

Ensuring Reliability and Validity

Efforts were made prior to the study to reduce potential threats to validity. School administrators were given a set of criteria/qualifications to consider when selecting lead teachers. These included selecting a teacher with a minimum of three years teaching experience, possess the ability to lead professional development in front of their peers, and demonstrates a strength in science content knowledge. Additionally, four types of action research validity as identified through Ivankova's (2015) research are represented in this study.

Outcome validity. Action-oriented outcomes occur from each month's lead teacher PLC and the collaboration helps drive instruction delivered at the following months PLC session. Furthermore, outcome validity occurs when lead teachers re-deliver to their grade level teams and then the teams also provide feedback as a voice back to the district. This encourages the goal of delivering a more effective professional development across the district.

Process validity. The research findings are the result of a series of reflective cycles such as the monthly PLCs. Re-delivery observations are ongoing throughout the year after each month's PLC. Lead teachers may feel validated when their ideas are shared and utilized across the district.

Democratic validity. Crockett City School System is one of the most progressive school districts in the State of Tennessee and science teachers from the district feel compelled to stay on top if not ahead of the process of understanding and implementing the new standards.

Catalytic validity. All stakeholders are undergoing the paradigm shift of science education and have a vested interest in succeeding while teaching the new standards. Therefore, the stakeholders have a sincere interest in the research, as they are a catalyst for action.

Reliability and Validity Concerns or Equivalents

The convergent mixed methods design may cause threats to validity. Unequal sample sizes on the qualitative and quantitative side as well as the use of different concepts or variables may make it difficult to merge findings. The inability to follow up on conclusions when the scores and themes diverge may pose a threat to validity. However, the researcher plans to mitigate this by adding additional interviews to the study if the need arises. Creswell (2014) suggests analyzing the study through the use of quantitative and qualitative validity as examined below.

Quantitative validity. The quality of the scores from the instruments used and the quality of the conclusions that can be drawn from the results are two critical factors that must be present for quantitative validity to occur. Quantitative instruments in this study such as the SETAKIST-R Self-Efficacy Survey has been tested in multiple research studies. The re-delivery observation rubric is a district tool that was adapted from the Tennessee Department of Education's Observation Rubric for Effective Professional Development. A potential threat to quantitative validity is the inadequate representation of data from the self-efficacy survey and the lead teacher re-delivery observations. While approximately 400 science teachers across the district will receive the opportunity to participate in the pre- and post-self-efficacy survey, there is no guarantee of who will actually commit to the study. Lead teachers re-deliver to their school approximately the same week each month and this may impact the quantity and variety of observations by the researcher.

Qualitative validity. Triangulation is a powerful technique for establishing credibility of qualitative data. However, there still exists some concerns within the qualitative validity of the study. First, the researcher's role has the potential for bias as the researcher is the individual that designs the instructional focus of monthly PLCs, manages the lead teacher model, and conducts the observations of the re-delivery session. It will be critical the participants understand the researcher's role in the school district is one of a support role and not an evaluator role. Additional steps will be put into effect to minimize threats to qualitative validity such as spending prolonged time in the field, using rich and thick descriptive language to convey the findings, and cross checking codes to look for consistent results in developing themes.

Closing Thoughts

The purpose of this study is to analyze the use of elementary and middle school science lead teachers for the purpose of delivering effective professional development during the transition to new standards. This mixed methods research study incorporates the use of quantitative and qualitative methods which were predetermined at the start of the research process, and the instruments were implemented as planned. The convergent design is intended to bring together the qualitative and quantitative data analysis from a variety of instruments so they can be compared or combined to answer the three predetermined research questions. The intent for this is to validate one set of finding with the other and supports the idea of triangulation.

CHAPTER 4: ANALYSIS AND RESULTS/FINDINGS

Presentation of Data

This research study was a fixed mixed methods design. It incorporated the use of quantitative and qualitative methods which were predetermined at the start of the research process, and the instruments were implemented as planned. Qualitative data was coded and re-coded for consistency and accuracy, themes were identified and additional numbers assigned for sub-categories. Qualitative data was prepared in Excel and verified prior to running analysis through the Statistical Package for Social Sciences (SPSS) software.

The purpose of this study was to analyze the use of elementary and middle school science lead teachers for the purpose of delivering effective professional development during the transition to new standards. Three research questions guided this mixed methods study and the results from the data are as follows:

Research Question #1

What was the relationship between effectiveness of the lead teacher re-delivery session and student achievement? Quantitative data was collected from the re-delivery observation rubric. Each re-delivery observed received an overall effectiveness score. A spreadsheet was created, and each teacher present in the re-delivery session was assigned a code and listed in column one. The overall effectiveness score was entered in column two. In the third column, the teachers' average student achievement scores from the science district assessment that followed the re-delivery was entered for each teacher. See Appendix A depicting how the data was organized and prepared for analysis.

A Pearson *r* correlation coefficient was calculated for the relationship between the observation rubric overall effectiveness scores and the student's science district assessments. A strong positive correlation was found ($r(30) = .734$, $p < .001$), indicating a significant linear relationship between the two variables. Higher overall effectiveness scores from the re-delivery observation rubric tends to result in higher student achievement.

Table 5

Descriptive Statistics

	Mean	Std. Deviation	N
Observation Score	21.69	8.449	32
District Assessment Post	65.234	11.4492	32

Table 6

Correlations

		Observation Score	District Assessment Post
Observation Score	Pearson Correlation	1	.734**
	Sig. (2-tailed)		.000
	N	32	32
District Assessment Post	Pearson Correlation	.734**	1
	Sig. (2-tailed)	.000	
	N	32	32

** Correlation is significant at the 0.01 level (2-tailed)

While the researcher did identify a strong positive correlation with significance, one variable of the correlation contained only three values, which could cause statistical limitations. These three values are representative of the only three school's re-delivery sessions that could be used for analysis.

The researcher recognized three factors that limited the number of re-delivery observations. First, beginning in August, the researcher asked lead teachers to invite her to the re-delivery sessions. It took a great deal of encouragement and reassurance to teachers that the researcher was not an evaluator. They were reminded that by watching re-delivery sessions and hearing questions from teachers and how they responded, allowed adequate feedback for the researcher to prepare for the following month's PD session. As the year went on, lead teachers began to be more open about inviting the researcher to attend.

Second, timing of the re-delivery sessions interfered with how many sessions the researcher could observe. For example, most elementary school lead teachers re-delivered at faculty meetings one week following their district PLCs. Most elementary faculty meetings are on Thursdays after school. Therefore, only one elementary school could be observed each month. The researcher noticed the middle schools were typically re-delivering during their planning time. Most often they did not find out until last minute they were re-delivering during their planning session, and did not give the researcher ample time to plan to attend.

Finally, several re-delivery observations occurred between the months of March and May. However, there were not any science district assessments that occurred after those re-delivery sessions to compare assessment scores of students to the overall effectiveness score from the observation rubric. The state science assessment is usually given at the end of the school year, however due to the transition to new standards, no scores were released in year one.

The overall effectiveness score from the re-delivery observation rubric was calculated from three re-delivery sessions at schools N, R, and S. Qualitative observations analyzed from each of these sessions further support the quantitative conclusions.

School N received the lowest overall effectiveness score of a 13 out of a possible 36 points. School N conducted their re-delivery session with 13 middle school science teachers, after school, during a faculty meeting. Of the middle school science teachers present, two of the 13 were lead teachers, and no administrators attended the session. The session lasted 45 minutes. This redelivery session lacked engagement, the lead teachers did not re-deliver the message with fidelity, and there appeared to be a culture not conducive of a growth mindset.

The session started off strong with the district PowerPoint on display and the teachers arriving in a timely manner. The two lead teachers began the presentation and adhered to the message at first. After approximately five minutes, the lead teachers got off script and were derailed by questions from their peers such as "What is the curriculum hub?" and "Where is this website?" These were questions coming from science teachers that should have been explained to them in a previous re-delivery session when school started three months prior. The lead teachers paused to answer their questions. Of the two lead teachers, one consistently answered teachers' questions correctly and the other incorrectly. When the presentation approached the section where the lead teachers should have modeled how to write clear targets in three-dimensions and then have teachers practice this strategy, they said, "and then she showed us how to……” and “you will want to….” The lead teachers referred to what the CCT had done in their district PLC, and did not actually model with lead teachers the examples themselves. At this point in the re-delivery session, science teachers are eating food, working on their computers, grading papers, and there is little engagement.

School R received an average overall effectiveness score of a 23 out of possible 36 points. School R conducted their re-delivery session with 11 middle school science teachers, after school, during a faculty meeting. Of the middle school science teachers present, three of the 11 were lead teachers, and the school’s STEM Administrator attended the session. In this session, there was a positive culture for learning and teachers were engaged, but the lead teachers created confusion by skipping a step when re-delivering the strategy.

The session started off with the district presentation on display and copies of the handouts that would be needed. Teachers naturally congregated to their grade level groups, and the lead teachers began by introducing the strategy. Science teachers in this session were identifying the Science and Engineering Practices (SEPs) and Observable Features in given scenarios. The process involved three steps. First, the teachers read the scenarios of a science lesson, and identified the SEPs present in the scenario. Then, in collaborative discussions, teachers would validate the SEPs they found in the lesson. Finally, teachers had to match the SEP with its observable feature. The lead teachers decided during their presentation to skip identifying the SEP and discussing with the group, and go straight from reading the scenario to matching the observable feature. However, this greatly confused the teachers and at one point the frustration escalated when someone said, “Can you at least give me some time to read some of these?” The packet of observable features was intimidating enough, and by skipping the discussion stage after reading the scenario greatly confused everyone. At this point in the re-delivery, the STEM Administrator interjected and said, “We did this same exercise with the CCT in our administrator’s meeting last month. When we did this exercise, we broke it down first by deciding as a group on one SEP presented in the scenario, and then used the packet of observable features to validate our choice. Let’s try that.” Round two of practice was much more manageable, and all teachers appeared to understand the process. Great discussion followed the exercise and the session concluded after 45 minutes.

School S received the highest overall effectiveness score of a 34 out of possible 36 points. School S conducted their re-delivery session with 8 elementary school science teachers, before school, during a faculty meeting. Of the elementary school science teachers present, the 3-5 STEM Lead Teacher presented, and no administrators attended. In this session high levels of engagement were present as well as a culture for learning, and the lead teacher presented every aspect of the message with fidelity.

This session had a similar re-delivery to school R, in that the teachers were practicing a strategy where they identified SEPs from given scenarios, participated in discussion about the SEP, and then matched the SEP to an observable feature. The lead teacher used the district presentation as a guideline to pace herself and present information. She monitored the room to give ample time for teachers to read, and she allowed for discussion amongst team members to analyze the scenario and pick an SEP.

When it came time to using the observable features, she modeled how to use the packet as a tool and navigate through it. She confirmed that by matching an observable feature to the SEP, teachers could validate they were using the SEP during instruction with fidelity. The lead teacher engaged others by asking questions, and not always telling them the information. In conclusion, the lead teacher asked teachers to think of other ways using the observable features would support instruction in the new science standards and teachers responded that, "We could use these tools when we are planning instruction and writing assessments that should be aligned to SEPs."

In each of the three schools' sessions, a culture conducive to learning and re-delivering the message with fidelity, all played a role in the success of the session. This qualitative analysis further supports the statistical analysis from the Pearson *r* correlation.

In conclusion, the quantitative data analysis shows higher overall effectiveness scores from the re-delivery observation rubric, tends to result in higher student achievement. While the researcher is aware the sample size was smaller than intended, there were enough participants to validate a strong positive correlation with significance, as well as substantial qualitative data from the observations to support this conclusion.

Research Question #2

What was the relationship between the district's lead teacher model and teacher self-efficacy? This quantitative/qualitative strand utilized the Self-efficacy Teaching and Knowledge Instrument for Science Teachers (SETAKIST). This sixteen question pre- and post-self-efficacy survey was administered in September, 2018 and again in April,

2019. Teachers participating in this survey received a consent form per school district and IRB regulations. The survey was anonymous, but participants utilized a personal code consisting of their birthday and zip code so that the researcher could match pre and post data. To disseminate the survey, the researcher sent it first to the elementary and middle school level curriculum and instruction directors. Then, the directors forwarded the email request to building principals and asked them to forward the survey request to all science teachers in their building.

To explore the data the researcher matched the pre and post codes. Next, the researcher categorized the questions due to them being organized for a two-factor solution. Questions 2, 4, 6, 8, 10, 12, 15, and 16 related to the teaching efficacy construct of the survey. Questions 1, 3, 5, 7, 9, 11, 13, and 14 related to the knowledge efficacy construct of the survey. Additionally, items that were negatively worded (Question #2: I do not feel I have the necessary skills to teach science), needed to be reversed-scored in order to accurately assess the data.

A paired sample t test was calculated to compare the pre-self-efficacy survey to the post-self-efficacy survey results from 11 teachers. With the paired sample t test, there was one dependent variable (science teaching efficacy or knowledge efficacy) measured at the continuous level over time. The mean scores from the pre and post-self-efficacy test were compared to see if the intervention, the lead teacher model, had statistical significance.

The science self-efficacy survey elicited a statistically significant increase in the pre and post- test only for question #14, $M = -0.364$, 95%CI(-0.703,-0.25),$t(10) = -2.39$,p

< .05. Question #14 stated, “I know how to make students interested in science.” Due to the statistically significant difference between means ($p < .05$), we can reject the null hypothesis and accept the alternative hypothesis for question #14 only.

No significant difference from pre to post-test were found for any other questions in the survey. See table 8 and 9 for results.

Table 7

Paired Samples Test for the Knowledge Efficacy Construct of the SETAKIST

		t	df	Sig. (2-tailed)
Pair 1	Pre1 – Post1	1.789	10	.104
Pair 2	Pre3 – Post3	-.430	10	.676
Pair 3	Pre5 – Post5	1.305	10	.221
Pair 4	Pre7 – Post7	1.000	10	.341
Pair 5	Pre9 – Post9	-1.491	10	.167
Pair 6	Pre11 – Post11	1.399	10	.192
Pair 7	Pre13 – Post13	-1.936	10	.882
Pair 8	**Pre14 – Post14**	**-2.390**	**10**	**.038**

Table 8

Paired Samples Test for the Teaching Efficacy Construct of the SETAKIST

		t	df	Sig. (2-tailed)
Pair 1	Pre2 – Post2	-1.150	10	.277
Pair 2	Pre4 – Post4	-1.472	10	.172
Pair 3	Pre6 – Post6	.000	10	1.000
Pair 4	Pre8 – Post8	1.491	10	.167
Pair 5	Pre10 – Post10	.803	10	.441
Pair 6	Pre12 – Post12	-1.305	10	.221
Pair 7	Pre15 – Post15	-1.174	10	.267
Pair 8	Pre16 – Post16	-.690	10	.506

For research question number two, there were statistical limitations due to too few data points. Of approximate 300 elementary and 80 middle school science teachers across the district, only 62 teachers completed the pre-survey in the fall and 29 teachers completed the post-survey in the spring. Of that sample, only 11 teachers completed the pre and post-self-efficacy survey.

While there is not enough quantitative data to completely answer research question two, there was one qualitative question asked on the post-self-efficacy survey that stated, “Describe how the lead teacher model affected your confidence in teaching the new science standards.” Of the 25 responses, two qualitative ideas emerged. First, teachers claim that their confidence in science teaching increased because the lead teacher model provided someone they could go to for support within their building. The teachers felt that their lead was knowledgeable, gave them the support that they needed, helped focus their instruction, and made them want to do better. One teacher stated, “I knew that there was someone in the building that I could go to for help.” Another teacher claimed, “I felt I had support, and that gave me confidence.”

The second idea was that the lead teacher model increased one’s confidence in teaching the new science standards because a lot of time was spent deconstructing standards with colleagues, which created rich discourse and left teachers feeling like they understood to a greater depth how to teach the standards. One response was, “Deconstructing and being able to work with the standards by breaking them down and talking them through with colleagues, gave me a much deeper understanding of what I should be teaching.” These reports lend themselves to an increase in science teaching and science knowledge efficacy, which is what we had hoped the survey data would support. However, due to the statistical limitations of too few data points on the self-efficacy survey, the researcher is unable to draw a comprehensive conclusion at this time for what the relationship was between the district's lead teacher model and teacher self-efficacy.

Research Question #3

How did the district's current lead teacher model impact self-reported science teaching practices? Historical data from the lead teacher re-delivery report, self-efficacy survey, and the lead teacher full day reflection each provided unique themes that supported one another for how the district's current lead teacher model impacted science teaching practices.

The lead teacher re-delivery report was a Google survey document teachers were required to fill out after each re-delivery session they facilitated at their school. Throughout the school year, elementary and middle school lead teachers attended five after school professional development sessions. Lead teachers were supposed to re-deliver to their school within approximately one week of the PLC. Teachers self-reported when and where the re-delivery occurred, who was present, what topics were presented and how they were re-delivered, and lastly there was an opportunity for them to pose any questions they may have for the district level staff. This was done in compliance with the C^3 grant and usually took the lead teachers less than three minutes to complete.

Historical data was analyzed for the purpose of answering research question three. The researcher analyzed 227 lead teacher reports from throughout the year, and was able to categorize them into five themes since she had the perspective of knowing what information they received first hand at their PLC. The themes indicated how the lead teacher model may have impacted science teaching practices as a result of the re-delivery. Lead teachers simply delivered the message, customized their re-delivery, aligned topics, provided opportunity for discussion, and the occurrence of re-delivery sessions all emerged as themes that may have impacted science teaching practices as a result of the lead teacher model.

Delivering the message. The lead teacher re-delivery report revealed teachers conducted re-delivery sessions that were verbatim indicated they presented whole group, read straight from the PowerPoint that was used in the lead teacher sessions, and in many cases phrases such as "I relayed information" and I "showed her lessons and resources" were used in their reporting.

The post-self-efficacy survey had an open-ended question that stated, "Describe how the lead teacher model impacted your instruction." Responses from 25 individuals were collected and analyzed. The first theme that occurred was 12% felt the lead teacher model had no impact on their instruction. While that percentage is overall low, the respondents were emphatic in their statements claiming, "The lead teacher regurgitated what was said, the lead teacher presented information but could not help with content, and the presentation was a sage on the stage." This information is additionally supported from the observation rubric conducted by the researcher at one of the lead teacher middle school science re-delivery sessions. The researcher noted that during the session, the lead teacher stated, "Then, she showed us how to highlight the clear target with the three-dimensions." Instead the lead teachers were supposed to model this, and ask the teachers to practice highlighting the clear target with three different colors to identify the three dimensions of science teaching. Therefore, the lead teachers completely missed the opportunity to model the strategy and engage the adult learners, making this a session where the message was simply passed on.

Customizing the re-delivery. Many comments in the lead teacher re-delivery report indicated teachers took the information they received from the lead teacher session, and thoughtfully crafted a message to delivery to their staff based on the needs of their school and possibly the strategies their administration wanted to highlight. These reports included phrases such as, "I modeled for the teachers," "I took the strategy and immediately applied it instruction so I would feel more comfortable presenting about it," and "I invited my technology coach to partner with me during the re-delivery since modeling digital instruction was a part of the session." Finally, one report indicated that a lead teacher that was presenting on the topic of traditional and digital interactive notebooks, took the initiative to collect traditional exemplars from around the building to show as examples during the presentation.

Alignment of the topics. It was evident in every comment of the lead teacher re-delivery report that the topics teachers re-delivered were aligned with what the school district had facilitated at the lead teacher PLC. Furthermore, the topics and strategies the school district was covering during the PLCs were directly aligned to upcoming standards. It was intentional that teachers during lead teacher PLCs and re-delivery sessions would have purposeful resources for upcoming standards and units. Topics over the course of the year included a focus on 2D and 3D science instruction, observable features, clear targets, pacing guides, blended units, task based performance assessments, wireless projection, interactive notebooks, and digital tools to enhance instruction.

The post self-efficacy survey had an open ended question stating, “How did the lead teacher model impact your instruction?” Teachers indicated that they were able to walk away from the lead teacher re-delivery sessions with relevant resources that could be immediately implemented.

Opportunities for discussion. Of the 227 entries in the lead teacher re-delivery report, 22 teachers specifically mentioned they provided an opportunity for discussion which significantly increased teachers understanding of the strategy. Comments such as, “through discussion we eliminated confusion for how to format our clear targets” showed that lead teacher re-delivery sessions provided an opportunity for rich discourse. Another example is a comment in the lead teacher re-delivery report that indicated after teachers evaluated a few assessment items as required in the re-delivery PowerPoint, they retrieved some of their own assessment items to evaluate them together based off of the same strategy they had just learned.

The post self-efficacy survey had an open ended question stating, “How did the lead teacher model impact your instruction?” The open-ended question on the self-efficacy survey further supports this theme because teachers reported in their responses that the lead teacher model allowed them to deconstruct standards with their lead teachers and have conversation for how to teach those standards. These are opportunities that might not have been afforded had it not been for the lead teacher model.

The occurrence of re-delivery sessions. The researcher analyzed from the lead teacher re-delivery report the time and date the elementary and middle school lead teachers indicated they re-delivered their sessions. The analysis showed 54% of the middle school lead teacher re-delivery sessions occurred during their grade level planning time, and 29% during their faculty meetings. In contrast, 74% of the elementary school lead teacher re-delivery sessions occurred during their faculty meetings and 16% during planning. According to the report, two teachers indicated that they were not given time by administration to conduct their re-delivery sessions and they had to in one case email the notes, and in the other case create a voice recorded email of the past two sessions for re-delivery.

Full Day Professional Development Sessions

Elementary and middle school lead teachers were asked to complete a reflection from their full day PLC sessions. Data from 90 entries was analyzed from the two full day lead teacher PLC sessions that were held during the first semester of the school year. One of the open-ended questions from the reflection asked teachers, “What was your favorite takeaway from the lead teacher full day sessions?” Elementary and middle school lead teachers reported that the lead teacher full day session provided an opportunity for them to talk to content experts which increased their pedagogy, they learned new strategies for implementing digital and traditional resources, and they were grateful for having an opportunity to network with other teachers in schools across the district about upcoming standards prior to teaching those units. There were several instances throughout the reflection where lead teachers shared as side notes their gratitude and thanks for the opportunity. One teacher commented, “I always love and appreciate these days so much, and I always walk away with so much.”

Support for Teachers in the Standards Transition

The Tennessee Academic Standards for Science were adopted in 2016 and the 2018-2019 school year has been designated as the first year of implementation. The Tennessee Department of Education (TDOE) has strategically designed a three year implementation process for the new science standards with explicit goals for each year, and our district is adopting the same process. The three goals for year one of implementation are:

1. Teachers know and teach every science standard.
2. Students are appropriately engaged in all of the science and engineering practices throughout the school year.
3. Teachers would start to see how the crosscutting concepts (CCCs) are manifested in what they teach.

In preparation for year one, the school district created comparison documents and crosswalks that showed where topics in the old standards would now be taught in the new standards. The district also formed a curriculum team that met three times in the spring prior to the first year of implementation to dive into the grade level science standards. The researcher conducted an exercise where the nomenclature for each standard was removed. Teachers worked together to group them into big ideas or topics. Then, they added the nomenclature back to each standard and quickly realized that some standards were paired across disciplines. For example, in 8th grade a life science standard for fossils was taught in a unit that included an Earth science standard about the rock cycle and specifically sedimentary rocks. This was exciting for teachers to realize they no longer had to teach standards by discipline. The days of nine weeks at the beginning of the school year for life science, nine weeks during the winter for Earth science, and nine weeks after winter break for physical science were now a thing of the past. Pairing together standards that could be taught across discipline or through the other two dimensions preserves the paradigm shift from the old science to the new. From this exercise, units were developed with a suggested pacing guide that included the ordering of standards and a timeline of dates for instruction.

The goals for year one emphasized the biggest need which was to dive in and start teaching the new science standards. The Tennessee Department of Education (TDOE) provided in year one a support document called a reference guide. The reference guide had each standard listed for K-12 science, with an explanation of that standard, and a suggested SEP and CCC. The explanation for each standard was typically 6-8 sentences and might include more detail about what the standards was asking for, some examples of how to teach this standard, and what might be considered beyond the scope of the standard. This compilation was written by the TDOE Science Coordinator and released the summer prior to year one implementation. The state did not release any blueprints or sample assessment items for the state assessment. Therefore, in a district that emphasizes backwards planning, there was no example of an assessment to start with. The state released a series of model lessons that highlighted how to teach a standard and connected it with a science and engineering practice.

Grades K-8 and Biology each received eight model lessons highlighting one of the eight SEPs in each lesson. Professional development was offered the summer prior to year one implementation for teachers to see these modeled lessons. Our district offered these resources in a traditional and digital delivery for all science teachers to have access.

Other than a comparison matrix, scope and sequence, and a subscription to an online textbook platform called Discovery Education, the district did not provide any additional resources. This in part was intentional. The researcher expected to utilize the lead teacher model to disseminate across the district the process for deconstructing the new standards. Through the productive struggle in year one it was the researcher's hope that teachers would take more ownership in their new science curriculum.

Historical data was collected from 48 participants of the district's mid-year science curriculum survey, 17 participants from the C^3 end of year science survey, and 85 participants from the lead teacher full day reflection question that stated, "For future planning, what would you like to see included in the next professional development sessions?" Qualitative analysis suggests three areas for additional support during the implementation of new science standards. Recommendations for science curriculum, science assessments, and suggestions for future professional development emerged as themes from this data.

Science curriculum. Teachers that reflected on the science curriculum from year one implementation made suggestions for the pacing guides, deconstruction of standards, and resources.

The first suggestion is that the timing and order of the pacing guides needed to be renegotiated. For example, 7th grade teachers allocated too much time to teach the chemistry unit because in the past teaching chemistry included not just determining if chemical equations were balanced, but balancing equations to substantiate the Law of Conservation of Mass. In the new standards students only had to determine if chemical equations were balanced, and teachers did not fully realize until they were deconstructing standards and teaching them for the first time that balancing equations was now beyond the scope of their standard and taught in high school chemistry. Additionally, 7th grade did not allow enough time for cells and cell processes due to the addition of mitosis and meiosis, and asexual vs. sexual reproduction. Taking time from chemistry and adding it to cells was a suggested solution.

Additionally, standards may need to be reordered. For example, in 6th grade the Carbon Oxygen Cycle was taught first at the beginning of the year because it heavily relied on students analyzing and interpreting data from graphs, and teachers felt like that skill would best be introduced at the beginning of the year. When in fact, the teachers realized the 6th grade students new to middle school are not mature enough for that content, and it is better taught with human impact in the spring semester. Balancing out the time allocated for standards and units, as well as the placement and order of standards needs to be revisited prior to the following school year.

Historical data revealed that science curriculum could better be improved with additional practice deconstructing new science standards using the explanations, suggested SEPs, and CCCs recommended by the state. Teachers believe more practice and conversation about what the standards are asking, coupled with their experiences from teaching the new standards for the first time, will provide clarity for what to teach for each standard. Teachers recognize the standards in their current form are too vague, and are not confident enough with how deep to teach a standard. Clear expectations for what to teach for each standard would positively support curriculum and instruction.

Finally, teachers suggest to improve science curriculum, honest conversation about curating resources needs to occur at the district and school level. Resources as identified in the data include lists of and access to materials, supplies, and equipment necessary to execute lessons in the new science standards. Resources also identified in the data include the need for modeled or exemplar lessons, and a central location to house and/or access resources.

Science assessments. The Tennessee Department of Education announced that in year one all students in grades 3-8 and Biology would take a TN Ready test at the end of the year, but would not receive scores or data. This process is typical in year one of a standards transition as it gives time for the state officials and the test writing company to validate the items on the assessment. However, the underlying stress of an end of the year state assessment, regardless of whether teachers will see scores or not, is still present. In year two of implementation students would test again and see scores, but because it is a baseline year they would not count for growth and/or achievement. In year three of implementation TN Ready Science would be fully operational and scores would count for growth and achievement.

Since the state of Tennessee did not release blueprints or sample assessment items for the state science assessment, the district leaders used their best judgment as to how to navigate science assessments in year one. The school district chose to administer three science benchmarks in middle school, and two science benchmarks in elementary grades 3-5 spread evenly over the course of the year covering a sampling of standards. Because the district leaders were creating assessment items and science benchmarks simultaneously with the deconstructing of the units, the science benchmarks were cold exams and the teachers did not have an opportunity to review them. The goal of these summative assessments was to attempt to keep teachers on pacing, model two and three dimensional science assessment items, and provide a sampling of data from across the district. In between the district benchmarks, teachers were responsible for creating their own unit assessments.

Responses from teachers making suggestions in regards to science assessments were coded into three categories: expectations for assessment items, the need for exemplar items, and consideration for the timing of assessments.

Teachers shared their frustrations when it came to writing assessment items because they did not have clear expectations for what the standards were asking for. They felt standards were too vague and they second guessed to what depth to cover each standard. Therefore, teachers did not feel like they were consistent with others on their grade level team or across the district for writing assessment items as they were completely subjected to interpretation of the standard. Responses also indicate teachers are not sure how to write a two or three-dimensional assessment item and are reverting back to the one-dimensional fact recall or vocabulary type questions. Suggestions from teachers connect back to similar suggestions within the first theme for science curriculum which is the need for a more precise deconstruction of each standard with explicit expectations for what and how to teach.

Additionally, data reveals the need for exemplar assessment items aligned to the new science standards. Teachers do not have a bank of items to pull images, models, or data from, nor do they have access to an exemplar of an item related to each new standard. Teachers suggest being able to see items on the benchmark ahead of time with the possibility of participating in a review process of the assessment.

Finally, teachers suggest that the timing of district assessments affects instruction. Considerable attention should be given to insure benchmarks can be completed in one class period, and they are ready a few weeks prior to the testing window so that teachers may review them. Many suggested that middle school science should move away from benchmark testing to common unit assessments. Too much instructional time is lost to administering unit tests and district science benchmarks. By moving to common unit assessments, teachers would have exemplar items, and the district would have data throughout the year on all standards instead of a sampling of them.

Future professional development. Teachers suggest several areas of professional development that will support them in the transition to new science standards. Amongst them, the most prevalent was the need for the modeling of standards specific lessons. Topics mentioned included fossils, mitosis and meiosis, and astronomy. Teachers crave the ability to see the new standards in action, with layers of SEPs and CCCs folded into instruction. Another popular need for professional development in the new science standards is to see how technology could be blended with traditional instruction for each of the standards. Finally, teachers want more clarification for how to incorporate SEPs and CCCs into instruction and their clear targets. Teachers want to know how to use the observable features tool for SEPs to make sure they are implementing the practices with fidelity.

Conclusion

In conclusion, there was a significant correlation between the overall effectiveness score of a lead teacher re-delivery session and student achievement. As effectiveness scores increased, so did achievement. There was not enough statistical data to conclude that the lead teacher model had an effect on science teaching self-efficacy. However, analysis from a variety of qualitative tools suggested the lead teacher model did impact teacher's self confidence in science knowledge and science teaching. Historical data from the lead teacher re-delivery report, self-efficacy survey, and the lead teacher full day reflection each provided unique themes that supported one another for how the district's current lead teacher model impacted science teaching practices. Finally, historical data from the science curriculum survey, C^3 end of year science survey, and lead teacher reflection indicated suggestions for how to support teachers in the areas of science curriculum, assessment, and future professional development as they continue the implementation of the new science standards.

CHAPTER 5: DISCUSSION AND CONCLUSIONS

Summary of Findings

The purpose of this study was to analyze the use of elementary and middle school science lead teachers for the purpose of delivering effective professional development during the transition to new standards. Research findings indicated there was a significant correlation between the overall effectiveness score of a lead teacher re-delivery session and student achievement. As effectiveness scores increased, so did achievement. There was not enough statistical data to conclude that the lead teacher model had an effect on science teaching self-efficacy. However, analysis from a variety of qualitative tools suggested the lead teacher model did impact teacher's self confidence in science knowledge and science teaching. Historical data from the lead teacher re-delivery report, self-efficacy survey, and the lead teacher full day reflection each provided unique themes that supported one another for how the district's current lead teacher model impacted science teaching practices. Finally, historical data from the science curriculum survey, C^3 end of year survey, and lead teacher reflection indicated suggestions for how to support teachers in the areas of science curriculum, assessment, and future professional development as they continue the implementation of the new science standards for the following school year.

Discussion of Results in Relation to Literature

Findings for research question one indicated there was a significant correlation between the overall effectiveness score of a lead teacher re-delivery session and student achievement. Mullen's (2009) study revealed that professional learning communities may be viewed from three different perspectives: organizational, cultural, and leadership. In the lead teacher model, all three perspectives were present. From an organizational perspective, the goal was to build school capacity and each school had a lead teacher representing them either by grade band (elementary school) or grade level (middle school). Professional learning communities were viewed as a model for implementing change, which is accomplished by promoting staff collaboration and reflection while keeping at the forefront the goal of improving student achievement. From a cultural perspective, all stakeholders equally shared the goal of transforming schools into communities to enhance learning for students and teaching for educators. From a leadership perspective, professional learning communities provided an opportunity to build leadership capacity in teachers through networks for discussing issues regarding instructional practice, acclimating new teachers, fostering cross-curriculum integration, and bridging the school to the community.

Professional learning communities are a proven method for delivering effective professional development when implemented with fidelity. For this reason, the research design included a component for observing the lead teacher’s re-delivery sessions. The re-delivery observation rubric was used by the Crockett City School System Instruction and Curriculum Department to evaluate the quality of a re-delivery session. This observation rubric was built on five attributes that evaluated the re-delivery session’s learning communities, leadership, learning designs, implementation, and outcomes. During a re-delivery session, a lead teacher shared strategies learned from district level

PLCs with those they are responsible for representing as a lead teacher. An overall effectiveness score for each attribute was assigned and factored in to a total score.

Mullen's (2009) study supported the use of the re-delivery observation rubric as a tool for research because he concluded that the three key characteristics to an effective professional learning community include:

1. Focus on learning rather than teaching.
2. Dedicate oneself to a culture of collaboration.
3. Commit to school improvement and collaboration.

All three key characteristics from Mullen's (2009) study complimented the re-delivery observation rubric instrument, and supported the data analysis which concluded as the overall effectiveness score of a lead teacher re-delivery session increased so did student achievement.

Findings from research question two indicated there was not enough statistical data to conclude that the lead teacher model had an effect on science teaching self-efficacy. While there is not enough quantitative data to answer research question two, there was one qualitative question asked on the post-self-efficacy survey that stated, "Describe how the lead teacher model affected your confidence in teaching the new science standards." Of the 25 responses, two qualitative ideas emerged.

First, teachers claim that their confidence in science teaching increased because the lead teacher model provided someone they could go to for support within their building. The teachers felt that their lead was knowledgeable, gave them the support that they needed, helped focus their instruction, and made them want to do better.

Thornton's (2010) study triangulated this idea because he found that teacher leaders served their schools in many ways such as mentoring their peers, influencing policy and change, improving instruction practices, and developing teacher leadership capacity. Acting as a lead teacher gives professionals purpose and meaning in ways different than that of the classroom teacher.

The second idea was that the lead teacher model increased one's confidence in teaching the new science standards because a lot of time was spent deconstructing standards with colleagues, which created rich discourse and left teachers feeling like they understood to a greater depth how to teach the standards. This idea is supported from research conducted by Lakshmanan, Heath, Perimutter, and Elder (2010) who concluded that the most important benefit from participation in PLCs was increased self-efficacy, and they believe this was possible due to the confidence gained from the repeated implementation of new instructional methods immediately following instructional training.

Historical data from the lead teacher re-delivery report, self-efficacy survey, and the lead teacher full day reflection each provided unique themes that supported one another for how the district's current lead teacher model impacted science teaching practices. Lead teachers simply delivered the message, customized their re-delivery, aligned topics, provided opportunity for discussion, and the occurrence of re-delivery sessions all emerged as themes that may have impacted science teaching practices as a result of the lead teacher model.

Teachers self-reported the opportunity for discussion as a factor for impacting science teaching practices. This is further supported by the literature and is evidenced in the study conducted by Mintzes, Marcum, Messerschmidt-Yates, and Mark (2013). Interviews from participants in their study suggested that professional learning communities provided teachers with an opportunity to collaborate with colleagues in small grade level groups, try out ideas on their own students, observe graduate interns interacting with children, and experience outcomes of their work on children's behavior.

Personal Reflections and Lessons Learned

Designing the study, researching literature, submitting an IRB, conducting and analyzing research, and drawing conclusions has allowed for much reflection about the lead teacher model and how it impacted professional development during the implementation of new science standards.

Lead teacher observations. Only three re-delivery sessions and the teachers present in those sessions were used to analyze the data for research question one. While a strong positive correlation was found indicating higher scores from the re-delivery observation rubric tends to result in higher student achievement, a greater number of re-delivery observations would have solidified the findings. Three factors that limited the number of re-delivery observations included the barrier of the lead teacher accepting the researcher as a participant and not an evaluator, the timing of the re-delivery sessions interfered with how many sessions the researcher could observe each month, and finally the researcher did not align the timing of the observations to occur prior to a district assessment.

It is my recommendation for future studies, the researcher strategically schedule the re-delivery observations instead of waiting for an invitation. It is not likely the researcher will observe at least one re-delivery session led by each lead teacher. However, there are three district science assessments for both elementary and middle school and each of those align with a session that occurs prior to them. If the researcher intentionally schedules the observation for elementary and middle schools and coordinates with administration to pre-select the dates, then six observations could be utilized for the study instead of three. Another innovative suggestion is to observe re-delivery sessions digitally. Each of our elementary and middle schools have been provided a district funded SWIVEL. These are IPads positioned on bases that swivel and follow the teacher as they teach. The microphone is worn around the teacher's neck and the sensor causes the swivel to follow the teacher while they instruct. The school system also recently purchased the Teaching Channel which allows teachers to upload videos for feedback. Each lead teacher could be asked to video at least one of their re-delivery sessions over the course of the school year and post it on the Teaching Channel to receive feedback from district leadership.

Self-efficacy survey. For research question number two, there were statistical limitations due to too few data points. Of approximate 300 elementary and 80 middle school science teachers across the district, only 62 teachers completed the pre-survey in the fall and 29 teachers completed the post-survey in the spring. Of that sample, only 11 teachers completed the pre and post-self-efficacy survey. Additionally, the survey per district request had to go from the researcher, to the Directors of Instruction and

Curriculum, the school principals, and then the science teachers. If the researcher cannot directly email and send reminder emails to the population sample to participate in the pre- and post-self-efficacy survey, then I would suggest creating a control group of 30 teachers that sign IRB and district approved consent forms, and are not anonymous to the researcher. For the purpose of answering research question two for whether the lead teacher model influenced science teaching self-efficacy, knowing the participants allows the researcher to follow up if surveys are not completed and gives the researcher the option to add interviews to the study if necessary.

When reflecting on the instrument to assess science teacher self-efficacy, I would choose to utilize a different instrument. I chose the SETAKIST because it contained two constructs, one for science knowledge efficacy and one for science teaching efficacy. I felt the science knowledge component was an important aspect to pursue during the transition to new science standards. The SETAKIST does not provide as much validation following its publishing in 2000 as I had once thought. In an attempt to discuss the findings from my data and the concern for the low sample size, I exchanged correspondence with the co-author of the SETAKIST, Dr. Robin K. Hensen, PhD. Dr. Henson is a Chair and Professor at the University of North Texas and was abundantly helpful. He responded that while he has continued his research on self-efficacy, the SETAKIST has not been widely used since its publication. I requested from Dr. Henson his opinion about the type of test I was running with the data because I wasn't finding significance in its analysis. I wanted to validate the reason was because my sample size was low, and not because I chose to run the wrong statistical analysis. In correspondence, Dr. Henson confirmed that the type of test utilized to analyze the data is unique to the researcher's study, but a simple way would be to run a dependent samples t-test (Henson, 2020). This evidence supported reasoning that the researcher ran a solid analysis, but would not find significance due to the statistical limitation of sample size.

In the future, I would recommend utilizing Albert Bandura's Science Teaching Efficacy Belief Instrument (STEBI) as the instrument of choice. The STEPI coupled with a control group would serve well to answer the research question for what the relationship was between the lead teacher model and science teaching self-efficacy.

The necessary balance. Principals were given the autonomy to select their lead teachers, and it is typical to select a candidate that exhibits a strength in their designated content area. However, I noticed from the re-delivery data that many lead teachers self-reported they either carried the message or customized their re-delivery. Evidence throughout the study showed that while many teachers are strong in their content, they may not have had experience coaching or working with adult learners. This, in my opinion, played a role in the success of their re-delivery. This is confirmed through the literature when Fogleman, Fishman, and Krajcik (2006) encouraged that the initial criterion for selecting lead teacher candidates should include a combination of proven content knowledge, ability to communicate and collaborate with others, and are respected by peers. While the lead teacher model focused throughout the year on strategies to increase science content knowledge, it did not focus on strategies for how to deliver effective professional development to peers. In the future it would be important to kick off the year with strategies for all lead teachers for working with adult learners and even modeling what an exemplar re-delivery session would entail. As evidenced from the data supporting research question one, higher scores from the re-delivery observation rubric tends to result in higher student achievement. Therefore, it is crucial that we provide all necessary supports for teachers to re-deliver with fidelity.

An extension to the study. A component to this study that should be considered for exploration is, “How did the administrator as instructional leader impact the lead teacher model?” On several occasions over the course of the school year, K-2 lead teachers verbally expressed their concern to me about the lack of support from their administration for science teaching in early elementary. They shared that they did not feel their work as a lead teacher was “valued” in their school setting nor were they given time to teach science in their schedule. If given the opportunity to add this component to the existing study or to continue my study through this lens, I would do so.

In collaboration between principals and district officials prior to the kick off to a new school year, it needs to be emphasized that there is an opportunity to grow elementary lead teachers within a building. Considerable time at the principal meeting should be spent reinforcing the lead teacher model, and how the success of the model is dependent on the support of the building level administration. Evidence from the dates and times documented for lead teacher re-delivery sessions shows that most elementary lead teachers were given approximately 20 minutes at faculty meetings to re-deliver, and in two cases lead teachers were told to re-deliver over email.

Conversations either overheard or shared with me indicate that some administrators are more actively involved with their lead teachers than others. Taking an interest in what the lead teacher learned at their PLC, helping leads to customize their re-delivery session, or attending the re-delivery session shows the lead teacher that the administrator genuinely finds an interest and values the work the lead is doing. It is a missed opportunity to not develop teacher leader capacity within a building and reap the benefits that can occur from schools with strong teacher leadership. Thronton (2010) noted that in order to capitalize on building teacher leadership, one must support change by making time (staff meetings, PLCs and collaborative planning), communicate effectively, use PLCs for teacher leadership, have a shared vision and make that vision actionable, and provide public recognition to teachers with incentives. Furthermore, principals should be visible in the professional learning communities. Playing an active role in the professional learning community not only shows a level of support from the principal, but makes them aware of the struggles and successes the group works through (Mintzes, Marcum, Messerschmidt-Yates, and Mark, 2013

Balyer, Karatas, and Alci (2015) completed a study in Instanbul, Turkey where the main purpose was to find out what the principals' role was in establishing professional learning communities and how effectively they perform this role at their school. Findings indicated that the principals in the study understood the intent behind professional learning communities and the benefits to using them, but felt they couldn't implement them successfully due to their excessive daily administrative tasks which included paperwork, filling out reports, writing letters, making phone calls, and attending meetings with parents, students and teachers. I see a direct correlation in the literature to what I witnessed teachers sharing with me, and I would like to extend my research to find a solution for how to support K-2 science lead teachers.

Finally, building leaders must emphasize that science receives a designated time in the master schedule for K-2 teachers. English / Language Arts (ELA) began using Unit Starters in Tennessee, which teach their standards through themes and essential questions. The Unit Starters incorporate non-fiction texts that are aligned to the science and social studies standards. Teachers build schema of science content during ELA, however this does not give students the opportunity to "do" the science. Therefore, the designated 45 minutes of time that used to be given to teach science has slowly slipped away from the teachers as many began to believe the reading of science during the ELA time sufficed. Huff (2016) warned that while Common Core State Standards (CCSS) may have components of science in them, they should not replace meaningful science instruction that is included in three-dimensional learning. Trygstad, Smith, Banilower, and Nelson (2013), concluded in their study referencing the 2012 National Survey of Science and Mathematics Education (NSSME) that schools and districts are not prepared to transition to three-dimensional learning. The greatest concern was evidence that elementary science is noticeably inadequate with an average of 20 minutes of instruction per day.

I believe the administrator as instructional leader has a large impact on the success of the lead teacher model. Further research on this component may lead to additional suggestions for how to support early elementary science teachers and those instructional leaders within their building.

Recommendations

Recommendations for the continued implementation of the Tennessee Academic Standards for Science through the support of the lead teacher model include supporting science curriculum, assessments, and future professional development.

Historical data was collected from 48 participants of the district's mid-year science curriculum survey, 17 participants from the C^3 end of year science survey, and 85 participants from the lead teacher full day reflection question that stated, "For future planning, what would you like to see included in the next professional development sessions?" Qualitative analysis suggests three areas for additional support during the implementation of new science standards.

To support science curriculum, teachers need rigorous and aligned resources to utilize for science instruction. Duncan and Cavera (2015) urge us to be reluctant to utilize existing lessons. Much of the classroom instruction prior to the development of the *Framework* may have claimed to be inquiry-based, but does not engage students with the three-dimensions. Now that science teachers have deconstructed and taught each standard in year one of implementation, the lead teacher model in year two can support the work of curating resources and writing three-dimensional science lessons. Teachers are asking for a location to house these documents. Mintzes, Marcum, Messerschmidt-Yates, and Mark (2013) recommend online repositories should be created so that once resources are curated they can be collectively shared. I suggest for year two launching The Science Curriculum Hub through a Google Site so that the deconstruction of each standard and aligned resources can be provided and accessed easily be science teachers.

Supporting science assessments requires encouraging teachers to apply and participate on state level item writing committees so they can first hand see the items as they are created and aligned to the new standards. Additionally, district level officials should begin offering professional development sessions in the summer prior to year two implementation to show teachers how assessment items that are written in two and three dimensions differ from those written in one dimensions aligned to previous standards. It is suspected that the state will not only use discrete (stand-alone) items on the assessment, but cluster items as well. There is no guidance as to what a cluster item will look like, but I believe that if we show through either professional development or lead teacher PLC sessions how to write performance tasks, then students will be adequately prepared for these new cluster items. Finally, the middle schools will move away from three science district benchmarks and pilot three district common unit assessments. This will reduce the amount of instruction lost to testing in the middle schools, and the district common unit assessments will model rigorous items in the new science standards.

Teachers are asking for professional development specific to standards that are new in middle school. For example, in the 8^{th} grade DCI for physical science, students no longer learn simply the parts of a wave. They are required to extend their knowledge about waves into communication systems. Additionally, the 8^{th} grade DCI for magnets, electromagnets, and generators, now expects students to extend that knowledge into understanding the components of electric motors. Utilizing the lead teacher model in year two, it will be extremely important to partner with the community to expose teachers to opportunities to dive into their standards. Keller and Pearson (2012) remind educators that with the added demands of teaching science in three-dimensions, districts should reach out to partners in education and their science community members to help supplement and support the transition to new science learning. Partners such as the professors and staff at our local university system, and the Tennessee College of Applied Technology (TCAT) are excellent places to start. We also have a plethora of Partners in Education (PIE) that will share their profession and expertise with lead teachers. Content dives can be conducted during lead teacher PLCs and will deepen teacher content knowledge directly impacting instruction to students.

Artifacts

Findings for research question one indicated there was a significant correlation between the overall effectiveness score of a lead teacher re-delivery session and student achievement. Evidence throughout the study showed that while many teachers are strong in their content, they may not have had experience coaching or working with adult learners. While the lead teacher model focused throughout the year on strategies in relation to science content knowledge, it did not focus on strategies for how to deliver effective professional development to peers. In the future, it is necessary for district leaders to provide professional development to lead teachers that will support facilitating successful re-delivery sessions. I suggest utilizing the existing summer professional development conference put on by the school district. This conference is offered one week in June and one week in July at one of the high school campuses, and all professional development from the school district is consolidated during these two weeks. Teachers are already accustomed to signing up for sessions and frontloading their 18 hours of PD for the school year. A three hour session offered for lead teachers should be mandatory prior to assuming the responsibility of lead teacher the following school year. The three hour session would begin with an introduction of the lead teacher model and expectations of the lead teacher throughout the year. Then, a comprehensive examination of the lead teacher observation rubric will highlight the five attributes of a successful PD session. Utilizing the observation rubric teachers will watch video clip scenarios of re-delivery sessions, have discussions about what is making the session successful or not successful, and score the session using the rubric.

Lead teachers should also understand, to develop the coaching aspect of a content expert, one must be self-reflect. Therefore, each lead teacher should be required to film themselves facilitating one re-delivery session during the course of the year utilizing the school district purchased SWIVELS. Then, teachers should upload it to the Teaching Channel and use the re-delivery observation rubric to self-asses. In return, the district consulting teacher will provide feedback as well to the lead teacher.

The implementation of professional development to support the lead teacher during the facilitation of re-delivery sessions captures an opportunity to develop leadership capacity and set the lead teacher up for successful year. As evidenced from the data supporting research question one, higher scores from the re-delivery observation rubric tends to result in higher student achievement. Therefore, it is crucial that we provide all necessary supports for teachers to re-deliver with fidelity.

Closing Thoughts

This record of study was intended to investigate the use of elementary and middle school science lead teachers for the purpose of delivering effective professional development during the transition to new standards.

The implementation of the Tennessee Academic Standards for Science, which was developed from the *A Framework for K-12 Science Education*, required a pedagogical shift for how we taught science. District leaders recognized the need for a unique and effective way to deliver professional development to support teachers in pedagogy, content knowledge, and sustainability during the transition. In order to support teachers throughout the implementation of three-dimensional learning and the new science standards, thoughtful and intentional professional development was critical. Therefore, it was the vision of the school district to implement a new method for delivering professional development to all stakeholders with the use of science lead teachers.

Research collected throughout the study and the first year of implementation of the new science standards indicated the lead teacher model was a solid mechanism for delivering effective professional development to science teachers. Thoughtful considerations for the model have been suggested, and this research provides actionable steps for how the lead teacher model the following school year can be utilized to continue supporting science teachers during the implementation of new science standards.

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APPENDIX A

Data preparation for research question one

RQ1: What was the relationship between effectiveness of the lead teacher re-delivery sessions and student achievement?		
Teacher ID	Overall Effectiveness Score (re-delivery observation rubric)	District Assessment 3 (Average % Student Achievement)
R601	23	76.1
R602	23	73.2
R603	23	74.1
R604	23	73.6
R701	23	65.2
R702	23	69
R703	23	55.6
R704	23	58.1
R801	23	61.8
R802	23	54.9
R803	23	70.3
N601	13	46.1
N602	13	70.9
N603	13	58.9
N604	13	55.5
N605	13	49.9
N701	13	63.4
N702	13	60.5
N703	13	53.2
N704	13	59.5
N801	13	56.9
N802	13	60
N803	13	48.7
N804	13	52.3
S302	34	72.2
S303	34	67.8
S304	34	72.6
S401	34	80.4
S402	34	90.9
S501	34	93.3
S502	34	76.9
S503	34	65.7