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Middle School Science Teachers' Experience with the Change to Inquiry-Based by Instruction

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Patricia Adams-Gouthro

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Walden University
2020

Abstract

Middle School Science Teachers' Experience with the Change to Inquiry-Based Instruction

by

Patricia Adams-Gouthro

M.Ed. University of Massachusetts Lowell, 2002

BS, Framingham State College, 1998

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

Walden University

November 2020

Abstract

Based on the National Research Council recommendations, an urban school incorporated an inquiry-based curriculum through the full option science system (FOSS) into its 9 middle schools; however, the teachers at LMS (pseudonym) have struggled to transition their instructional practices toward the new pedagogy. The purpose of this qualitative case study was to understand teacher experiences and challenges with implementing the FOSS curriculum and to determine the ways the new curriculum has helped teachers shift their instructional practices. The concerns-based adoption model (CBAM) was the framework that guided this study. The research questions focused on identifying the Levels of Use, Stages of Concern, and successes and challenges teachers had with implementing the FOSS curriculum. In this qualitative study, data were collected from a purposeful sample of 14 middle school science teachers who currently teach science using the FOSS curriculum and analyzed using observations of teacher lessons and teacher interviews. These data were coded categorically using a combination of *a priori* codes from the CBAM framework, the NGSS science practices, 5 E lesson plan, and open coding from the interviews. Research indicated that the FOSS curriculum was successfully implemented, and teachers are at a stage of implementation where they are looking to collaborate and share ideas to move forward with FOSS. Based on these findings, a 3-day PD was developed to address curriculum realignment, and a PLC was recommended to increase collaboration among middle school science teachers. These endeavors may contribute to positive social change if the district science coordinator provides teachers with strategies to align FOSS with state standards and opportunities for teachers to collaborate and share IBC units to improve instruction.

Middle School Science Teachers' Experience with the Change to Inquiry-Based by Instruction

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Dedication

This doctoral study is dedicated to my family and friends for encouraging me to finish this journey in my career. My journey began in 2014 when I decided a doctoral degree was one thing I had not achieved, and I really wanted to gain some insight on a new curriculum the district was thinking about implementing.

I dedicate this dissertation to my family and friends who have supported me through this process and encouraged me to not give up. My second dedication is to my dad who passed away before I could complete this journey. My dad did say he was not comfortable calling me “doctor”. I know he would have been proud of my accomplishment.

The doctorate degree is the ultimate dream for an educator. I could not have completed this chapter in my life without my support system pushing me to finish.

Acknowledgments

I would like to take this opportunity to thank my family for understanding that this doctorate took more time than expected. Thank you for allowing me quiet time on the weekends to work on the paper. To my number one cheerleader, my mom, who encouraged me not to give up on this dream.

I also want to thank Walden University for helping me fulfill my lifelong dream of finishing my doctoral studies. It has been a long journey and I could not have done it without the support of my chair Dr. Heather Caldwell and co-chair Dr. Amy White. I appreciate all the guidance and suggestions along the way. I also want to acknowledge Jennifer Krou for her APA expertise. Without her, my editing would have taken many more weeks to complete. I am very grateful for finding you.

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Section 1: The Problem

Introduction

In the context of widespread technological and social change, how teachers and their students conceptualize education and engage in instructional practices is evolving. According to the National Science Teachers Association (NSTA, 2016), the skills students need to be successful in today's society have been redefined by technological advancements, scientific innovations, increased globalization, and economic competitiveness. All of these changes have caused a shift in the workforce demands where students need to be able to solve problems and use their scientific knowledge to make informed decisions (NSTA, 2016). These changes have compelled many teachers and regulators to reexamine teaching content and practices.

The 2016 Massachusetts Science and Technology/Engineering (STE) standards are an adaption of the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) and emphasize students learning science content through participation in authentic scientific practices including inquiry-based model (Massachusetts Science and Technology/Engineering Curriculum Framework, 2016). These practices describe the processes that scientists engage in as they build models of natural phenomena and construct explanations for scientific questions based on evidence from their work (NSTA, 2016). To teach science in this way requires a shift from teacher-centered to student-centered, inquiry-based classroom practices (Crawford, 2012). Teaching using an inquiry model requires students to be engaged in the learning process and to develop their own knowledge and understanding of scientific ideas (Aceska, 2016; Andrini, 2016;

Crawford, 2012; Franklin et al., 2015; Hardianti & Kuswanto, 2017; Hassard & Dias, 2013; Lakin & Wallace, 2015; Rivera Maulucci et al., 2014; Pedaste et al., 2015; Taber, 2011; Volkinsteine et al., 2014; Yanto et al., 2019).

Although U.S. reform documents emphasize inquiry-based learning (IBL) as a central strategy for teaching science, many science teachers do not implement inquiry-based instruction consistently (DiBiase & McDonald, 2015; Lakin & Wallace, 2015; Lotter et al., 2014; NRC, 2012; Quigley et al., 2011; Zambak et al., 2017). Teachers often struggle to implement inquiry-based lessons due to beliefs about inquiry and time constraints, as well as a lack of available resources and supports. Many teachers are either not prepared to teach inquiry-based science, do not have beliefs that support inquiry teaching, or do not know what inquiry is (Crawford, 2012; Lakin & Wallace, 2015; McFarlane, 2013; Savasci & Berlin, 2012; Wong, 2016; Zambak et al., 2017). Some studies suggest that effective integration of inquiry-based instruction requires an understanding of the science process skills as well as knowledge of scientific inquiry (Miranda & Damico, 2015), while others indicate that changes in practice can be brought about through implementing an inquiry-based curriculum (Zambak et al., 2017). As these findings illustrate, there is a need for additional research on effective strategies for inquiry-based instruction.

The Local Problem

Leaders from a large school district, LMS Public Schools (pseudonym), in an urban area of Massachusetts, have responded to the calls for inquiry-based science education (Achieve, 2013; NGSS Lead States, 2013; NRC 2012). Yet for the past 10 years, teachers in the local district have struggled to consistently implement IBL practices with fidelity, according to a science curriculum coordinator at the school. This particular school district includes eight middle schools with a total population of 44,100 students, who are taught science by 40 science teachers varying in certification, expertise, and experience.

During monthly science vertical team meetings, science teachers across the eight district middle schools have voiced concerns that there was not enough equity in time, curriculum materials, or professional development to change their practices to be more inquiry-based. Administrators have encouraged the science teachers to plan lessons that were more student-centered; however, the results were inconsistent (Science curriculum coordinator, personal communication October, 2016). The science vertical teams in the district have written curriculum guides, which included suggested activities and lessons for teachers to incorporate more inquiry-based instruction. Yet, even with the suggestions, teachers continued to struggle in using an inquiry-based model for instruction, and the shift to inquiry-based teaching has not come to fruition, according to the science curriculum coordinator.

In order to assist with the known challenges, the local district has implemented an inquiry-based curriculum with fidelity. Implementing an inquiry-based curriculum ensures that all students have equal and appropriate opportunities to learn science (Bybee, 2014). However, simply adopting an inquiry-based curriculum does not mean it will be successful. It is also necessary to understand the experiences and challenges of the teachers implementing the curriculum (Zambak et al., 2017). The goal of the local school district in using the full option science system (FOSS) is to change teacher instructional practices and overcome some of the previous challenges by increasing inquiry–based curriculum units in all district middle schools.

The new inquiry-based curriculum has been implemented in eight middle schools; however, there is not available documented evidence, classroom observations, or interviews conducted with the teachers on the challenges and/or success of the executed units. In the view of the science curriculum coordinator, this information is vital in moving forward with the inquiry-based curriculum. It is important as a collaborative learning community to understand the challenges and concerns teachers face when implementing an inquiry-based curriculum to determine if this strategy assists teachers in shifting their instructional practices. There have been studies conducted on inquiry-based teaching methodology (e.g. Arslan, 2014; Hardianti & Kuswanto, 2017; Llewellyn, 2013; Yanto et al., 2019; Zion & Mendelovici, 2012); however, there are few studies on teachers' experience in implementing an inquiry-based curriculum (Crawford, 2012; Lakin & Wallace, 2015; Savasci & Berlin, 2012; Zambak et al., 2017).

Rationale

The literature reflects that inquiry-based instructional practices are needed to promote excellence in teaching and learning in the science classroom (NRC, 2014; NSTA, 2016). In the following subsection, I present evidence of the problem at the local and national level. This discussion is followed by an introduction to the problem as it appears in the literature.

Evidence of the Problem in the Local Setting

According to the district Unified School Improvement Plan (USIP), all content teachers must expand their knowledge of standards-based curriculum and create lessons utilizing best practices (see USIP, 2015). The NGSS calls for students to develop inquiry skills through science practices (NGSS Lead States, 2013). To develop a student's inquiry skills, teachers need to design lessons involving inquiry and implement them in their classroom (Lakin & Wallace, 2015; Lotter et al., 2014; Volkinsteine et al., 2014). Given this, the science curriculum coordinator determined through numerous vertical team meetings that best practices in sciences should include inquiry-based lessons. When science teachers employ inquiry-based teaching methods with fidelity, they fulfil the demands of the school improvement plan to provide excellence in teaching, according to the school's science curriculum coordinator. The LMS district's science curriculum provides a guide to what needs to be taught at different grade levels; however, at teacher meetings, teachers reported challenges in time, resources, materials, and content knowledge with implementing inquiry-based lessons in their classroom, the science curriculum coordinator noted.

The local district's goal in using the FOSS curriculum is to change teachers' instructional practices and overcome some of the previous challenges by increasing inquiry-based curriculum units in all middle school science classrooms. To date, however, no studies have been conducted to understand teachers' experiences and challenges with implementing this curriculum with fidelity or determine how the new curriculum has helped teachers shift their instructional practices, according to the school's science curriculum coordinator. This local problem is reflected more broadly in the literature as many researchers have focused on inquiry-based teaching methodology and the challenges teachers have implemented it (DiBiase & McDonald, 2015; Gillies & Nichols (2015); Mumba et al., 2015; Quigley et al., 2011; Sullivan-Watts et al., 2013). There are fewer studies on teachers' experiences implementing an inquiry-based curriculum and how they can overcome some of the challenges (e.g., Crawford, 2012; Lakin & Wallace, 2015; Savasci & Berlin, 2012; Zambak et al., 2017).

The further need for this study is evidenced by classroom observations by the science curriculum coordinator and discussions during monthly vertical team meetings that showed many science teachers believe they are implementing inquiry-based strategies if they are using laboratory activities in their lessons; however, lab activities do not always involve student's problem-solving and critical thinking (Lakin & Wallace, 2015; McLaughlin & MacFadden, 2014).

Evidence of the Problem in the Literature

One way to assist teachers with the challenges of shifting instructional practices may be to implement an inquiry-based curriculum (Zambak et al., 2017). There have been several inquiry-based curricula created to improve science teaching and learning (Creswell, 2012, Gillies & Nichols, 2015; Gomez- Arizaga et al., 2016, Rivera Maulucci et al., 2014). These curricula may be used to overcome challenges with lacking content knowledge or pedagogical skills (Gillies & Nichols, 2015).

A gap in practice exists as to if and how the implementation of the FOSS curriculum helps teachers at the local site to overcome some of the issues experienced previously with facilitating inquiry-based science in their classrooms (Daily & Robinson, 2016). This project study addressed the gap in understanding teacher experiences and challenges with implementing inquiry with fidelity, using the FOSS curriculum and to determine the ways in which the new curriculum has helped teachers shift their instructional practices. I used the Concerns Based Adoption Model (CBAM), a framework used in previous studies to examine participant concerns and use during the implementation of a new curriculum or program (Daily & Robinson, 2016; Gabby et. al., 2017).

Definition of Terms

Special terms associated with this study are described in this section.

Constructivism: A teaching philosophy that views learning as an active process in which individuals construct their own meaning through experience with science phenomenon (Hassard & Dias, 2013).

Hands-on learning in science: Learning that occurs by students conducting experiments and collecting data to solve problems (Hassard & Dias, 2013).

Inquiry-based learning: IBL in science is defined as an educational strategy in which students solve problems and construct their own knowledge about a science concept (Pedaste et al., 2015). Inquiry in the science classroom includes the following features: (1) the learner is engaged in gathering evidence for a scientifically-related question; (2) the learner focuses on the evidence in responding to the questions; (3) the learner uses the evidence/data gathered to develop an explanation; (4) the learner connects prior knowledge and experiences to the explanation of scientific knowledge;

and (5) the learner communicates and supports the explanation (Volkinsteine et al., 2014).

Scientific inquiry: The different ways in which scientists study the natural world and suggest solutions to problems that exist (Castle, 2014). The NRC (2012) reported that scientific inquiry be defined as: developing questions and hypothesizing, planning and executing an investigation, observing science phenomena, collecting and recording data as evidence, and using scientific knowledge to make an informed decision.

Twenty-first century learning: A wide range of knowledge of skills, work habits, and character traits, such as collaboration and problem solving, that is believed to be critically important to be successful in today's society (NRC, 2012).

Significance of the Study

This project study is of significance to the local district because it will inform leaders whether teachers are shifting their practice, and how the recently implemented FOSS curriculum is helping science teachers shift their instruction to be more inquiry-based and hence in line with the USIP. A local school district in Massachusetts recently implemented a new inquiry-based science curriculum, and it is important to develop an understanding of the experiences of the teachers as well as how this new curriculum helps teachers overcome the challenges that they have encountered (Science curriculum coordinator, personal communication October, 2016). Teachers often struggle shifting to inquiry-based instruction due to beliefs about inquiry and challenges they encounter (DiBiase & McDonald, 2015; Gillies & Nichols, 2015; Lebak, 2015; Miranda & Damico, 2015; NRC, 2012; Oppong-Nuako et al., 2015; Quigley et al., 2011; Silm et al., 2017;

Zambak et al., 2017). This study may provide the LMS school district with information necessary to plan for future professional development to further assist teachers shift their instructional practices and implement inquiry-based curriculum.

This study also has the potential to inform the research literature. Efforts to reform science education can be traced back 30 years (NRC, 2014); however, despite attempts to shift classroom practice toward a more constructivist, inquiry-based model, many teachers still follow a directive method, which is teacher-centered (Arce et al., 2014). Studies show that managing inquiry in the classroom, ensuring the quality of inquiry, time management, lack of content knowledge, pedagogical skills, and access to relevant inquiry-based resources are challenges that teachers encounter as they change instructional practice (Crawford, 2012; Quigley, et al. 2011; Zambak et al., 2017). The results will also be useful to other districts that are considering implementing this inquiry-based curriculum.

Research Questions

Inquiry-based teaching in science has been at the center of science education for decades, and research has supported inquiry-based instruction in the classroom versus traditional teaching methods (Abdi, 2014; Crawford, 2012; Maxwell et al. 2015; NRC, 2012; Rivera Maulucci et al. 2014). However, there is evidence that many teachers have not successfully shifted their instructional practices. In the local district. This is a key concern in science education (Lakin & Wallace, 2015; Meyer et al., 2013; NSTA, 2016), and much research has addressed what inhibits this goal in a local district during vertical team meetings. While some research suggests implementing an inquiry-based curriculum to help teachers shift their practices, it is currently unknown how the implementation of FOSS is progressing in a local district or if teachers have been implementing the curriculum. This case study, guided by a conceptual framework on change theory (SEDL, 2016), will answer four research questions about middle school teacher challenges and experiences implementing the FOSS curriculum.

RQ1: What are middle school science teachers' Stages of Concern (SoC) implementing the FOSS curriculum and shifting their instructional practices to an inquiry-based model?

RQ2: What is the Level of Use (LoU) of the new curriculum that is being implemented in the local district?

RQ3: What instructional strategies are teachers using that are consistent with the features of inquiry-based instruction (LoU)?

RQ4: What successes, challenges, and needs do teachers report when implementing an inquiry-based science curriculum?

Review of the Literature

A literature review provides the scholarly context within which the problem under investigation acquires definition and significance. In general, research reveals teachers encounter numerous challenges when they shift their classroom to a more inquiry-based model. The local district that is the subject of this investigation has implemented the FOSS curriculum and would find it useful to learn more about the experiences that teachers have with this curriculum and the changes that have resulted in their practices by virtue of implementation. This review situates the current work within the broader literature dealing with teachers implementing IBL in science. The review employs the conceptual framework of change theory to guide the research questions and methodology (SEDL, 2016).

Conceptual Framework

The broad conceptual framework for this study is the CBAM (CBAM, 2016), which provides a means of assessing and facilitating education reform. CBAM is a diagnostic framework that researchers can utilize to monitor and evaluate the complex process of implementing a new curriculum with fidelity. CBAM can be used to collect data on teachers' experiences as a shift in instructional practices to inquiry-based teaching is evaluated. The stages of concern and the stages of use, that comprise the CBAM, can be used during classroom observations and interviews to help garner teacher experiences with an inquiry-based curriculum (CBAM, 2016).

A few researchers have used the CBAM model in education to address teacher concerns and categorize the process of change implementing a new curriculum (Derrington & Campbell, 2015; Gabby et al., 2017; Grundy & Berger 2016; Matar 2017; Yeldell, 2017). All the above researchers agree the CBAM can be used in the first three years of implementing of a new curriculum or program and provides the administration with information essential in moving forward with the new initiative. The framework is often used in the educational world to help with research studies and assess instructional practices.

The CBAM framework, appropriate in a school district implementing a new curriculum, can provide schools with a lens to understand the change process and allows a researcher to identify how effectively a new program is being implemented (Southwest Educational Development Laboratory SEDL, 2016). The CBAM Stages of Concern and the Level of Use stage will be used as a broad framework for this study. The Stages of Concern is where a researcher or school leader can assess the challenges, attitudes, and perceptions as staff implements a new inquiry-based curriculum. This is a structured method for the leader or researcher to identify key concerns and identify the need to provide targeted support to help teachers shift instructional practices by placing the participant in one of the seven categories related to an innovation. The seven categories are all possible concerns related to the innovation of a new curriculum. In this study, I will adapt the stages of concern to evaluate the participants' concerns before and during the implementation of the FOSS curriculum, and how these concerns may be related to the research-based challenges that have been uncovered in prior research (Crawford, 2012; Quigley et al. 2011). Open-ended interview prompts are constructed around these factors, such as management of inquiry, beliefs about inquiry, and content knowledge necessary, known to challenge teachers when they consider implementing inquiry.

The next stage, Levels of Use, consists of the eight possible behavioral profiles that describe the actions educators may be taking implementing the new curriculum, and are depicted in Appendix D. These profiles will be used to frame formal open-ended interviews with teachers as well as the classroom observation protocol to determine individual levels of use with the inquiry-based curriculum being implemented in a local district.

Within the LoU the eight science practices from the Next Generation Science Standards (Lead States, 2013) will be used to frame the types of scientific inquiry that students are participating in. In addition, the 5 E model of inquiry will be used to frame the types of instruction that teachers are implementing to support inquiry. The 5 Es are an instructional model that include engage, explore, explain, elaborate and evaluate and are used in the science teacher's lesson plans. Specifically, using these constructs allows for the how the teacher is uses instructional strategies consistent with inquiry-based teaching within a particular FOSS investigation. The engage portion is how a teacher launches the lesson and gains the student's interest. The engage part is meant to be about five minutes. The lesson's explore normally takes about a half hour and is when students are actively involved with the science phenomenon. The elaborate and evaluate part of the lesson involves students processing what they learned and asking any questions they may still have and is normally no longer than ten minutes. The observation protocol tool has been designed to note if and how each practice and instructional strategy is being implemented during the lesson.

The CBAM framework can be used to determine the level of implementation that teachers have achieved; and identify the concerns among teachers as they change their instructional practice (Grundy & Berger, 2016; Yeldell, 2017). The CBAM framework is appropriate for this study as the proposed research site has adopted a new inquiry-based curriculum program for middle school grades, and the CBAM framework lends support to the researcher during data collection. Research questions #1 and #2 seek identification of teachers' stages of concern and levels of use in relation to the inquiry-based curriculum being implemented.

CBAM will be used as a framework to examine the teachers' experiences as they implement the FOSS curriculum and attempt to change their instructional practices to scientific inquiry. The components of CBAM will frame and categorize the questions asked during the interviews and provide categories for the development of the classroom observation protocols and assist in the analysis portion of this project study.

Review of the Broader Problem

The following topics organize the content in this literature review: the conceptual framework, the role of the next generation standards in promoting inquiry-based science instruction, scientific literacy, teaching beliefs about scientific inquiry, challenges to implementing inquiry-based instruction, FOSS curriculum and scientific notebooks. Research studies on these topics are synthesized in the literature review in order to situate the local problem into the educational professional field. The topics described below connect to the conceptual framework as teachers shift their instruction to be more inquiry-based.

Historical background. The Massachusetts Science Technology and Engineering (STE) standards were released in April of 2016 and are aligned to the Next Generation Science Standards (NGSS) (Lead States, 2013). The NGSS are K-12 science content standards that describe important scientific concepts and practices that will give all students the skills and knowledge they need to succeed in the 21st century (DESE, 2016). All curriculum and instruction in science, at the local site, are supposed to be centered on these standards. After much research and consideration by the NRC and the Department of Elementary and Secondary Education (DESE), the 2016 standards were intended to drive coherent, rigorous instruction that emphasizes mastery of core ideas and applying science engineering practices (DESE, 2016). This focus requires the teachers to modify their instructional practices to be more student-focused and less teacher-centered (Crawford, 2012). The NGSS standards support inquiry-based instruction as a means to shift instructional practice.

The adoption of the NGSS has changed the focus of science education and is built on inquiry-based instruction as well as relevance and rigor. The 2016 NGSS framework structured science learning around three components: the practices, key crosscutting concepts, and the essential content. The practices describe the behavior scientists and engineers engage in to complete their work. The key crosscutting concepts and content apply to all areas of earth and space, physical, life and engineering and technology (NRC, 2014). In order for instruction to be more inquiry-based, teachers have to move away from teaching isolated facts and instead focus on the science concepts that cross disciplines as well as allow students the opportunity to explain science phenomena and solve problems by engaging in science practices (Krajcik & Delen, 2017). The practices align with IBL, where students carry out investigations, make sense and organize data, and communicate information to present findings.

There have been studies conducted to examine a method for how teachers could design science instruction to align with the NGSS. This teaching shift involves the need for teachers to engage learners in investigating and explaining the science phenomenon in order to improve student learning (Heller et al., 2012; Kloser et al., 2017; Roth et al., 2011). Further, Castle (2014); provided evidence that the new framework focuses on student-centered versus teacher-centered learning, which can be challenging to teachers.

Scientific literacy. Scientific literacy is the capability to acquire and comprehend scientific knowledge as well as apply and evaluate that knowledge to make informed decisions in society. Scientific literacy is at the center of curriculum reform and the transformation of instructional practices to reflect inquiry-based concepts (Crowell & Schunn, 2016; Hassard & Dias, 2013; McFarlane, 2013; Shumow & Schmidt, 2015). A common goal of science instruction is to promote scientific literacy among K-12 students using scientific inquiry (Crowell & Schunn, 2016; Hassard & Dias, 2013; McFarlane, 2013; Shumow & Schmidt, 2015). One reason is that twenty-first-century jobs require more scientific knowledge and a more scientific mindset than ever before (Shumow & Schmidt, 2015). Researcher also supports teaching for scientific literacy as it resonates with the notion of science content being relevant to the students' lives (McFarlane, 2013). Scientific literacy for every student has become a central theme of science education**.**

Some research studies that have been conducted make the connection between student engagement, inquiry-based learning, and scientific literacy. Student engagement and motivation tend to decline as students move through middle school, especially in science (Shumow & Schmidt, 2015), and a shift to an inquiry-based instructional framework may remedy this problem, as lessons within this framework become more student-centered. Students who value what they are learning are more motivated and engaged; hence educators need to assist students in finding value in their learning, which will lead to increased engagement, interest, and performance (Shumow & Schmidt, 2015). Students are taught how to think constructively in inquiry-based science. They recognize that scientific literacy coordinates ideas about technology and allows them to become functional members of the global community (McFarlane, 2013). Indeed, lack of student performance in science education can be traced to the methodological and instructional approaches being used in the classroom that remain teacher-centered (Crowell & Schunn, 2016; Hassard & Dias, 2013; McFarlane, 2013).

A major challenge of science education in the twenty-first century is to change teaching practices to focus more on what students do than what teachers say to increase scientific literacy and prepare students for 21st century jobs. Making science active and relevant to the students' lives begins to recognize its value (McFarlane, 2013; Shumow & Schmidt, 2015). As outlined in the NGSS, the framework of scientific practices supports scientific literacy because it challenges the traditional view of teaching science to students and encourages classroom practices that reflect students learning science by participating in authentic scientific inquiry.

Teacher Change and Inquiry-Based Instruction. Many researchers have explored the complicated aspects of scientific inquiry as it may apply to classroom teaching. Inquiry-based science instruction focuses on the nature of science and advances science practices in the classroom (Lead States, 2013). Inquiry learning involves teachers creating a classroom environment that fosters students asking questions, collecting data as evidence, and constructing their own meaning of the science concepts. Once students have collected and recorded data, they analyze and interpret the data produced during their investigations to derive meaning from the data (NRC, 2012). Numerous studies reviewed teacher change and the methods in which teachers create a classroom environment that fosters students asking questions, collecting data and evidence, and constructing their own meaning of the science concepts (Abdi, 2014; Arce et al., 2014; Castle, 2014; Crawford, 2012; Gillies & Nichols, 2015; Lakin & Wallace, 2015; Pedaste et al., 2015; Rivera Maulucci et al., 2014; Taber, 2011; Volkinsteine et al., 2014). Through quality science instruction, teachers can reinforce and advance 21st century skills and science practices.

The above researchers also suggest that inquiry-based instruction challenges teachers to establish a classroom environment that encourages students to ask questions, collect data as evidence, and construct their own meaning of the science concepts (Hassard & Dias, 2013). Castle (2014), Rivera Maulucci et al. (2014), Gillies and Nichols (2015), and Volkinsteine et al., (2014) support the concept of inquiry-based instruction in the classroom and conducted studies on the different levels of inquiry as seen in the science classroom. All four studies focused on middle school teachers implementing inquiry-based lessons because it provides students with opportunities to explore with science concepts. Many studies have supported the research that most teachers understood inquiry; however, they faced a barrier as they tried to convert their knowledge to practice (Castle, 2014). Understanding a teacher's experiences while implementing inquiry-based lessons in their classrooms may allow discovery of why the inquiry-based approach is not a common instructional practice (Rivera Maulucci et al., 2014). Teachers' experiences with inquiry can help determine if teachers are comfortable implementing this type of instruction in their classrooms. Overall, teachers reflected positively on their experiences but also expressed concerns about challenges like time and resources. Inquiry-based teaching provides students with a better understanding of science content and can assist students develop 21st century skills like problem solving, critical thinking and content literacy (Volkinsteine et al., 2014).

Crawford (2012) and Lakin and Wallace (2015) also supported inquiry-based instruction and investigated how teachers can effectively shift their classroom to be more inquiry-based. The Crawford case study focused on methods to support teachers in mastery of the knowledge base of science, and the essential features of scientific inquiry. The researcher concluded that for inquiry teaching to be authentic in the classroom, the teacher first needs to be given opportunities to engage in scientific inquiry themselves, which will help the teacher gain confidence with this teaching methodology (Crawford, 2012). Lakin and Wallace examined the validity of teacher's use of inquiry-based strategies and examined the experience of the inquiry-based lessons in the classroom.

Knowledge of the nature of inquiry. Studying teachers' experiences with the implementation of the science curriculum can uncover what teachers know about the nature of inquiry. A recent study (Crawford, 2012) investigated how teachers shift their classroom instruction to be more inquiry-based while being supported in mastery of the knowledge base of science, and the essential features of scientific inquiry. The researcher concluded that in order for inquiry teaching to be authentic in the classroom, the teacher first needs to be given opportunities to engage in scientific inquiry themselves, which will help the teacher, gain confidence with this teaching methodology (Crawford, 2012).

Castle (2014) found that the middle school teachers in her study understood three levels of inquiry (guided, open and structured) and that many were attempting to utilize structured inquiry in their classrooms; however, they faced a barrier as they tried to convert their knowledge of inquiry into practice. Both studies support the claim that understanding the nature of inquiry is not enough to guarantee successful implementation in the classroom. A further related issue is that a teacher's perception of what an inquiry-based lesson looks like may not be what students experience in the classroom. Lakin and Wallace (2015) examined the validity of teacher's use of inquiry-based strategies and examined the experience of the inquiry-based lessons in the classroom. This study compared the teacher and students' perceptions of the lesson, and the researchers found a discrepancy between teacher and student perception of inquiry-based lessons. In this study, teachers reported higher levels of inquiry-based learning in the classroom compared to what the students perceived.

Beliefs about inquiry. Research shows that teachers come to the science classroom with beliefs about how students learn science and how they feel science should be taught, which can be a challenge to shifting instructional practices. Some studies have reported that teachers' beliefs about inquiry instruction play a critical role in how they deliver science instruction in their classrooms (Alhendal et al., 2016; Atar, 2011; DiBiase & McDonald, 2015; Lebak, 2015; Wong, 2016), and hence need to be considered when new practices are implemented (Alhendal et al., 2016). Teachers' beliefs regarding inquiry teaching and learning affect how teachers teach the science content and whether or not they implement inquiry-based lessons.

Teacher beliefs about inquiry-based instruction can be shaped by their prior experiences. For example, research shows that a teacher’s willingness and ability to integrate inquiry into their classroom is tied to their beliefs about instruction (Atar, 2011; Atar & Gallard, 2011). The results from the first study indicated that teachers’ practices were directly related to their belief system about inquiry, so if they have traditional beliefs about science teaching, it was difficult to implement inquiry-based science. Other research indicates that even a teacher having reform-oriented beliefs about science instruction does not predict that they will teach in a method consistent with that belief (Lebak, 2015). In this case study, a case study methodology was used to examine the intricate relationship between beliefs, practice, and change related to inquiry-based instruction in the classroom (Lebak, 2015). Findings revealed shifting instruction from a traditional model of instruction to an inquiry-based model corresponded to a significant shift in a teacher’s belief system and teaching practice.

A common way to investigate teacher’ beliefs have about inquiry is with a survey or a questionnaire about their beliefs and current instructional practices of Inquiry-Based Learning (IBL). In their studies, both DiBiase and McDonald (2015) and Silm et al. (2017) administered surveys or questionnaires to teachers to collect their beliefs and opinions about inquiry-based instruction. The results from DiBiase and McDonald (2015) support the findings of Lebak (2015), indicating that 86% of teachers believed in cooperative groups but stated that there were challenges in facilitating cooperative group activities. Teachers in the study struggled with managing classroom inquiry activities and were concerned with student mastery of content. It was concluded from the study that teachers’ beliefs about how science should be taught in the classroom were consistent with inquiry, but many lacked the thorough understanding about the implementation of inquiry in the classroom and were asking for greater direction and knowledge (DiBiase & McDonald, 2015). The study called for more research on teacher beliefs about inquiry, especially in an urban setting. Silm et al., (2017) supported this notion concluding even with training of IBL, teachers were reluctant to implement IBL in their classrooms due to implementation issues.

Savasci and Berlin (2012) supported the researchers above and examined factors that influence this complex interaction between teacher beliefs about science inquiry and teacher practices by studying four science teachers working in different school environments. Using a constructivist framework, a model was developed showing that teacher education, background, content knowledge, and prior experience shaped these teacher’s beliefs and subsequent practices (Savasci & Berlin, 2012). Voet and De Wever (2017) conducted a study and concluded that teachers with a greater sense of effectiveness would more open to new teaching ideas like IBL. These studies confirm the notion that teacher beliefs as well as prior experience on student-centered learning, will influence the science classroom.

Other methods of helping teachers align beliefs with practices were conducted by Atar (2011) and Atar and Gallard (2011). The researchers focused on understanding teacher beliefs about inquiry and factors that influence a teachers’ ability and willingness to implement inquiry-based instruction into their classroom. This study suggested that to accomplish the goal set by educational reform; teachers must be supported and encouraged to begin implementing inquiry-based science lessons. Another study conducted by Atar and Gallard (2011) specifically examined teachers developing a sound appreciation of the nature of science to understand inquiry-based instruction, which is reflected in their beliefs about inquiry. Teachers without the content knowledge and prior experience with inquiry will have difficulty transforming inquiry practices into the classroom (Atar & Gallard, 2011). These two studies recognized the need for studies investigating teachers' characteristics and implementing the inquiry in the classroom.

Many studies that have been conducted on beliefs about inquiry-based instruction conclude that teachers have a positive attitude and belief system about inquiry and recognize the benefit of inquiry; however, implementation is difficult due to other challenges like materials, professional development, management and time. Researchers agree that teacher perception of inquiry will determine the implementation of inquiry in the classroom.

Other challenges to inquiry-based instruction. Apart from beliefs and knowledge about inquiry, teachers encounter other challenges when implementing inquiry-based instruction. It is evident from the research that even when teacher have beliefs that are consistent with inquiry, they struggle shifting their instructional practices and are reluctant to change them (Castle, 2014; DiBiase & McDonald, 2015; Gillies & Nichols, 2015; Kazempour & Amirshokoohi, 2014; Lakin & Wallace, 2015; Lebak, 2015; Lochner et al., 2015; Lotter et al., 2014; NRC, 2014; Zambak et al., 2017).

The reluctance to shift to inquiry-based instruction comes from the challenges that include new materials (DiBiase & McDonald, 2015; Mumba et al., 2015; Quigley et al., 2011), time constraints (DiBiase & McDonald, 2015; Gillies & Nichols, 2015; Quigley et al., 2011) and the pedagogical process of transforming knowledge about inquiry into practice (Gillies & Nichols, 2015; Mumba et al., 2015; Quigley et al., 2011; Tseng et al., 2013; Zion & Mendelovici 2012). Advancement with inquiry is dependent on teachers' time, and effort and willingness to overcome challenges as teachers guide students in the inquiry process (Mumba et al. 2015). All of the research studies above agree that professional development in the area of content knowledge as well as pedagogical skills to prepare for inquiry-based lessons are key to the successful implementation of inquiry-based lessons.

Gillies and Nichols (2015) and Quigley et al., 2011 conducted studies that examined the challenges for grade six teachers teaching scientific inquiry units. The experiences of teachers implementing inquiry-based lessons were positive, but they identified challenges that included the time necessary to ensure the necessary content was covered as well as student focus on quality content. The findings from these studies are aligned with Tseng et al. (2013), who concluded it was important to design the inquiry experiences and ensure they are student-centered, which takes time for teachers to implement. Both studies also provided evidence for the importance of educating teachers to integrate inquiry-based science into their lessons and support teachers as they implement inquiry-based instruction.

Content knowledge. Some research shows the relationship between teachers' science content knowledge and their capacity to deliver inquiry-based instruction (Atar & Gallard, 2011; Crawford, 2012; Gillies & Nichols, 2015; Savasci & Berlin, 2012;

Thomson & Nietfeld, 2017). Atar and Gallard (2011), Crawford (2012), Gillies and Nichols (2015), and Savasci and Berlin (2012) have concluded many teachers are faced with challenges implementing inquiry science into the classroom because they do not have adequate content knowledge or pedagogical skills. This is a concern today because there is an increased emphasis on teaching science through an inquiry-based model where students do not simply learn about science but are also doing science, and the teacher's role will shift to one of facilitator (Gillies & Nichols, 2015; Lebak, 2015).

Teachers with higher content knowledge have a higher self-efficacy about their ability to teach science. Al Sultan, Henson & Fadde, (2018) supported this concept in a study that examined if teachers were properly trained in science content teaching methods. They have higher scientific knowledge levels to teach. Efficacy in science content was supported by Thomson and Nietfeld (2017), who concluded emphasis should be placed on preparing teachers with strong content knowledge. Teacher training should be centered on inquiry-based learning. Teachers need adequate content knowledge to successfully teach their students (Thomson & Nietfeld, 2017).

Gillies and Nichols (2015) conducted a study of nine grade six teachers who implemented two inquiry-based science units in their classroom instruction. The study reported on the teachers implementing two cooperative inquiry science units. The results were positive in the teacher experience; however, they reported challenges to implementation, including content knowledge and time. Lebak (2015) and Fitzgerald et al. (2013) supported the notion that teachers who lack content knowledge and prior experience with inquiry-based instruction will have difficulty transforming inquiry into the classroom. The teachers identified challenges while teaching inquiry science that included their perception that they did not have the content knowledge or instructional skills to shift instruction. A focus on teachers' content knowledge in relationship to implementing inquiry is crucial. If teachers are educated properly in science content and teaching methods, they have a high efficacy about their ability to teach science (Al Sultan, Henson, & Fadde, 2018). In addition to content knowledge, teachers in these studies also expressed concerns about other challenges such as time, classroom management, and resources.

Resources. Scientific inquiry is not always integrated into a teacher's lesson plans for many reasons; for example, the teacher may lack understanding of inquiry-based instruction or not having the necessary materials. Teachers need time and resources to effectively make changes, so their instructional practices reflect inquiry-based methods (Gillies & Nichols, 2015; Shaw, 2006). Normally, students conduct experiments to prove a scientific phenomenon. Teachers often believe that if students are conducting experiments, then the teachers are implementing inquiry-based instruction. However, students should be exploring the phenomenon and constructing their own knowledge about a topic (Gomez-Arizaga et al., 2016; Taber, 2011). Scientific inquiry has to be designed and planned effectively, and this includes having appropriate materials for students.

To develop a student's science inquiry skills, teachers need to effectively implement inquiry-based lessons with fidelity in their classrooms and have appropriate materials and resources readily available. According to Shaw (2006), FOSS includes a section that describes materials preparation and management, which can help with the challenge of managing resources. The FOSS kits provide organization and structure to teachers and students by providing science content and material resources (FOSS, 2020; Fulton, 2017; Larsen, 2018). This can be beneficial for teachers not comfortable implementing inquiry-based lessons in their classrooms. All the materials for individual investigations are organized and readily available to make science more appealing for students and help students achieve a deeper understanding of science (FOSS, 2020; Fulton, 2017; Larsen, 2018; Shaw, 2006).

Teachers are often not comfortable with scientific inquiry because of their limited knowledge of the concepts and materials needed to implement, and this can cause a difficulty in adapting lessons to the inquiry-based modality. This was evident in a local district where various suggestions for the use of curriculum guides over the years resulted in the district's adoption of an inquiry-based curriculum through FOSS. The literature review demonstrates a gap in practice with resources being a challenge for teachers.

Professional development. Concerns about preparedness and content knowledge while implementing inquiry-based instruction, and addressing beliefs about inquiry, can be addressed with effective support and professional development. The results from various studies (Capps & Crawford, 2013; DiBiase & McDonald, 2015; Kazempour & Amirshokoohi, 2014; Lakin & Wallace, 2015; Lebak, 2015; Lotter et al., 2014; Marshall & Smart, 2013; Oppong-Nuako et al., 2015; Silm et al., 2017; Wong, 2016) conclude scientific inquiry must be an central part of science teacher's professional education and teachers need quality professional development centered around the focus of inquiry instruction.

Many teachers do not feel prepared to integrate inquiry-based instruction in their lessons and need professional development to guide them. DiBiase and McDonald (2015) completed a study with 275 middle-grade teachers from four districts in order to deepen knowledge about teachers' attitudes, values, and beliefs about inquiry. The results of this study re-emphasized what was found above that teachers may believe in inquiry, but they still do not feel prepared to integrate inquiry into their lessons (DiBiase & McDonald, 2015). The study concluded that professional development for teachers must include scientific inquiry methods for teachers to implement into their lessons. Such professional development would assist with the challenge of teachers not feeling prepared to implement inquiry activities. Lotter et al. (2014) and Marshall and Smart (2013) supported the importance of creating a community of practice around inquiry that would support teachers through continued professional development. Support with professional development includes management of the classroom and the time needed to implement inquiry-based lessons.

A study completed by Wong (2016) supported the notion that beliefs influence classroom decisions and what is taught in the classroom. Wong's research focused on 21 middle school mathematics and science teachers and discovered that participating in an online program that emphasized inquiry-based instruction influenced participant's beliefs (Wong, 2016). Overall, participants in the study moved toward holding more student-centered views on their science teaching. The results from this study indicated the importance of professional development in assisting teachers in being aware of their beliefs and the influence it can have on their teaching. Silm et al. (2017) and Capps and Crawford (2013) supported the notion that effective professional development where teachers are engaged in inquiry-based instruction and can reflect on their practice can assist teachers shift their implementation of IBL lessons. This study's results indicated that the beliefs about inquiry were maintained; however, teachers integrated inquiry in their lessons more frequently after examining their teaching and reflecting on their instructional practices (Silm et al., 2017). Results from these studies provided evidence that changes in both practice and beliefs are an interactive process.

Oppong-Nuako et al. (2015) completed an in-depth study on the levels of inquiry being implemented in the classroom, and the study supported professional development as a means to address items not evident in the teacher's practice. Lebak (2015) and Wong (2016) completed case studies examining the complex relationship between belief and practice. Results from these studies also support the importance of collaborative professional development to assist teachers in shifting their instruction to inquiry-based modalities. Kazempour and Amirshokoohi (2014) completed a qualitative study that examined high school teachers' experiences and beliefs about inquiry-based teaching. The study concluded the importance of professional development in assisting teachers in shifting their instructional practices. This concept of professional development assisting teachers in shifting their beliefs was supported by the Wong (2016) study. If teachers do not hold student-centered beliefs, this will negatively impact classroom practices, and professional development to shift teacher beliefs.

Implementing Inquiry-Based Instruction

There are multiple methods available to a district to provide resources and to assist teachers in shifting their instructional practice to an inquiry-based model however, the 5 E model has gained the most attention. The 5 E Instructional Model can be described as a 5 E-cycle consisting of engagement, exploration, explanation, elaboration, and evaluation (DiBiase & McDonald, 2015; Idsardi et al., 2019; You et al., 2019). The 5 E learning cycle involves the teacher presenting a question for students to solve, and then the students going through various phases: engage, explore, explanation, elaboration, and evaluation. The 5 E cycle starts with acknowledging students' prior ideas about a topic and ends with students evaluating their understanding about a specific science concept. Activities and lesson plans can be implemented using the 5 E cycle (Abdi, 2014). While using the 5E model, the teacher must also construct an environment that is conducive to an inquiry-based classroom in which the students act like scientists, experiencing science firsthand (Abdi, 2014). The NSTA in coordination with the NGSS claim that scientific practices in the classroom can be centered on the 5 Es of inquiry to develop high quality lessons that support understanding of science phenomenon (Creghan & Creghan, 2013; Idsardi et al., 2019; You et al., 2019).

One way to implement inquiry is with a comprehensive inquiry-based program like FOSS. However, implementing a new curriculum must be accompanied by teacher training and support and the opportunities to reflect on practice. The FOSS curriculum is aligned to the 5 E model of engagement, exploration, explanation, elaboration, and evaluation and supports teachers with all the materials and science content needed

(Appendix G). This can help save time that teachers would otherwise spend creating their own inquiry lessons.

Full Option Science System Curriculum (FOSS)

There have been numerous studies centered on the FOSS curriculum to assist teachers in shifting their instructional practice to be more inquiry-based. Cromley et al., 2016; Gillies and Nichols 2015; Gomez- Arizaga et al., 2016; Sullivan-Watts et al., 2013 have all conducted studies analyzing the FOSS curriculum and have concluded a kit-based curriculum can assist teachers with all the materials and science content needed, which can assist teachers in implementing an inquiry-based classroom environment. The FOSS curriculum is based on educational research through the NRC (2012), which suggests students should be given opportunities to discover, explore, and think like scientists (Cromley et al., 2016; Sullivan-Watts et al., 2013). The FOSS curriculum is one method of assisting teachers in shifting their instructional practice to be more inquiry-based.

A few studies have been conducted that examine teachers' experience while implementing an inquiry-based curriculum like FOSS and have concluded that the FOSS curriculum can create a learning environment where the focus is on students understanding science phenomena. The Gillies and Nichols (2015) study involved examining teacher perception of teaching inquiry-based science and concluded that teachers have difficulty implementing inquiry-based instruction for various reasons. Another study conducted by Gomez-Arizaga et al. (2016) supported the FOSS curriculum concluding that the FOSS curriculum provides opportunities for student scientific experimentation that is needed to understand science better. The FOSS program bridges research and practice with strategies to engage students and teachers in learning experiences that lead to a deeper understanding of science concepts (FOSS, 2020). The FOSS curriculum is based on educational research through the NRC (2012), which suggests students should be provided with opportunities to discover, explore, and think like scientists (Sullivan-Watts et al., 2013). The FOSS curriculum follows the guided inquiry parameters where students are given a focus question and then spend time gathering evidence to answer the focus question presented by the teacher. The FOSS curriculum can assist teachers with their experience implementing inquiry-based instruction because it provides the resources and materials needed.

The structure of the FOSS curriculum supports the student-centered learning environment created by shifting instruction to be more inquiry-based. There have been a few studies conducted analyzing the structure of the FOSS curriculum (Cromley et al., 2016; Gomez-Arizaga et al., 2016; Sullivan-Watts et al., 2013). The FOSS curriculum is aligned with the NGSS standards as well as the 5 E model of inquiry (FOSS, 2020). The curriculum is divided into individual investigations, which begin with activating prior knowledge and allowing students to communicate their misconceptions about a certain science concept (Sullivan-Watts et al., 2013). This is completed by a variety of methods embedded in each investigation, and the activities help students become involved in the science they are about to explore. Each investigation also has a specific focus question to guide the investigation. The next stage in the investigations is the exploring with real materials with the goal of collecting data about a specific problem that is under study.

Next, the students make sense of the data that were collected and communicate their findings. An inquiry-based curriculum, like FOSS, can be a method to assist teachers in shifting their instructional practices because it is characterized by a strategically sequenced set of hands-on activities designed to build comprehension of basic science concepts (Sullivan-Watts et al., 2013). Sullivan-Watts et al, (2013) addressed one of the challenges teachers often have, which is having the time and resources to shift instructional practices. Having a set curriculum assists the teachers with the challenge of time and resources because these are offered to the teacher in sufficient magnitude.

Science Notebooks

A science notebook is an integral component of implementing inquiry-based instructional practices and a useful tool in shifting instructional practices. The science notebook has been a theme in many studies on scientific inquiry implementation (Campbell & Fulton, 2014; et al., 2017; Jaladanaki & Bhattacharya, 2014; Krajcik et al., 2014; Mason & Bohl, 2017; Robinson, 2018; Ruiz-Primo & Li, 2013;). The science notebook can be used as a strategy to promote scientific inquiry by providing opportunities for students to engage in the science phenomenon.

The science notebook helps students organize their observations and data and maintain a record of their learning for future investigations. Notebooks are a good way for students to incorporate visual elements such as illustrations and concept maps of their data (Campbell & Fulton, 2014; Jaladanaki & Bhattacharya, 2014; Mason & Bohl, 2017; Robinson, 2018; Shelton et al., 2016). Robinson (2018) supports the idea of interactive science notebooks in which students write, glue, or tape investigation pages into their notebooks to complete. Graphic organizers, templates, and notebook pages can assist students with their writing in science.

According to Campbell and Fulton (2014), there are three goals for students and teachers when implementing science notebooks. The first is that the notebook is to reveal a student's thinking about science content. It is a place for students to think deeply about science content. The second goal of the science notebook is that it is to be a place for students to replicate the work of scientists. Students plan, investigate, collect data, interpret data, and construct explanations. The last goal of a science notebook is to be used to develop and exercise literacy skills. Robinson (2018) supported the notion of the importance of students recording information daily in their science notebooks. It will assist them in recording their scientific learning and retaining information.

Notebooks are an intricate constituent to kit-based programs, where students are actively engaged with science materials and are confirming ideas about investigations through small and whole group discussions (Campbell & Fulton, 2014). The science notebook is usually a composition notebook where students record their science work by using drawings; writing and the data collection can provide the teacher with information on student conceptual understanding (Fulton et al., 2018). Science notebooks are a location for students to record their data and observations from STEM learning experiences, to write down any questions or misunderstandings they may have, and reflect on their science knowledge of ideas (Mason & Bohl, 2017; Rider-Bertrand, 2012; Robinson, 2018). It also provides a space where scientific evidence and research can come together to help students construct their own meanings of ideas and to broaden their understanding of STEM concepts while acknowledging their prior knowledge. The science notebook is an active place for teachers to view student work and communicate with students on their knowledge and development of science phenomenon, including misconceptions.

There have been numerous studies conducted on the effectiveness of science notebooks as a type of formative assessment during inquiry-based instruction (Campbell & Fulton, 2014; Fulton et al. 2017; Fulton et al., 2018; Jaladanaki & Bhattacharya, 2014; Mallozzi, 2013; Mason & Bohl, 2017; Plummer, 2015; Rheingold et al., 2013; Roberson & Lankford, 2010; Robinson, 2018; Ruiz-Primo & Li 2013; Shelton et al., 2016). The science notebook can provide the teacher with information on student understanding (Fulton et al., 2017; Shelton et al., 2016). An example of a technique of formal assessment of the notebook is the use of a rubric to guide the assessment.

Providing effective feedback as a component of formative assessment is another common theme in research studies about notebooks. Research has found that for the formative assessment to be effective in improving student learning, it should be provided continuously (Mallozzi, 2013; Mason & Bohl, 2017; Robinson, 2018; Ruiz-Primo & Li, 2013). Jaladenaki and Bhattachanga (2014) explored teacher experience using an interactive notebook and a rubric to provide feedback to students. In this study, the notebook was an effective, powerful strategy that promoted inquiry and is focused well on students' individual learning. Ruiz-Primo & Li (2013) and Shelton et al. (2016) also supported the idea of formative feedback in student notebooks. These studies concluded that effective feedback involves the teacher's first examining students' work and responses from investigations and then providing students with comments/feedback that will improve the quality of their learning of science phenomenon as well as address their misconceptions. Teachers can use the information reflected in students' notebooks as a formative assessment data source to determine a students' level of understanding of science content (Mason & Bohl, 2017; Robinson, 2018; Ruiz-Primo & Li, 2013; Shelton et al., 2016).

Studies have been conducted where researchers have explored diverse ways that a teacher can guide students in setting up their notebooks. The teacher's role is critical to the science notebook success (Campbell & Fulton, 2014). This can be a change in instructional practice for many teachers who have not used notebooks before. Teachers can use notebooks as a central place for students to record observations from investigations, write down questions they may have from their experiences, and reflect on their learning and understanding as they deepen their knowledge of STEM concepts (Mason & Bohl, 2017; Rider-Bertrand, 2012; Robinson, 2018). The science notebook is a place for teachers to view student work and communicate with students on their knowledge and development of concepts.

Studies conducted on science notebooks provide information and suggestions for teachers shifting to inquiry-based instruction. For example, a recent study by Mallozzi (2013) explored an interactive notebook as an instructional tool that provides students with the time needed to record what they are learning and own their understanding of a science concept while addressing prior knowledge. This specific notebook was set up as two columns in which students wrote all the factual information on the right side of the notebook and their own interpretation on the left. The study cited the teachers' importance in setting up their notebooks as a critical part of integrating the notebook into the curriculum. Shelton et al.(2016) also supported the interactive notebook as a means to foster inquiry and focused on the drawing and writing component as formative assessment strategies.

Writing in science is a natural way to integrate science and literacy. The NGSS calls for learners to be engaged in science and the science notebook provides a tool for students to record observations, thoughts, and data like scientist do (Achieve, 2013; Campbell & Fulton, 2014; Fulton et al., 2017; Jaladanaki & Bhattacharya, 2014; Shelton et al., 2016). By keeping a laboratory notebook, students can develop and practice their science skills that are needed to design experiments, make observations and summarize findings (Fulton et al., 2017; Roberson & Lankford, 2010; Shelton et al., 2016). The FOSS curriculum provides suggestions for effective notebook implementation, which incorporating the notebooks.

Implications

Inquiry-based instruction has been recommended by the NRC and is a prevalent theme in the Next Generation Standards. The NGSS recommends teachers integrate science practice and cross cutting concepts in their teaching as well as traditional science subject matter (NRC, 2012). Implementing scientific inquiry in lesson plans has been the responsibility of the teacher, but as this literature review illustrate,s there are challenges that teachers face that prevent them from doing so, including their beliefs about inquiry, their content knowledge, time challenges, and access to inquiry-based lessons. Teachers in the local district reflected these challenges; hence an inquiry-based curriculum was implemented. Based on the literature review, there are gaps in understanding the experiences that teachers have implementing an inquiry curriculum such as FOSS, as well as whether such a curriculum helps teachers circumvent some of the challenges. The findings from this qualitative project study may provide valuable information about the implementation of this new curriculum and may lead to the creation of a professional development program for teachers.

Summary

The literature review provided a synthesis of a comprehensive examination of studies conducted on what inquiry-based instruction looks like in the classroom as well as the beliefs and challenges teachers face while shifting instructional strategies. The challenges included time, content knowledge, beliefs about instruction, and lack of resources and mirrored those that teachers at the local site were experiencing. There was a scarcity of literature on teachers implementing inquiry-based curriculum with fidelity or the ways such a curriculum might circumvent challenges to implementing inquiry. This scarcity in the literature led this study's purpose to understand if and how the recently adopted Full Option Science System (FOSS) curriculum helps teachers align their practices with inquiry-based instruction and to identify what challenges they had with this current implementation. The CBAM model guided the research questions for this project study.

The following sections include a justification of the proposed qualitative methodology. This methodology section is inclusive of the research design and approach, research problem statement and questions, participant selection, access to participants and the local research site, data management, data collections and analyses, research strategies, reliability and validity measures, data presentation, ethical considerations, and protection of participants' rights.

Section 2: The Methodology

Introduction

In Section 2, I describe the methodology of this qualitative case study designed to understand teachers' experiences and challenges in a local district where an inquiry-based curriculum was implemented. I gathered data for this qualitative case study by analyzing lesson plans, observing classrooms, and conducting one-on-one interviews. The following research questions were the center of my research study:

RQ1: What are middle school science teachers' Stages of Concern (SoC) implementing the FOSS curriculum and shifting their instructional practices to an inquiry-based model?

RQ2: What is the Level of Use (LoU) of the new curriculum that is being implemented in the local district?

RQ3: What instructional strategies are teachers using that are consistent with the features of inquiry-based instruction (LoU)?

RQ4: What successes, challenges, and needs do teachers report when implementing an inquiry-based science curriculum?

A qualitative approach was appropriate for this study because I wanted to capture the experiences of teachers implementing a new curriculum. A case study is a qualitative design that relies on observing the participants in a bounded system in this case the school and the classroom (Creswell, 2012; Hyett et al., 2014; Merriam & Tisdell, 2015). Creswell (2012) defined case study as "an in-depth exploration of a bounded system based on extensive data collection" (p. 465). Yin (2017) agreed with Creswell and stated that a case study could provide a more holistic approach to data collection and provide a more descriptive result. The purpose of this project study was to first determine the level at which teachers are implementing a new inquiry-based curriculum and then provide a deeper understanding of the experiences and challenges teachers have had with shifting their instructional practice to be more inquiry-based.

In this methodology section, I detail why a case study was most appropriate for this study. I also describe how participants were selected for my study and how I scheduled the interviews and observations. Instruments used for the data collection are described as well as the results from those instruments revealing the teachers' experiences and challenges with implementing the new curriculum.

Qualitative Research Design and Approach

A qualitative research design was the most suitable research methodology for conducting this project study. A qualitative case study is a detailed description and analysis of a bounded system, like a school system (Bogdan & Biklen, 2007; Creswell, 2012; Hyett et al., 2014; Merriam & Tisdell, 2015; Thomas & Magilvy, 2011; Yin, 2017). Qualitative research looks at a specific construct in a natural setting, unlike quantitative studies, where variables are manipulated. A qualitative study is also most relevant when there is a desire to make generalizations from a sample population (Lodico et al., 2010; Merriam & Tisdell, 2015; Thomas & Magilvy, 2011). As the researcher for this study, I was most interested in the LMS School System teachers' level of use implementing a new inquiry-based curriculum as well as learning about their experiences and challenges with it. There were multiple sources of data collected (observations and one-on-one interviews) that facilitated an understanding of the local problem.

There are numerous types of qualitative research designs, including phenomenology, grounded theory, and ethnography (Hyett et al., 2014; Petty et al., 2012). Different types of qualitative research have different focuses, address distinct types of research questions, and involve distinct sample selection and data analysis techniques (Merriam & Tisdell, 2015). For example, phenomenology relies on gathering the lived experience of participants. Phenomenology was not appropriate because the data would be collected from the perspective of the individual (Creswell, 2012; Hyett et al., 2014; Petty et al., 2012). My data collection focus was not discovering of lived experiences of the teachers, but rather on the experiences they have as they shift their instructional practices in the classroom. Ethnography was not appropriate because such an approach considers the culture of a group (Lodico et al., 2010), which was not the goal of this study. Grounded theory, which requires the development of a theory (Creswell 2012), was also not appropriate for this study.

I concluded that a qualitative case study was the best choice to examine the experiences of middle school science teachers shifting instruction to be more inquiry-based. A case study provides a detailed analysis of a bounded system, such as classrooms and the activities of teachers and students who participate in such systems (Petty et al., 2012). A qualitative case study encourages attempts to understand such phenomena (i.e., classrooms from the perspectives of those who interact in them; (Merriam & Tisdell, 2015). Thus, the most appropriate form in which to study the challenges experienced by science teachers implementing a new inquiry-based curriculum was the qualitative case study.

For this case study, I used elements from the CBAM, SoC, and LoU, classroom observations, which included observing parts of the 5 E lesson plan, and one-on-one interviews to collect data. The purpose of the research I collected was meant to first determine the level at which teachers are implementing a new inquiry-based curriculum and then provide a deeper understanding of the experiences and challenges teachers have had with shifting their instructional practice to be more inquiry-based.

Participants

This qualitative study was conducted in a large urban district where there are approximately 40 middle school science teachers in nine different schools. Purposeful sampling was used to select participants, which included 14 teachers from six different middle schools. A researcher should create a list of criteria that are relevant and aligned to the research questions and then screens for candidates who meet these criteria (Merriam & Tisdell, 2015; Ritchie et al., 2013). Several criteria helped identify those teachers who could provide reliable, in-depth information concerning the implementation of the new FOSS curriculum. Those criteria are as follows:

- Teaching in the local district and in grades 6-8
- Have at least 3 years of experience teaching science
- Have a secondary level (initial or professional) teaching license in Massachusetts for grades 6, 7, and 8
- Have implemented at least one inquiry-based curriculum unit this year

Homogeneous purposeful sampling allowed me to select individuals based on common characteristics (see Creswell, 2012; Ritchie et al., 2013). The setting for this case study, in which the participants worked, is a shared district that is currently implementing the FOSS curriculum. In this district, nine middle schools are involved in the FOSS inquiry-based curriculum implementation. I had intended for the sample size to be at least 10 participants, drawn from at least five of the nine middle schools in the district. An ideal sample size for qualitative studies is between eight and 12 participants (Baskarada, 2014). The middle school teachers had to meet the selection criteria, and the selected teachers provided the totality of the data used in this case study (see Saunders-Stewart et al., 2015). I continued interviewing potential participants based on the selection criteria until all teachers who were willing to participate had been given the opportunity. This resulted in 14 teachers from six middle schools being included in the case study.

Procedures for Gaining Access to Participants

Shaw (2013) showed that gaining access to participants is an essential element in qualitative studies. I worked with the science curriculum coordinator, and the district Coordinator of Research, Testing and Assessment to gain access to participants in the local district. After gaining permission from the Walden Institutional Review Board in March of 2019 (approval #05-30-19-0530999) to conduct my study, I obtained permission from the school district. This began with support from the science curriculum coordinator who read my proposal and assisted me in emailing the Coordinator of Research, Testing and Assessment to ask him about the protocols and procedures I needed to follow for conducting research in the district. I was provided with “The Policy Manual of the Public Schools,” which outlines the guidelines for conducting research in the district. I typed a proposal for the district to review ensuring I complied with the district policies. The Coordinator of Research and the Science Curriculum Coordinator supported my research and assisted me in obtaining school committee approval. In May of 2019, I presented my study to the school committee and was granted permission

The science curriculum coordinator served as gatekeeper at the district level and helped me access the participants for the study. Gatekeepers are individuals at the site that help gain access to participants (Creswell, 2012). I was granted preliminary permission via email, from the Coordinator of Research, Testing and Assessment, and then presented my study to the school committee. The coordinator required a brief summary of my study, how I was recruiting teachers, and an explanation of how this would not interfere with the teachers’ job performance. I also included a letter of support from the science curriculum coordinator and ensured it aligned with the district policy.

Once I had the school committee approval in May 2019, I prepared and sent an email explaining the purpose of my study to the middle school science teachers eligible to participate in the study. The district science curriculum coordinator was included in these emails. I obtained a list of all the middle school science teachers who met the selected criteria from the science curriculum coordinator. In my email to the potential participants, I provided them with the goal of my study and the necessary consent forms they needed to return to me. Any teacher interested in participating in the study sent the consent form back to me via interoffice mail or emailed within a 2-week period.

The informed consent acknowledges that the willing participants are aware the study is voluntary, and the participants have been given information about the study including the procedures and risks involved with the study (Lodico et al., 2010). Participants of a study must comprehend the voluntary nature of the study, sign a consent form that guarantees confidentiality, and be debriefed as to their understanding of informed consent (Lodico et al., 2010). Fourteen participants completed the informed consent before the observations and one-on-one interviews were conducted. Teachers did not provide lesson plans, instead I used the 5E lesson plan template during my observations to note which parts of the 5E were visible during the investigation.

Establishing the Researcher-Participant Relationship

Trust between the researcher and the participant is essential because the researcher is dependent on the participant for guidance in unfamiliar territory (Creswell, 2012; Merriam & Tisdell, 2015; Petty et al., 2012). It is vital for the researcher to initiate and maintain a professional relationship for the duration of the study and remains respectful and non-judgmental (Bogdan & Biklen, 2007).

I have been a teacher in the local district supporting this study but have no supervisory role. I formed positive relationships with the other teachers in the district, and we have a collegial relationship. It was a possibility, however, that I would not know the participants in the study.

Before each observation and interview I reviewed the goals of my study and reinforced that I was only there for research and had no supervisory role. I helped create a trusting environment by ensuring the teachers I was interested in their experiences implementing the FOSS curriculum and was hoping to make things better moving forward. After the observations and before the one-on-one interviews, I reviewed the observation notes with each participant. During the interview, I was able to create an atmosphere in which the participants were comfortable discussing their experiences with me.

Protection of Participant Rights

The protection of human subjects in research studies is important legally and ethically and must be given careful consideration. According to Demirdirek (2011) and Creswell (2012), researchers have an ethical responsibility to ensure no harm comes to the participants and that their lives are not disrupted because of participation. In this qualitative project study, I protected the participants by following the requirements of Walden University and adhering to district policy.

Once the approval was obtained from Walden University and district personnel, I presented a brief summary to the school committee. I made initial contact with the qualified potential participants through their school email that included an explanation of the purpose of the study and an informed consent document for the participants to sign. Obtaining informed consent is a critical element of protecting the participants from any risks (Creswell, 2012; Hammersley, 2014; Houghton et al., 2013; Yin, 2017). The informed consent document provided a basic overview of the purpose of the study as well as information reassuring the participants they are contributing freely in the study and would not be coerced in any way. Once I had a list of willing participants, I emailed them the interview questions, LoU, and SoC that would be used during the one-on-one interview. The participants also emailed me a convenient class period and day for the observations and interviews.

Matters of privacy and confidentiality are important ethical considerations that must be addressed in qualitative studies (Creswell, 2012; Petty et al., 2012; Yin, 2017). To protect the teachers in the study, all data collected remained confidential. Pseudonyms were established that included a school code, grade level and number. No other identifying information about the participants was included. All of the raw data were transcribed into a Google Doc that is password protected and is my personal account. After the data were transcribed into Google Docs the original raw data was stored in a locked file cabinet. All data will be stored for a period of five years after the conclusion of the study. After this time, I will dispose of the data by shredding the documents and removing the electronically stored files from the Google Documents In order to maintain confidentiality, interviews were conducted in a neutral location of the participant's choice.

Data Collection

This project study seeks to understand teacher experiences with the use of inquiry-based instruction to teach middle school students. To answer this inquiry, qualitative data were collected from two sources including (a) observations of inquiry-based lessons, and (b) interviews with science teachers. My initial proposal included the collection of lesson plans however it was discovered teachers were not writing explicit lesson plans. I used the 5E lesson plan template as part of my observation. This provided insight into what portions of the 5E were visible during my observation. Multiple data sources added to the credibility of research (Yin, 2017). The CBAM, which frames this study, includes the Stages of Concern (see Appendix C) and Levels of Use (see Appendix D), which were used for data collection. Permission was granted from SEDL to use their instruments for my study (see Appendix B). Data Collection did not begin until I had received approval from Walden University's Institutional Review Board.

The CBAM Levels of Use was used to assist me in designing my own interview questions in order to explore how this particular FOSS curriculum was implemented and what challenges teachers encountered. The LoU and SoC instruments were used as a way to categorize teacher experience with the change. Research has indicated the CBAM instruments can be given to a teacher as a diagnostic tool and can be part of an interview (Gabby et al., 2017; Grundy & Berger 2016; Yeldell, 2017). These researcher-designed questions answered research questions 2, 3, and 4. In addition, classroom observations and lesson plans were used to address research question 3.

The CBAM LoU and SoC were emailed to the participants with the interview questions and further discussed during the one-on-one interviews. The stages of concern and levels of use were discussed during the interviews and addressed research questions 1 and 2. Teachers were asked to identify their LoU and SoC with implementing the FOSS curriculum. The LoU can determine if and how the new curriculum is being implemented and the SoC can address challenges and perspectives teachers have on shifting their instructional practices.

Observing classrooms and analyzing lesson plans has been found to provide insight into the wide range of instructional practices being utilized by the teacher (Capps

& Crawford, 2013). Using these data collection methods along with the CBAM instruments will allow me to understand teacher experiences and challenges with implementing inquiry using the FOSS curriculum and determine the ways in which the new curriculum has helped teachers shift their instructional practices. Each data collection tool is described below.

Lesson Plans

The NSTA, in coordination with the NGSS, claim that scientific practices in the classroom can be centered on the 5Es of inquiry to develop high-quality lessons that support understanding of science phenomenon (Aji et al., 2018; Creghan & Creghan, 2013; Enugu & Hokayem, 2017). The science curriculum coordinator in the district for this study encourages science teachers to use the 5 E lesson plan (Appendix G). The 5 E lesson plan aligns with the FOSS curriculum and includes the following components: engage, explore, explain, elaborate and evaluate, (described above). There are certain times teachers spend on each 5 E component of the lesson plan being implemented. Recent studies examined the professional journey of science teachers and how they utilized the 5 E lesson plan in their studies (Bahng & Lee, 2017; Enugu & Hokayem, 2017).

One lesson plan was requested from each participant for observation. All participants were asked to forward a lesson plan via Google or email. The lesson plan was to align with the lesson to be observed and provided information on which FOSS kit was being implemented, plans for instructional strategies, and organization of the lesson. This data addressed research question 3. The lesson plan can serve as evidence of instructional strategies that are aligned with inquiry-based instruction. If teachers did not provide a formal lesson, a lesson outline was accepted if it met two criteria: the lesson outline matched the observed lesson and contained the FOSS module observed. Having the lesson plan information prior to the lesson allowed time to review the lesson that I observed and understand which FOSS lesson I was observing. I discovered that none of the teachers wrote formal lesson plans, and only one out of 14 teachers provided a lesson outline. As a result, I used the lesson plan template during the observations to take notes on the 5E portions of the lesson that were visible during the investigation.

Observations

Observational data represents an authentic encounter with the phenomenon of interest (Merriam & Tisdell, 2015) and is often used in qualitative studies. I observed the lesson that coordinated with the lesson plan or lesson outline collected from each participant. The observation was scheduled for 45 minutes (one class period). An observation checklist and recording sheet were used during the observations to record what happened, when, and what opportunities to engage in inquiry/science practices were occurring (see Appendix F). The observation checklist consisted of columns on which I recorded the time at which the 5E components of the lesson occurred, which of the 5Es were evident in the lesson, a brief description of what the teacher and students were doing during the lesson, a notation of which science practices were evident and any other notes or questions I may ask during the interviews. I noted any additional indicators of inquiry (notebook usage, material management, cooperative groups) and how they were used in the lesson. The science practices columns included indicators of the NGSS science and engineering practices that students engaged in during each lesson. Opportunities for inquiry-based activities can be measured according to the science practices that are present. A teacher that is implementing an inquiry-based lesson using the 5 E lesson plan can be seen spending about five minutes engaging students in the lesson, at least a half-hour allowing students to explore with science phenomenon and collecting data, and finally, about ten minutes elaborating and expanding. During the last ten minutes, the teacher should be wrapping up the lesson and allowing students to process what they learned and ask any remaining questions (Abdi, 2014; DiBiase & McDonald, 2015).

Interviews

After the observations were completed, I conducted one-on-one interviews with the participants. A digital voice recorder was used to record the interviews. Qualitative interviews allow for a greater depth of detailed information, and the researcher can expand the inquiry essentially without limit (Merriam & Tisdell, 2015). Open-ended questions can guide the conversation, ensure that bias is not present, and become an important evidence source (Baskarada, 2014). During qualitative interviewing, it is important to ask open-ended questions to get the participant's broadest perspective (Bogdan & Biklen, 2007). The interview questions were designed to capture teachers' perspectives of the use of the FOSS and change in their instruction (Appendix H).

I used the CBAM framework to design my interview questions and utilized the LoU and SoC at the beginning of the interviews to establish what level of implementation teachers were at with the FOSS curriculum. The CBAM is a diagnostic tool that researchers can utilize to evaluate the change process in the school (SEDL, 2016). I used the tools to evaluate the LoU and SoC (Appendix C and D) to determine how the curriculum was being implemented and what challenges the teachers currently had. Teachers were specifically asked what LoU and SoC they identified with on the chart. These tools have been validated by a few research studies that seek to understand the change process occurring with implementing a new curriculum (Gabby et al., 2017; Grundy & Berger, 2016; Yeldell, 2017). The LoU and SoC were appropriate diagnostic tools used at the beginning of the interviews to understand the change process happening in the middle schools in the local district.

Fourteen one-on-one interviews were conducted with the participants immediately following the observations. Each teacher was given the choice to interview off-site; however, all participants decided to schedule the interview at the school site. Each teacher participant was scheduled for a 45-minute interview, and two teachers, because of time constraints, opted to answer a few questions via email. I received those responses within two days of the interview. Each in-person interview lasted approximately 30-45 minutes.

Before each interview, I explained participants' rights, collected their forms and reviewed the purpose of my study. I asked each question and created a consistent dialogue where I could ask clarifying questions of the participants as needed. I took notes answering each interview question. I also identified the SoC and LoU of each participant by asking each participant to identify which stage they identified with implementing FOSS. Once the interviews were completed, I reviewed the answers with the teachers for accuracy. After the interviews, I reviewed the audiotaped recordings and compared them to my handwritten notes. I created a WORD computer document for the purpose of analysis to transcribe the interview questions and answers. All original notes are stored on a password-protected computer and the raw data, and original tapes are kept in a file cabinet and will be kept for a period of five years,

Sufficiency of Data Collection

Participants were selected to share their experiences with implementing the FOSS curriculum. Data collection was considered sufficient when saturation was reached. Failure to reach data saturation impacts the quality of the research conducted and hampers content validity. Data saturation is reached when there is enough information to replicate the stud when the ability to obtain additional new information has been attained, and when further coding is no longer feasible (Creswell, 2012; Fusch & Ness, 2015, Yin, 2017). Both sources of data, interviews, and observations, were therefore analyzed multiple times until producing the same results, and no new information emerged. The lesson plans were not collected but rather became part of the observation data. During the interview, participants were asked probing questions to elicit detailed responses about their experiences shifting to the FOSS curriculum.

System Tracking Data

Once data were collected from observations and audio recorded interviews, Google docs were used to electronically store the data. I scanned all the signed consent forms, observations and interview responses and saved as pdfs into my personal Google drive. Once the observation notes were completed, I typed them into Google docs and will store all the raw data in a locked file cabinet for the duration of five years. The observations included the notes I took on the lesson plan template of the science practices observed and the parts of the 5E lesson I observed. I transcribed the interview line by line into a WORD document in Google Docs. All the transcribed data is stored on Google Docs on my home computer, which is password protected and easily accessible by me. All data will be stored for the duration of five years.

Role of the Researcher

During the data collection, I served as the interviewer and observer of this study. I have been teaching in the school district for 20 years but serve no supervisory role. I explicitly explained to all participants the purpose for the study and that my role would strictly be as a researcher.

I have experience with the FOSS curriculum and taught it for two years before moving to a position at the high school. I was also an integral part of the original curriculum alignment of the FOSS modules. This first-hand experience and knowledge helped me know the background on how FOSS was structured and gave me the foundation for my research.

As a researcher, I conducted myself in a professional manner respecting each participant’s time and ethics. Once the teachers agreed to participate in my study, I let the teachers choose the day and time that would be best for me to observe. I was able to schedule multiple participants in one day, working around their schedules.

Data Analysis

The purpose of this qualitative case study was to increase understanding about the experiences and challenges teachers have had implementing an inquiry-based curriculum, using FOSS, and to determine how the new curriculum has helped teachers shift their instructional practices. I used a qualitative approach to collect, transcribe, and analyze the data to address the local problem and research questions. The data analysis process in qualitative studies involves selecting the units of study, coding these units into categories, and finding themes within the coded categories (Cho & Lee, 2014; Ravitch & Carl, 2016; Patel (2014); Saldana, 2015). I will be using coding practices established by Merriam and Tisdell (2015), Creswell (2012), Patel (2014), and Saldana (2015). There were 14 participants from six different middle schools who met the inclusion criteria and volunteered to participate in my study. I assigned each participant a pseudonym that included a letter representing the school where they taught and a number representing their grade level assignment.

Once the data were collected and reviewed, I used Microsoft Word to initially transcribe the interview transcripts and classroom observations. While the initial research plan included collecting and analyzing lesson plans, teachers did not provide them. Notes about the elements of a 5E lesson plan present in the observed lesson were included in the observation protocols and analyzed as part of that data set. Each interview was audiotaped, transcribed, and reviewed several times for accuracy. Next, I created a codebook using Google Sheets to organize all the data analyses.

The analysis provided further information into the Stages of Concern (SoC) a teacher had and the Levels of Use (LoU) with the FOSS curriculum (research question #s 1, 2, 3, and 4) as well as the challenges and success teachers had with implementing the

FOSS curriculum. Qualitative data analysis is a process that allows collected data to be organized in a manner to bring meaning to the data (Creswell, 2012).

Coding Procedures for interviews

I used two coding strategies for reducing the data into themes. First, I used selected constructs from the conceptual framework as a priori codes. Next, I used a word cloud program to begin the open coding process, where I looked for categories of words and phrases that emerged.

A priori coding. I began with a series of a priori codes, developed from key concepts from the conceptual framework. The a priori codes included the CBAM LoU and SoC, science practices, and the 5E lesson plan. Teachers stated what their LoU and SoC were and I verified this information by identifying evidence from statements in the interview transcripts. During the observation, I tallied which science practices and parts of the 5 E lesson were visible during the FOSS investigation based on the framework's constructs.

Open coding. After a priori coding I used open coding to examine the data for emergent words and phrases that emerged from the data. I started with a word cloud program called WORDLE (Appendix I). Next, I reviewed the interview transcripts for other key words and phrases related to or missing from the word cloud. I color-coded the challenges, successes, needs notebook usage, and professional development. I then began collapsing like terms together and began organizing the words into categories. The categories led to the themes.

Codebook. Once the interviews and observations were transcribed and clarified for accuracy, I organized the sets of codes and data into a codebook. I used a Google Spreadsheet with multiple sheets to organize the transcribed data. This served as my codebook for my first level of coding. The first sheet I developed listed each interview question, answer from each participant, and recorded the research question addressed. This organization allowed me to refer back to the responses and have them all on one sheet. The a priori codes, based on the 5E and the eight science practices, were placed in the second spreadsheet. On another sheet, the a priori codes for the LoU and SoC were recorded. This included which category the teacher identified with and interview evidence to support or negate this category. On a third spreadsheet, I identified the challenges and success teachers had shared with me during the interviews. I completed this by color-coding the transcribed interviews for the challenges and successes in implementing the FOSS curriculum. On the fourth spreadsheet, I began coding the data for the interviews by first creating a word cloud to look for the most used phrases. Those 30 final terms were added to the codebook. I reviewed the interviews and the word cloud to look for other terms and phrases that frequently appeared in the interviews. Finally, a fifth sheet was created to code the key words and phrases that emerged from the observations and these were added to the codebook.

Developing themes. After both data sets were analyzed using a priori and open coding and recorded in a codebook, I began combining the key terms and phrases into similar categories (Appendix J). These categories were further combined in logical groups to emerge as themes relying on the research questions for guidance.

Creating the themes is a method of making meaning from the data collected that is related to the conceptual framework and research questions that guide the study (Creswell, 2012; Merriam & Tisdell 2015; Patel, 2014; Saldana 2015). The four common themes were identified from all three data sources and are aligned to the research questions and conceptual framework. Table 1 lists the four themes that were identified.

Table 1

Summary of Themes Derived from Interviews

Theme	Description
1	Teacher response to change
2	Integration of inquiry-based instruction
3	Teacher confidence in shifting instruction
4	Professional development needs

Analysis of Observations

Teachers were asked in the initial email if they would be willing to have me observe one FOSS investigation. Each teacher participant was asked to provide a lesson plan for the lesson I would be observing. A lesson plan template is recommended but not required by the school district. Observations were scheduled on dates when on-on-one interviews could be conducted immediately afterward. This allowed for immediate comparison of interview responses with actual teaching practices and triangulation completed during data analysis. I recorded detailed descriptions of the FOSS investigation, science practices, and the 5 E parts of the lesson observed in the lesson (Appendix G). It was discovered during the observation scheduling that the teachers were not writing explicit lesson plans. Therefore, during each observation I used the lesson plan template and circled the levels of the 5 E lesson observed during the investigation and I noted evidence of each for the 5 Es. The 5 E lesson plan and the NGSS science practiced served as a priori codes. I then used open coding for the notes I recorded on the observation template.

First cycle. The data collected from the classroom observations were level one coded using the NGSS science practices and the 5 E as a priori codes. Teachers and students were observed for their use of each 5 E component of the lesson and what NGSS science practices that may have occurred during the lesson. Since teachers did not provide a lesson plan, I also wrote notes on the lesson plan template of the parts of the 5E lesson I observed. Aspects of the lesson gave opportunities for the five Es of engage, explore, explain, elaborate and evaluate, consistent with the FOSS curriculum were coded (Appendix G) relative to the 5Es. During my observation of the FOSS investigation, evidence of science practices was also recorded and verified based on student actions in the classroom.

Second cycle coding. Like the analysis of interview data, during the second cycle of coding, I used open coding to read over the notes from the observation of each participant and highlight key words or phrases, as suggested by Patel (2014). Similar words or phrases were color-coded using the highlighting tool for notebook (orange); focus question (red); material usage (pink), instructional strategies (magenta). I also noted the student and teacher role during the observed lesson. This was all recorded in the codebook and the data collected were used to support the categories and themes that had emerged from the interview data.

Third Cycle coding. The observation data were used to support the themes that emerged from the interview data. A thematic analysis approach (Cho & Lee, 2014; Patel, 2014; Ravitch & Carl, 2016;Saldana, 2015) was used to review which of the parts of the 5E and science practices were more prevalent. The 5Es present in the lesson are a guide for teachers as they implement an inquiry-based lesson. The 5Es became part of Inquiry-Based Instructional Strategy theme (Appendix J). The 5Es recommended by the NSTA in coordination with the NGSS to support high quality lessons that support understanding of science concepts (Creghan & Creghan, 2013). The FOSS curriculum follows and integrates the 5 E into each investigation. The science practices also support the inquiry-based lesson (NGSS, 2019).

Analysis of Interviews

The interviews were structured to help identify the participant's challenges and success with shifting instruction to be more inquiry-based while implementing the FOSS curriculum. The interviews occurred immediately following the observations in a predetermined area chosen by the participant. The interview protocol and CBAM instruments guided my interviews (Appendixes C, D, and H). I analyzed a total of 14 one-on-one interviews and this occurred before I analyzed the observations. In addition to the interview questions, each teacher first identified their LoU and SoC with curriculum implementation. The LoU and SoC served as a priori codes. Upon completion of the interviews, participants reviewed the transcripts and received a summary of the findings.

Later, the recorded interviews were transcribed into Google Docs verbatim. I listed each interview question and participant answer into Google Docs, which allowed me to review and compare the data with the handwritten notes.

First cycle coding. First, I used a priori codes based on SEDL's (2016) LoU and SoC criteria to identify the teacher's LoU and SoC with the FOSS curriculum. For coding purposes, I used the following a priori codes in the interview data: LoU 1 (Routine), LoU 2 (Refinement), LoU 3 (Integration), LoU 4 (Renewal), SoC 3 (Task), SoC 4A (Consequence), SoC 4B (Collaboration) and SoC 4C (Refocusing). In order to confirm participant's self-reported LoU and SoC, I verified the identification of the LoU and SoC with key words and phrases in the transcribed interviews I used suggestions from SEDL (CBAM, 2016) on what key words I should look for in the interview data to help indicate which LoU and SoC the teacher was in and if it aligned to where they stated they were (Appendix E).

I went through the interview transcript looking for key words and phrases that provided confirmation for a teacher being at a particular level on the chart (Appendix E). I reviewed the codes of the LoU and SoC to look for similarities in the other emergent codes from the interview. Some of these key words were present in the emergent codes from the interview. These codes were added to the third pass categories and added to the themes that had emerged from the data. The LoU and SoC provided more evidence for the emergent themes (Appendix J).

Second cycle coding. After a priori coding, the second cycle included an open process looking for descriptive words and phrases from the interview transcripts. These words were grouped into categories and eventually themes. I began by using a word cloud program, WORDLE (wordle.com) to create a word cloud of the transcribed interview data (Appendix I). WORDLE is a tool that allowed me to customize a word cloud. The word cloud allowed me to visually see which words were most common in my interviews. The words that occurred the most appeared larger on the WORDLE. The WORDLE also eliminated pronouns and other common English words in the word cloud. The WORDLE I created started with 100 words, which I reduced to 50 in order to narrow the focus of the most common words and then finally reduced to 30. This data analysis involving open coding was recorded on a Google Sheet (Appendix J). I reviewed the WORDLE cloud results adding and combining key terms (i.e. student and kid; student and students). This combining of terms ended with 30 words as a reasonable amount to focus on and I could begin to see meaning in those terms.

After the WORDLE helped identify the most used words/phrases, those 30 terms were added to the codebook (Appendix J). During the second coding pass, I combined a few key words/terms from WORDLE and collapsed the list into 20 words. Once I reviewed the word cloud, I was curious about a few key concepts that did not appear to emerge directly from the WORDLE. This led to me reviewing the interview transcriptions and color-coding for some emerging phrases and ideas about notebook usage (orange), professional development needs (yellow), challenges with implementation (pink), and successes with curriculum implementation (green). These other key ideas aligned with the RQ I had developed therefore I was looking for specific data on these items and I wanted to align them or add them to the WORDLE.

Third cycle coding. During the third coding pass of the interview data, I began organizing the key terms into categories (Appendix J). This occurred by grouping similar codes into categories. There were five categories that I organized all the codes into. One example was the challenges identified from the interview and the SoC. Some of these challenges included the following words: time, materials, curriculum, standards, grade, and management. This eventually collapsed into the theme on PD and Teacher Response to Change. Another category I developed was Inquiry-Based Practices which included the words notebook, think, FOSS, investigation, and student/kids. This category led to the theme on integration of Inquiry-Based Instruction. I continued to use open coding that collapsed into categories until I arrived at four themes: Integration of Inquiry-Based Instruction, Professional Development Needs, Teacher Confidence in Shifting Instruction, and Teacher Response to Change.

Establishing Credibility

Several steps were taken to ensure that this research study maintained high quality. First, I engaged in member checking with each teacher that I interviewed, ensuring that my account of his or her words was accurate and truthful. I went over each interview question with them and read to them what I had written down. I also shared the observation data that I collected in their classroom by sending a copy of each teacher's observation via inter-office mail. After my interview notes were confirmed, I coded the data looking for similar categories, which eventually developed into themes in the data. Once I had established the main themes and analyzed the results, I shared a summary of my findings with the teachers.

I used the observation data to triangulate what teachers described in their interviews to ensure accuracy. Triangulation involves comparing and checking the various data sources to confirm information (Creswell, 2012; Yin, 2017). Triangulation was achieved by comparing the transcriptions and themes from the multiple data sources. I reviewed the key words and phrases from the interview transcripts and from the observations. The observation data were used as evidence from the already emerging themes from the interviews. The interviews served as the main data source and the classroom observations including lesson plan notes helped support the findings and confirm the themes.

Discussion of the Findings

The purpose of this study was to understand teacher use of, experiences with, and challenges with implementing the FOSS curriculum and to determine the ways in which the new curriculum has helped teachers shift their instructional practices. There were four research questions guiding the data collected from the lesson plans, observations, and interviews. The interview protocol, observation and lesson plan templates, as well as the CBAM instruments SoC and LoU that were used are in this study assisted in providing rich descriptions of data that would help in answering the research questions that would help the school district move forward with the FOSS curriculum (Appendixes C, D, F, G, and H).

Overview of Themes

Data from the 5 E lesson observations, and one-on-one interviews were analyzed to identify four emergent themes (Figure 1). I used a priori and open coding to analyze the data and answer the four research questions. This analysis led to the four themes that emerged from the collected data collected which included teacher response to change, teacher confidence in shifting instruction, integration of inquiry-based instruction, and professional development needs.

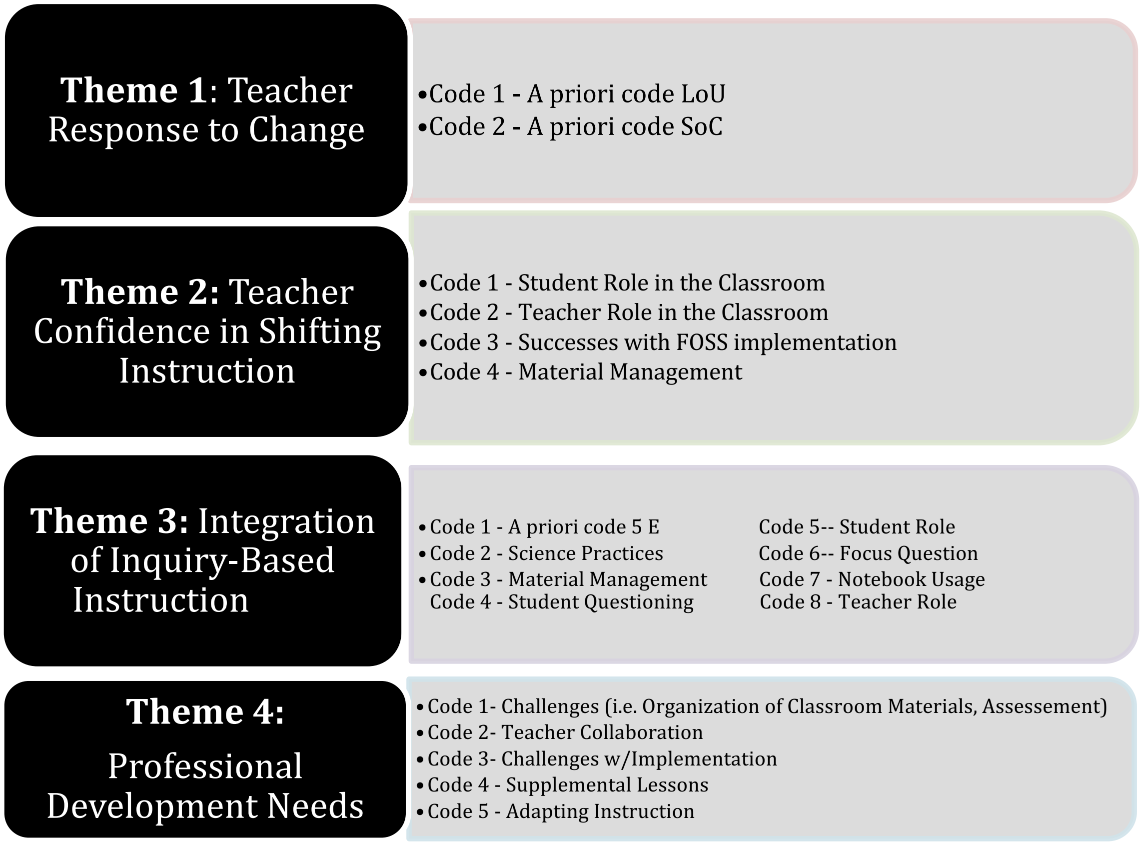

Figure 1. Codes within the themes.

Theme 1: Teacher Response to Change

This theme emerged from the interviews and observations with each participant identifying their LoU and SoC implementing the FOSS curriculum. Identifying the LoU and SoC provided some insight into how teachers identified themselves with shifting their instruction to be more inquiry-based. During the interviews and observations, I learned about the teachers' experiences shifting their instruction to be more inquiry based. The individual teacher response to change was evident in these data sets.

Each teacher self-identified their LoU and SoC and then I looked for evidence of this in the interview transcripts. This LoU is in response to the level of implementation where teachers saw themselves. Twelve teachers were confirmed to be in the refinement level of use, which is a strong indication that these teachers were ready to help increase the success of the program (CBAM, 2016). Teachers who are in the refinement stage indicate a need for teachers to review the current curriculum being implemented and discuss supplemental lessons (SEDL, 2016). During the interviews, teachers shared with me the different lessons they were implementing. Teacher B6-1 shared a supplemental lesson on the Human Body that she felt enhanced the FOSS investigation. Another teacher, F8-4 stated: "there were some standards missing from the FOSS so that supplemental material had to be added into the curriculum." Supplementing lessons to make it better is a key component of the refinement stage.

Interview questions number three and 12 specifically focused on how the FOSS curriculum had helped them shift instruction and what the role of teacher and student were in the classroom. Eight teachers responded that FOSS was a good framework to follow and was a sufficient manner for students to discover science content (teachers A6-2, D6-3, A7-2, C7-5, B8-1, A8-2, F8-3, F8-4). All 14 teachers also stated that the role of student and teacher had changed in the classroom. "Shifting to using the FOSS curriculum has made me more of a facilitator of the student learning. The teacher circulates the room to check for understanding as the students explore with hands on manipulatives trying to solve a problem" (teacher B6-1). One teacher (A7-4) specifically stated she felt more confident in her abilities to teach inquiry-based science using the FOSS curriculum.

The second part of the teachers' responses to the change theme identified what stage of concern teachers had with implementing the FOSS curriculum. Every teacher indicated their stage of concern to be collaboration and refocusing. The SoC helped identify the concerns teachers have implementing a new curriculum, which can provide information that can have an influence on the change process (CBAM, 2016). The CBAM provides descriptions and strategies to guide change for each stage. The collaboration stage indicates teachers are looking for consistent time to collaborate with one another about FOSS implementation. Teacher B8-1 stated, "teachers need time to meet with the same grade level teams." Teacher B6-1 and Teacher A7-3 discussed the importance of sharing supplemental lessons to develop commonality among all classrooms. Teacher B7-1 supported these statements about collaboration. Teachers indicated they wanted to meet with other teachers is evidence they are in the collaboration stage of the SoC.

The evidence from the data supports the importance of refocusing and collaboration will be key to moving forward with the FOSS curriculum in the district. The a priori codes were combined with the descriptive codes to become patterns which developed into themes. This theme derived mainly from the information teachers provided pertaining to their LoU and SoC. All of the teachers were implementing FOSS at varying levels and had different areas of concern. According to the CBAM framework, change is a process not an event and this process takes time (SEDL, 2016). Changes in classroom practice can take from three to five years to be fully implemented. Theme one answered research questions one and two identifying what stage teachers were at implementing FOSS and what concerns they had.

Theme 2: Teacher Confidence in Shifting Instruction

The theme of teacher confidence emerged from my observations and interviews on the teachers' experience shifting their science instruction to be more inquiry-based using the FOSS curriculum. This theme contributed to answering research question three which focuses on the teachers shifting instruction to be more inquiry-based as well as research question four where I was seeking to understand the successes teachers had with implementing the FOSS curriculum. Teacher confidence can be viewed as a success for all of the teacher participants. Each participant indicated that the FOSS curriculum increased their confidence in shifting their instruction to be more inquiry-based. The data revealed teachers were more confident in shifting their instruction because the FOSS curriculum provided the teachers with all the resources they needed including lesson plans and materials. Teacher A7-4 stated: "FOSS provides detailed video explanations of how to teach specific lessons which makes me feel more confident knowing I am teaching what I am supposed to be teaching in the correct way."

Other key terms that emerged into the teacher confidence theme were successes identified during the interviews, teacher role, student role, and material management. The teachers stated their classrooms were now more student-centered and hands-on. Students were now more active participants generating their own knowledge about science practices. This was evident in the observation where teachers let students explore with science phenomenon. Teacher A7-4 stated, “kids are excited about doing science.” Teachers A7-4, B6-1, and A7-3 agreed that the FOSS was motivating and engaging students. Teacher B8-1 discussed how the focus question was designed to “hook” the students’ interest.

Teachers indicated another benefit to the FOSS curriculum was that FOSS provided all the lessons and materials. This increased the teachers’ confidence in knowing they were implementing inquiry units. Another aspect of teachers having more confidence in implementing the inquiry-based lessons that teachers shared was that they no longer needed to write explicit lesson plans because everything they need is outlined in the FOSS manual. Teacher B7-1 stated, “All the materials teachers need are at their fingertips.” It became clear implementing the FOSS assisted the teachers in having more confidence in their abilities to shift instruction from teacher-directed to being more inquiry-based. The FOSS curriculum is assisting in building teacher confidence because it guides teachers in implementing inquiry-based instruction effectively (FOSS, 2020). Theme 2 provided evidence for research question two.

Theme 3: Integration of Inquiry-based Instruction

Multiple codes from the two data sources contributed to the emergence of the theme, integration of inquiry-based instruction. These codes included the evidence of science practices, the 5Es, FOSS investigations, notebook usage and assessment, the focus question, student centered, and teacher/student role in the classroom. This theme contributed to answering research question three which was attempting to discover what instructional strategies teachers were using that are consistent with inquiry-based instruction.

Inquiry-based learning involves creating a classroom environment that fosters students asking questions, collecting data, and constructing their own meaning of science concepts (Castle, 2014; Pedaste et al., 2015; Rivera Maulucci et al., 2014; Volkinsteine et al., 2014). In an inquiry-based classroom, students are involved in their learning and teachers are seen facilitating the learning. The observations and interviews revealed how teachers shifted their instruction to be more inquiry-based using the FOSS curriculum. The observations provided evidence that students were more involved in exploring with science content using the science practices to engage in science phenomena. The 5Es are an instructional model for inquiry-based instruction and were present in the observations of FOSS investigations.

The science practices describe behaviors scientists engage in as they investigate science phenomenon and solve meaningful problems. The evidence of science practices is an essential part of inquiry-based instruction where students are investigating the natural world and solving problems (NRC, 2015). Figure 2 displays the result of the science practices that were observed in the classrooms.

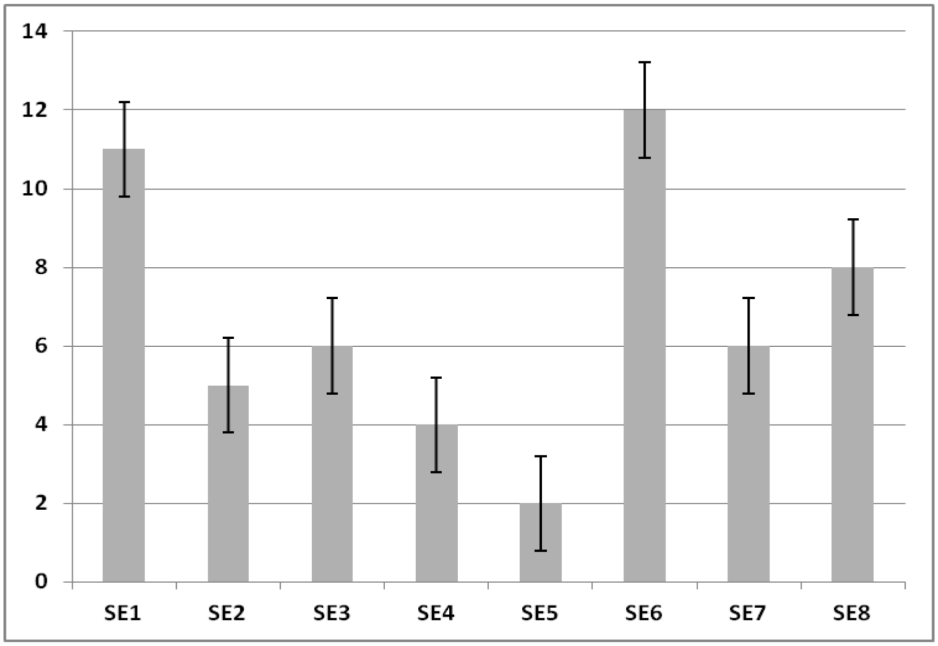

Figure 2: Results of 8 Science Practices*

**Note.* The vertical axis represents number of teachers while the horizontal axis represents the 8 science practices.

The science practices and the 5 E lesson plan are a model for hands-on, student-centered learning and were evident in the teacher lesson plans and observations. Figure 2 displays the science practices teachers used: (1) asking questions, (2) developing and using models, (3) planning investigations, (4) analyzing and interpreting data, (5) using mathematical thinking, (6) constructing explanations, (7) engaging in argument and (8) communicating information.

None of the teachers wrote formal lesson plans, but used the FOSS website for their lesson planning. FOSS is divided into modules, which are subdivided into 8 to 10 *investigations* (i.e., lessons). The FOSS teacher manual includes a detailed explanation of how the investigation should unfold in the classroom. FOSS also aligns each investigation to the NGSS standards and the science practices. There are also teacher notes for how to implement the 5E parts of the lesson plan.

The 5Es can serve as a guide for implementing inquiry-based instruction (Idsardi et al., 2019). From observing, it was determined that “engage” from 5 E is the most utilized part of each lesson. The focus question guides the students’ inquiry and makes the goal of the unit very clear to the teacher and is designed to engage students with the science phenomenon, and gives the students a challenge to be met or a mystery to be solved (FOSS, 2020). The focus question guides each investigation and makes the learning goal explicit. Two teachers were not implementing FOSS, but rather a supplemental lesson. However, these two teachers launched their lessons with a problem that students were trying to solve, which is similar to the focus question. The students were observed utilizing a notebook format for laboratory wrote the focus question in their journals. One teacher pre-printed the focus question for students to paste in their notebooks. The teachers using a binder also had students write down the focus question. Some of the focus questions would cover multiple days’ lessons; however, it was observed that the teacher started each day by revisiting the focus question and connecting the focus question to the days’ lesson. The focus question was a way to engage students and get them interested in the science investigation. Presenting students with a question to solve is a major component of inquiry-based instruction and allows for discovery of science phenomena (FOSS, 2020).

The next part of the 5E lesson plan that was observed is the exploration portion. For FOSS, this is the active part of each investigation. Embedded within active learning are several pedagogical elements (FOSS, 2020), which include questioning, planning, observing, recording, discussing, and writing explanations. The teachers stated during the interview that by using FOSS students are experiencing the science content and are active in the learning process. Every teacher interviewed stated that one of the benefits to FOSS were the materials and manipulatives that students are exposed to and use during the exploration portion of the lesson. Throughout my observations of the investigations in various classrooms, students were observed gathering meaningful data using the FOSS notebook sheets. I observed various FOSS investigations including the chemical interactions module, the electromagnetic force module and human systems.

After students have explored with science phenomenon and collected data, they generate an explanation. For the explanation portion of the lesson plan, students use their collected data as evidence from which to answer the focus question (FOSS, 2020). The FOSS notebook sheets at the end of each investigation helps the students think about their observations and explain the science content. I observed 11 teachers facilitating the explanation part of the investigation. Three teachers were also observed asking the students to summarize the days' findings for homework. The explanation portion of the 5 E can be used as formative assessment and as a basis for forming the instruction for the next day. I observed three teachers implementing this part of the 5 E. Teacher A8-2 was observed elaborating what the students had learned about forces to a new situation incorporated in a video. Students were observed completing a response sheet applying what they had learned to a new situation. Teacher A7-3 was completing a unit involving milkweed bugs. Students were observed applying their knowledge to factors that will affect their hatching. The elaborate portion of the 5 E was less common than the engage, explore and explain stages.

While analyzing the data collected, the connection between the type of 5 E lesson (e.g., engaging, exploring) and the science practices (SE 1-8) was evident and verified through the observations of students and teachers in the classroom. The 5 E lesson plan and the science practices are examples of the integration of inquiry-based instruction. The “engage” part of each lesson involves the focus question, which aligns with SE1 where students are asking questions. Students exploring science materials and collecting data were observed with SE3, SE4, and SE5. Once students began explaining and elaborating on their discoveries, I observed SE6, 7, and 8. Students were frequently encouraged by the teacher to look back at the data they had collected and to use that data as evidence to answer their focus question. Science practices are an integral part of the inquiry-based classroom where students are exploring with science phenomenon in order to develop their own understanding.

In addition to the 5E lesson plan guiding the FOSS investigations were specific instructional strategies used to support inquiry-based instruction. One such strategy was the implementation of the notebooks in the classroom to encourage writing in science. Through observations of 14 participants, I gained insight into the use of science notebooks at the middle school level. I observed that all teachers were using either a notebook or binder to complete their FOSS investigations. The notebook was being used as a tool for inquiry-based learning where students were recording their science investigations using FOSS notebook sheets and using the notebook to record their science thinking. Teacher 6-3 stated, “Students, draw, color, write, and draw what they discover during an investigation.” Teacher 6-3 and 7-6 discussed the importance of using the notebook sheets included in the FOSS manuals. All the participants agreed the notebook is an important tool in implementing inquiry-based lessons. Individual notebooks are a personal assemblage of observations, data collection, drawings, and thoughts about science.

Hands-on learning and student-centered classrooms are two other approaches to teaching that support inquiry-based instruction. Inquiry-based instruction involves specific instructional learning strategies to move curriculum to be more hands on. This is evident in the responses from teachers about their experiences shifting instruction to be more inquiry-based. In the interview, participant 6-3 stated, “FOSS has allowed for more hands-on student-centered learning and FOSS provides support to teacher inquiry where the teacher becomes the facilitator.” Participant E7-6 supported this by stating, “Students are exploring with content, while I check for understanding.” A7-4 stated, “The student role is to listen, explore and participate in their own learning.” F8-3 stated, “Kids are investigating with science phenomena, and this becomes the focus of the classroom.”

Student engagement is a major component of inquiry-based learning and was evident during the observations in which I recorded the role of the teacher and student during the investigation. Every classroom I observed involved students engaged and at the center of the learning process, asking questions, and investigating with the science content. Student engagement was also evident in the students recording science data in their notebooks. The teacher was observed facilitating the students as they explored with science content. Teachers were seen asking clarifying questions and checking for understanding.

The theme of inquiry-based instruction emerged from the observations and interviews of the 14 middle school science teachers and aligned with RQ 3. The goal of this project study was to determine if teachers had shifted their instruction to be more inquiry based and the data collected provided evidence that the teachers had shifted their instruction to be more inquiry-based. This was prevalent in the 5E portions of the lessons, the science practices students were utilizing, and the use of science notebooks in the classrooms to promote students exploring with science phenomena and developing their own understanding of science concepts.

Theme 4: Professional Development Needs

A final theme that emerged from the observations and interviews were the professional development needs the teachers identified. The theme of professional development needs emerged in response to research question four. Teachers identified the challenges they had with implementing the FOSS curriculum which led developing ideas for effective professional development. During the interviews, teachers were asked about professional development that had been offered as well as their ideas for PD to improve the FOSS implementation. The coded words challenges, needs, teacher collaboration, supplemental lessons, and adapting instruction emerged into the PD needs theme. All the teachers indicated that moving forward with the FOSS curriculum, they were looking for collaboration and sharing of supplemental lessons to make FOSS better. This theme provided evidence for RQ 4.

A few key challenges emerged from the data collected in relation to the shifting of instruction to be more inquiry-based. During the interviews, teachers were asked what challenges they had encountered implementing FOSS. Teacher 8-1 stated, “I feel there are some gaps in what is being taught and the state standards.” Teacher 8-5 supported this statement and said, “the curriculum is a little restrictive and there needs to be some supplemental lessons implemented.” Teacher 6-2 stated there needs to be more vocabulary integrated for ELL learners. Teacher 7-3 also supported the need for supplemental lessons. The key challenges that emerged became the focus for my planned PD.

Another challenge that was a consistent concern was the formative assessment of the science notebooks. During the interviews, it became clear there was not a consistent rubric or way to assess or use notebooks. All teachers I observed had different methods for assessing the notebooks and providing feedback to students about their content understanding. All the teachers observed had developed a grading rubric to evaluate the notebooks for completeness. Every teacher had a set of criteria for students to apply to set up their notebooks and complete investigations. This method of grading was designed to hold students accountable for maintaining their science notebook. This is a challenge for teachers because they are uncertain of the expectation for notebooks or what the best assessment method is. Teacher 7-3 stated, “We need a consistent method for notebook implementation.” Teachers B8-1, F8-3, F8-4, A7-2, A7-3, A7-4, C7-5, E7-6, and B6-1 shared their notebooks rubrics and each was very different from one another. Every teacher interviewed agreed it would be a good idea to share rubrics teachers are using and maybe to have a standard method. The suggestion was made that there be a few choices per grade level for teachers to use eliminating the challenge of how to grade the notebooks.

Developing ways to provide effective feedback to students was a concern that teachers discussed during the interviews. The notebooks are a medium for providing feedback (FOSS, 2020) and were one element that was discussed with teachers during the interviews. The feedback provided by a teacher can help students reflect on their learning and change their thinking. Multiple teachers discussed the importance of students revising the ideas in their notebooks. Revising notebook entries helps students clarify their understanding of science concepts and helps them prepare for summative assessments. One teacher (A7-2) was observed using the line of learning where students record their prior ideas first and then build on these concepts throughout the FOSS investigations. Another teacher (F8-3) utilized the focus question at the end of the investigation to have students summarize their learning. The teacher then provided written feedback to students on their understanding and misconceptions. One other teacher provided sticky notes for feedback as an alternative to writing directly in the journal. I observed multiple methods of feedback as a means of formative assessment. Part of the PD will be to create PLCs among the middle school teachers. One of the topics for the monthly PLCs will be to share assessment ideas.

Teachers expressed the need for professional development to enable them to shift from a presenter model toward more of a collaborative model. Four teachers (A7-3, C7-5, E7-6, D6-3) agreed that the professional development that had been offered in the past was helpful depending on the presenter from FOSS. Most of the professional development that had been offered in the past was from a representative from FOSS presenting certain FOSS curriculum units. The teachers agreed it had not been beneficial for a presenter to read through everything in the FOSS manual with them, but rather model for them how to use the Foss manipulatives for certain investigations. This type of professional development has only happened a few times and teachers expressed the need for this to be more consistent. Some teachers stated they could probably use their own teachers for this type of training instead of paying someone from FOSS.

Multiple teachers (teachers B8-1, F8-3, F8-4, B7-1, A7-2, A7-4, B6-1, A6-2, and D6-3) stated they would prefer continuous PD throughout the school year to collaborate with other teachers. The teachers discussed with me that there could be different after school sessions held once a month where teachers could meet and plan a future investigation. The professional development could be differentiated based on the needs of the teachers and how long they have been implementing FOSS.

Research Question 1 and 2

The first two research questions focused on the components of the CBAM, which framed my observations and interviews and provided categories for the classroom observations. Part of the CBAM framework was to establish the participants in the studies' levels of use (LoU) and stage of concern (SoC) implementing the FOSS curriculum. The LoU is a key component of the CBAM framework and identifies the extent to which the teacher was implementing the FOSS curriculum. Teachers could be at the beginning stage of implementation, still working through challenges or at a more advanced level and have expertise implementing the curriculum (CBAM, 2016). The Levels of Concern are: Observation, Preparation, Mechanical Use, Routine Use, Refinement, Integration and Renewal The stages of concerns teachers have with implementing the new curriculum provide insight into how the teachers are acting in regards to the new curriculum and focuses on the personal reactions and attitudes toward the change and the SoC is a key component in identifying teacher concerns in implementing a new curriculum. There are seven categories of concern related to innovation, FOSS. The Stages of Concern are: a 1 is Unconcerned, 2 is Informational, a 3 is Personal, 4 is Management, 5 is Consequence, 6 is Collaboration and 7 is Refocusing.

The interviews included asking the teachers what LoU and SoC they could identify with while implementing the FOSS curriculum. Once the teachers had identified their LoU and SoC I analyzed each interview for evidence of the teacher Lou and SoC to determine if what the teacher said and was aligned with the responses during the interviews. It was determined from the observations and interviews that each participant was implementing FOSS therefore the LoU a priori codes that were used were: LoU 1 – Routine, LoU 2 – Refinement, LoU 3 – Integration and LoU 4- Renewal. The SoC a priori codes were: SoC 1- Unrelated, SoC 2 – Personal, SoC 3- Task Management and SoC 4 – Impact.SoC was further coded into 3 levels: 4A – consequence, 4 B – Collaboration, and 4 C – Refocusing. There is a detailed table displaying this information including evidence for each of the LoU and SoC in Appendix E.

For the SoC, the teacher participants identified themselves in the consequence, collaboration, and refocusing stage. After analyzing the transcribed interview data, it was revealed nine teachers were in the task management phase. Teachers F8-4, B7-1, D6-3, A7-2, F8-3, A6-2, A7-3, E7-6, and B6-1 discussed concerns with material management, prepping of the materials for student, and time constraints with implementing lessons and grading. This evidence is part of the task management phases where teachers are still figuring out how to implement the new curriculum effectively. Even though 14 teachers identified themselves in the consequence phase, only three stated they were concerned about the effect the FOSS curriculum was having on student learning (teachers A7-4, C7-5, and A8-2). It was also revealed that the majority of teachers were in the collaboration and refocusing stage. These teachers stated they were looking to make FOSS better by supplementing lessons and re-aligning FOSS with the NGSS (teachers A7-4, C7-5, B7-1, F8-4, D6-3, B8-1, A8-2, B6-1, A7-2, A7-3, E7-6, and A6-2). This information assisted me in developing a recommended PD plan for the district and is displayed Figure 1.

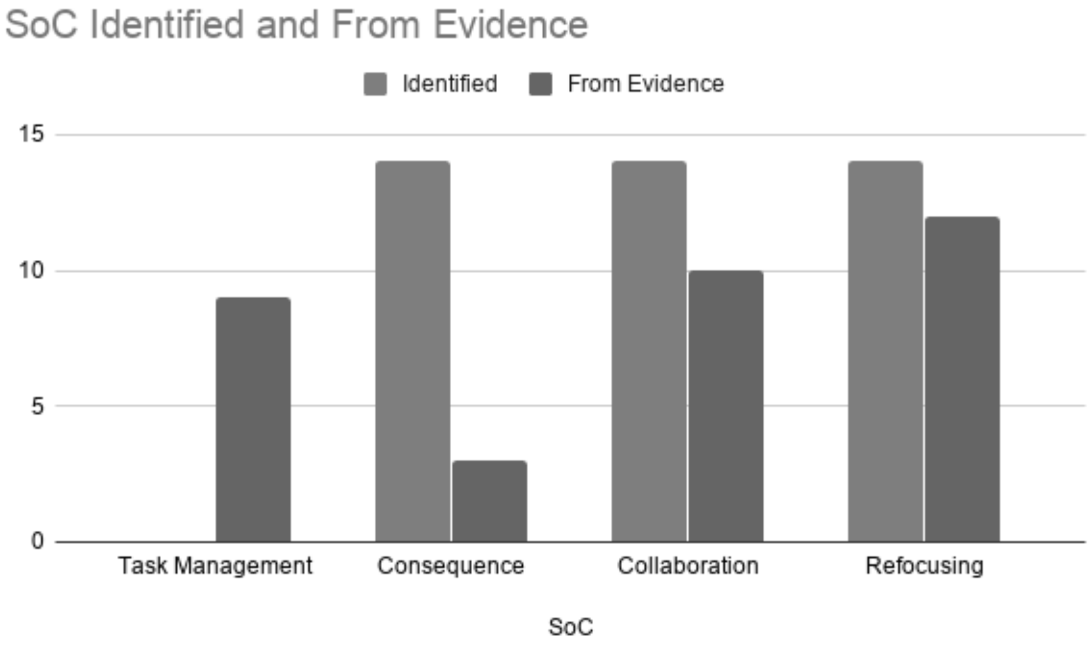

Figure 3: Stages of Concern

The next data I analyzed were the LoU the teachers had with implementing the FOSS curriculum. Teachers indicated three of the levels of use: routine, refinement, and renewal and many indicated they were in multiple categories. It was revealed from coding the interviews for the LoU that 14 teachers were in refinement and three were in the integration and renewal stage. Figure 2 summarizes the LoU data, which reveals most teachers are in the refinement stage. All the teachers made statements centered on "making FOSS better", adapting the lessons to make them better for students and supplementing to align to the NGSS. The four teachers in the integration stage were teachers that had begun supplementing lessons and were looking to collaborate and share these ideas (teachers E7-6, F8-3, A7-2, and A7-4). It is also evident from the interview data the four teachers who indicated they were in the renewal stage were really in the integration stage.

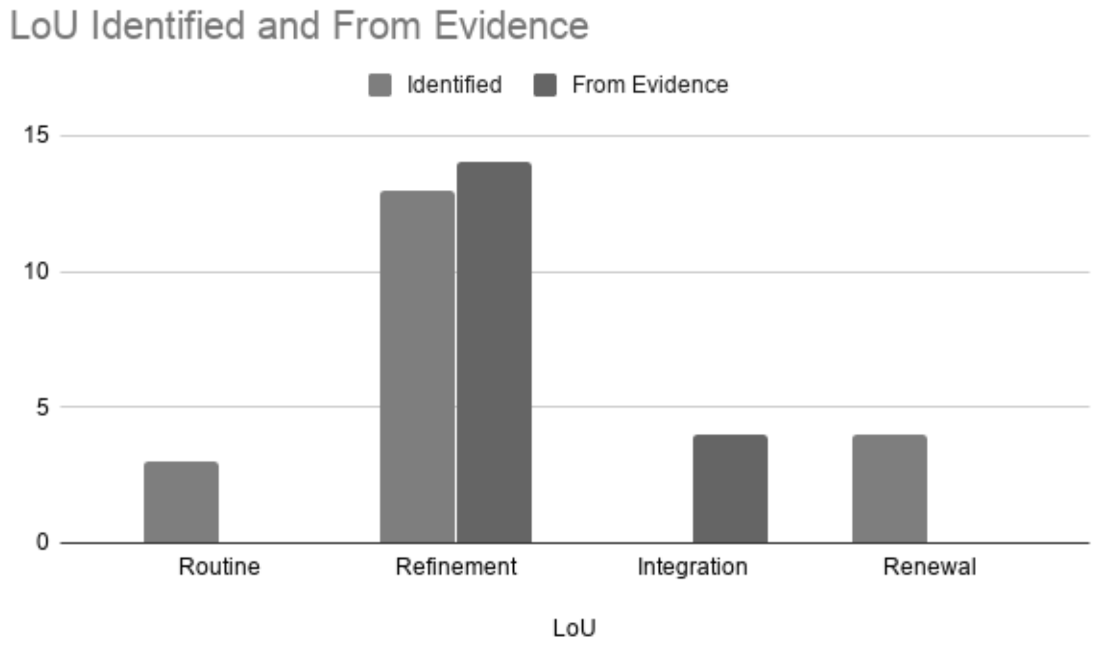

Figure 4: Levels of Use

One teacher, A7-3, indicated that the level of use depended on the specific FOSS unit and that it would be between a four and six on the chart. A four would indicate he/she was still managing the curriculum and a six that she was ready to collaborate and make it more her own. Evidence from the interview indicated the teacher was concerned about the standards being covered as well as material management and was looking for time to collaborate with teachers at the same grade level. Another teacher (E8-5) suggested that a concern she had was with the focus questions. She reported that most of the focus questions were open ended and got students interested; however, a few, she said, could be better written to promote greater interest. A few teachers stated the concern that there were gaps in the curriculum, even though a curriculum map had been written for the district and aligned to the NGSS (teachers A7-3, E8-5, and D6-3). It was revealed during the interviews that these gaps in the curriculum had led teachers to supplement specific lessons. Based on data analysis, 100% of the teachers were at a stage in their implementations of FOSS that they were ready for collaboration about their concerns with FOSS and possible supplemental material.

Research Question 3

Research question 3 addressed what instructional strategies teachers used that are consistent with inquiry-based instruction and theme three aligned with RQ 3. The observations I collected on the FOSS lessons related to the implementation of FOSS and inquiry-based strategies provided evidence for an inquiry-based classroom. In inquiry-based classrooms students ask questions, collect data, and construct their own meaning of science concepts (Gillies & Nichols, 2015). Twelve out of 14 teachers agreed that the FOSS curriculum had helped them shift instruction to be more inquiry-based. The FOSS investigations are more hands-on and student centered thus supporting an inquiry-based model. During my observation of the teacher lessons, I observed students exploring with science phenomenon and teachers facilitating and asking clarifying questions in 12 out of 14 classrooms, which is an indication that instruction had shifted to be more inquiry-based.

During my observations of FOSS lessons there were many instructional strategies teachers used indicating they had shifted their instructional practices to be more inquiry-based. One of these strategies was the use of the focus question to begin each investigation. This focus question is open-ended and provides the students with a problem that they will gather evidence for while learning the science content. The focus question was observed in all 14 teachers' classrooms, and students were responsible for writing them in their notebooks. The notebook is another important strategy for inquiry-based instruction that is consistent with FOSS. The science notebook was being used at different capacities in every classroom I observed. One final category of instructional strategies was with the organization and use of materials. During the interview numerous teachers stated the shifting of instruction to inquiry-based was easier because FOSS provides everything needed 6 of 14, or 43%. The teachers have all the materials they need and can just follow the script included with FOSS.

During the interviews, I explicitly asked teachers to explain how FOSS had affected the way they teach science and if FOSS had helped them shift their practices to be more inquiry-based. Fifty percent of the teachers reiterated that the FOSS provided all the materials including notebook sheets, which assisted them structure their classes to be more student-centered. The FOSS curriculum was helping teachers shift from a teacher-centered classroom to more of a student-centered classroom where the teacher facilitates student learning (teachers A8-2 and D6-3). Teachers followed the script provided by FOSS to shift their instruction.

It was evident from the observations and interviews that the science classrooms were more inquiry-based. There is also more consistency across the district because all students have access to the same curricular materials. Students were seen exploring with the science phenomenon and constructing their own meaning and teachers facilitate this learning by asking clarifying questions and supporting students.

Research Question 4

By discussing the teachers' successes, challenges, and needs when implementing an inquiry-based curriculum, teachers often commented that FOSS had helped them shift their instruction; however, they needed more time to collaborate, aligning the curriculum better to NGSS. These data, collected for research question four, led to the development of theme two: teacher confidence in shifting instruction, and theme four: professional development needs. More than 50% of the teacher participants during the interviews, referred to the successes with FOSS as the benefits of shifting instruction to be more inquiry-based.

All participants agreed that the most significant success to using FOSS was the increase in student involvement and engagement (teachers B6-1, D6-3, A7-2, A7-3, C7-5, E7-6, B8-1, A8-2, F8-4). Teachers reported that students were excited about doing science, and the content was relatable to them. One hundred percent of the teachers agreed most of the focus questions helped with the engagement piece providing open-ended questions for students to solve. Another success in using the FOSS curriculum was that the materials were all included, and the lessons were already designed for the teacher (teachers B6-2, B7-1, A7-4, E7-6, B8-1, A8-2, 8-3). This created increasingly efficient lesson preparation time and greater confidence in implementing inquiry-based lessons. Teachers also stated that FOSS had many great manipulatives for students, which increased student engagement (teacher A7-3). Teachers noted that FOSS also maps out the lessons to include the "launch, explore, summary" method of teaching and the science practices. All of the teachers involved in the study stated students they were able to make more of a personal connection with the curriculum and could relate to the science content being taught.

Teachers identified the following challenges implementing FOSS: differentiating for second language learners and special education students, time to prepare materials, time for grading notebooks, and gaps in the curriculum alignment with state standards. Two teachers were challenged by the lack of differentiated instruction for ELL students or special education students (teachers A6-2 and A7-2). These teachers discussed the amount of vocabulary, which could be overwhelming, and stated that there needed to be more activities to teach this vocabulary. Teacher A8-2 perceived a challenge was the sensitivity to the delivery of the materials. She stated that the timing of delivery of materials needed to be better. There was an instance, for example, where a teacher was ready for some live materials for which the delivery was delayed. As a result, she had to wait two weeks and eventually eliminated the investigation because she had to continue with the curriculum. These identified challenges were used to plan topics for monthly PLC meetings, which are an intricate part of the proposed PD for this project study.

One final aspect of research question four was for teachers to identify their needs moving forward with FOSS. The needs that were identified were: time to meet with grade like teachers to collaborate about pacing and supplemental lessons, extra support in the classroom, time to observe colleagues implementing FOSS lessons, and specified training from FOSS modeling investigations. The most common need among teachers was for consistent time scheduled for teachers to meet and collaborate with one another (teachers A6-2, 6-3, 7-1, A7-2, A7-4, C7-5, E7-6, B8-1, F8-3, E8-5). One hundred percent of teachers stated many teachers work in isolation in their buildings. Meeting with the same grade level science teacher more consistently would help in sharing ideas, aligning curriculum, and planning supplemental lessons. The teachers included that many teachers had different ways of assessing the notebooks and it would be great to have a common rubric for grading across the district. The sharing of rubrics to develop a common rubric for the district became an important topic for the monthly PLCs developed as part of the PD plan proposed for this project study.

Conclusion

Research question 1 asked, “What are middle school science teachers’ Stages of Concern (SoC) implementing the FOSS curriculum and shifting their instructional practices to an inquiry-based model?” To answer this question each participant was asked to identify what SoC they were at with implementing the FOSS curriculum. The SoC can provide a district a method to assess teacher challenges, attitudes, and perceptions of the implementation of a new curriculum. The data from the study provided evidence that all participants in this study were in the collaboration and refocusing stage which is an indication that teachers are ready to share ideas with others and have ideas to make the FOSS implementation even better.

Research question 2 asked, “What is the Level of Use (LoU) of the new curriculum that is being implemented in the local district?” Again, participants were asked to identify what LoU they implemented of the FOSS curriculum. The participants provided their LoU level, which can provide information to the district about what level teachers are at implementing a new curriculum. This can mean a teacher is not using the curriculum, routinely using the curriculum, refining the curriculum, or in the renewal stage (CBAM, 2016). The data from this study provided evidence that the teachers are ready for refinement and renewal. Teachers are looking for collaboration and sharing their ideas with others.

Research question 3 asked, "What instructional strategies are teachers using that are consistent with the features of inquiry-based instruction (LoU)?" Teachers shared what instructional strategies they felt would help promote IBL and agreed that the FOSS curriculum was helping shift instruction. I observed the following factors that are evidence for an inquiry-based classroom: student centered classroom, use of science practices, 5 E lesson plan, use of science notebook, teacher as facilitator, and students developing their own explanations for science concepts.

Research question 4 asked, "What successes, challenges, and needs do teachers report when implementing an inquiry-based science curriculum?" Teachers shared with me their benefits they have experienced with the new FOSS curriculum as well as their challenges. It was evident the successes of using FOSS is everyone has access to the same material and the students are more motivated with hands on learning. The challenges teachers shared included the need to share assessment and curriculum ideas with colleagues.

Study findings supported the development of a comprehensive professional development plan for the lead science teachers, which will include the development of a PLC for all the middle school science teachers. There will be three full PD days and the PLC will involve afterschool monthly study groups. The focus of the full PD days will be to train teachers on how to align the curriculum to the state science standards adding in supplemental lessons and focus on increasing collaboration among middle school teachers, so they can share supplemental lessons and curriculum ideas aligned with FOSS. Through the development of the PLC teachers can support and improve teacher content and knowledge. A PLC can help build collegiality, trust, and respect among teachers as they explore the challenges and success of FOSS implementation (Carpenter, 2015; Dogan et al., 2016; Woodland, 2016).

Discrepant Cases

When conducting a qualitative study, the researcher may encounter discrepant cases that need to be documented and analyzed. A discrepant case is any data that may offer an alternative viewpoint. This could be an interview, observation, or lesson plan that does not fit with the other data (Patton, 2002). This is a change in the norm but can offer critical information to the study. As the researcher, I explored these alternative explanations and considered why they may be different. I did not note any evidence of discrepant cases. Each teacher I observed was implementing the FOSS curriculum however due to the timing of my observations there were two teachers implementing supplemental engineering lessons instead of a FOSS investigation.

Project Deliverable

Findings from this study reveal the need for more consistent professional development that supports teacher collaboration and curriculum sharing regarding ideas related to the FOSS modules. It has been established that the teachers interviewed are implementing the FOSS curriculum; however, there are some challenges centered on material management and supplemental lessons. There are nine middle schools in the local district with 40 science teachers. Providing full-day PD for all these teachers is not feasible; therefore, the lead teachers from each middle school will participate in PD and share the information with the teachers at their schools. Establishing a PLC will allow a purposeful time for all the teachers to participate in consistent PD. The PLC topics will be designed for teachers to support one another and will assist in addressing the challenges teachers presented.

The deliverable portions of this project are three professional development days scheduled during the school year and the development of a PLC involving monthly study groups. The focus for each of the study groups and the professional development days will be based on the findings of the study and the needs of the teachers. The PLC will continue the work from the PD days and ensure all middle school science teachers are included.

The middle school teachers revealed they often work in isolation, and there are minimal opportunities to plan and collaborate with other science teachers at the same grade level. As a result of this project study, a professional learning community (PLC) is being developed and recommended as a means of supporting and improving teacher knowledge and skills. In the future, a PLC will be established between the science curriculum coordinator and all the middle school teachers. The goal of this PLC will be to help build respect, trust, and collegiality among the middle school teachers, as studied and recommended by Dogan et al. (2016), Carpenter (2015), and Woodland (2016).

Creating a PLC will address the concerns of teachers and help develop a supportive community.

Conclusion

The purpose of this project study was to understand middle school science teachers' experiences and challenges that confront them in shifting their instructional strategies to be more inquiry-based. The study employed a qualitative case study approach. The CBAM model was used to identify the stages of concern and the levels of use of teachers regarding the implementation of the inquiry-based curriculum. The main reason an observational case study was used because it encouraged and allowed an in-depth analysis of a bounded system, which, in this case, are the middle schools of a local urban district. Observational case studies allow the researcher to gather data based on participant observation. For this case study, the researcher observed the participants (teachers) during one of their FOSS lessons.

The teachers for this study were chosen using purposeful homogeneous sampling; therefore, those teachers who consented and fit the selected criteria were selected. This is an in-depth study; thus, a minimum of 10 and a maximum of 12 were sufficient for the study. I was successful in interviewing and observing 14 teachers from six of the nine middle schools. All data collected were kept confidential to avoid any harm to any of the participants. Qualitative data were collected through observations of a lesson implementing the inquiry-based curriculum and interviews. Once the data were collected, the content of the observational case study was analyzed for themes using a priori codes and a descriptive coding method. The themes that emerged were teacher confidence in shifting instruction, teacher response to change, professional development needs, and integration of inquiry-based instruction.

Section 3 is an outline of the project that I developed to address the findings of my study. The section includes a rationale for the selected professional development program, literature that supports the key ideas, a description of the program and a method to evaluate the effectiveness of the project. The project will focus on effective professional development to move forward with effective implementation of the FOSS curriculum.

Section 3: The Project

Introduction

It has been recommended by the NRC and NGSS that there needs to be a shift in science practices to be more inquiry-based (NRC, 2015; NGSS, 2014). This is supported by numerous studies on the importance of inquiry-based instruction as an instructional approach in which students gain a better understanding of science concepts (Andrini, 2016; Artayasa et al., 2018; Crawford, 2012; Hardianti & Kuswanto, 2017; Lakin & Wallace, 2015; Zion & Mendelovici, 2012). The research conducted in this qualitative case study explored teachers' challenges and successes as they shifted instruction to be more inquiry-based using the FOSS curriculum.

The purpose of this qualitative case study was to understand teacher experiences and challenges with implementing the FOSS curriculum to determine the ways in which the new curriculum has helped teachers shift their instructional practices. The findings of my case study provided evidence for the SoC and LoU teachers had with implementing FOSS as well as their challenges and success with the program. I developed a PD plan based on the four themes that emerged during data analysis: teacher response to change, PD, teacher confidence, and instructional strategies. The teachers indicated that they were implementing the FOSS modules and the curriculum was assisting them in shifting their instruction toward being more student-centered. The project was developed focusing on the needs expressed by the teachers. Teachers indicated a need for training on re-aligning the FOSS curriculum with the current NGSS standards, for adding in supplemental lessons not included in FOSS, and for consistent professional development through collaboration with other teachers throughout the district. This consistent collaboration can occur with the development of a Professional Learning Community (PLC).

The outcome of my research culminated in the development of a 3-day professional development program as well as the development of a PLC among middle school science teachers. On-line resources were designed based on current research. The target audience of this professional development is middle school science teachers in the LMS school district.

The purpose of this PD is to provide ongoing support for sustaining FOSS curriculum. The PD full-day workshops provide three days of training involving curriculum alignment to the NGSS and collaboration for middle school science teachers to share their supplemental curriculum ideas: lesson plans for FOSS and their assessment strategies for the science notebooks. The PD will occur in September, January, and May, ensuring time for teachers to implement the FOSS lessons and share their experiences. The PLC will be developed as a way to continue the work of the PD workshops and will involve all science teachers. The outcomes from my study indicate that many teachers are implementing FOSS and have had to supplement lessons for a variety of reasons. This includes science standards that are required but not covered in FOSS and differentiating lessons for diverse learners. Additionally, the PD allows teachers time to discuss assessments of notebooks. The outcomes from my study indicate there are a variety of ways teachers are assessing notebooks and providing feedback to students. This PD allows teachers time to share and streamline some of these methods and gives teachers time to collaborate with other teachers from other middle schools as they implement the FOSS curriculum in their classrooms.

This section includes the rationale for choosing a PD program for my project study, the goals of my PD, and a review of the literature supporting the project choice and design. A plan for implementing the project is included as well as an evaluation. Finally, the implications for social change and its impact on teachers in the district are discussed.

Project Description and Goals

The professional development program developed for this project includes four goals. The first goal is to learn and use collaboration strategies in science instruction during the academic year in order to facilitate and encourage collaboration among middle school science teachers to share supplemental lesson plans and curriculum ideas aligned with FOSS. The second goal is to streamline different methods for assessing science notebooks and develop a common rubric. The third goal is for teachers to update and create a curriculum map that will align to the NGSS and display supplemental curriculum ideas and notebook assessment ideas on Google docs for all science teachers to access. The final goal is to encourage teachers to observe their colleagues implementing the same FOSS lessons they implement. The district science curriculum coordinator and the middle school science teachers support these goals.

The overall goal of the plan is to equip science teachers with professional development where they can re-align curriculum and add in supplemental lessons to ensure all Massachusetts State Science standards are being met in various grade levels. The program I developed will provide teachers with an opportunity to collaborate with one another and create a more consistent curriculum. All middle school science teachers will have the opportunity to participate in the program. There is also the possibility the program will utilize the lead science teachers for the professional development. This would allow for less coverage of substitutes. It would be the lead teacher's responsibility to communicate any changes to the science teachers in their buildings. The goals of the PD and the PLC stem from the findings of the SoC teachers had with implementing the FOSS curriculum.

Rationale

A professional development program was the most logical choice for this project based on the outcomes of my data collection. When teachers engage in purposeful PD focused on content and collaboration among teachers, positive results occur (Carpenter, 2015; Darling-Hammond et al., 2020; Kennedy, 2016). The research questions for this study were designed to determine the SoC and LoC teachers had with implementing the FOSS curriculum. In addition, the challenges and successes to implementation were noted and analyzed. It became evident during the data collection that there were many successes in shifting to the FOSS curriculum, including more student engagement and an increase in students experimenting with science phenomena. However, some challenges were noted and were centered on collaboration, curriculum alignment, and supplemental lessons. Teachers are seeking time to observe one another implementing FOSS and share ideas about FOSS.

The findings in Section 2 and the CBAM framework served as a model for designing this professional development program. Evaluation of what teachers need from some PD was shaped by the current literature and the findings of the study, which highlighted the benefits and challenges teachers had while implementing the FOSS curriculum. The plan addresses the concerns of the teachers regarding curriculum alignment, common assessments, and teacher collaboration.

Based on the teacher participant data I analyzed through the observations and interviews, PD training was planned three times a year and a PLC meeting every month. I also recommend that teachers observe one another in other schools. The PD training designed for this study focuses on the training for curriculum alignment with the NGSS and collaboration of teachers in discussing the best way to implement FOSS units and the designation of the necessary supplemental lessons.

After completing the data collection for my study, I identified several factors that impacted the implementation of the FOSS curriculum. These factors included the need to collaborate on supplemental lessons, identify standards not covered within the FOSS curriculum, and streamline feedback and assessment of the science notebooks.

Review of the Literature

The purpose of this section is to provide a scholarly literature review of current research on the main ideas in the PD plan I have developed for the district. The PD plan stems from the problem of this case study, which was to understand the experiences and challenges teachers have had implementing an inquiry-based curriculum using FOSS. The outcome of this qualitative study included the following themes: Teacher Confidence in Shifting Instruction, Teacher Response to Change, Professional Development Needs, and Integration of Inquiry Based Instruction. I used these themes to help develop the PD plan. The PD is meant to allow teachers to collaborate with one another to address the challenges and benefits teachers had with the FOSS curriculum and what topics are important moving forward.

Strategy Used for Searching the Literature

This literature review focuses on defining the important topics from the data collected to develop PD for the district that will assist teachers in re-aligning the curriculum with the NGSS and adding supplemental lessons and sharing best practices centered around inquiry-based learning and the FOSS curriculum. Data for this literature review were obtained using the ERIC search engine through Walden University and by reviewing references to studies related to the themes I had discovered. I used many key terms in my search*: formative assessment of science notebooks, feedback in notebooks, levels of scientific inquiry, effective PD for science, curriculum alignment, science notebook rubrics, writing in science,* and *curriculum alignment in science education*. A review of the literature resulted in identified themes relating PD and collaboration to assist teachers in moving forward with the FOSS curriculum. These themes included formative assessment in science notebooks, writing in science, levels of scientific inquiry, curriculum alignment with NGSS, levels of scientific inquiry, and effective professional development.

Effective Professional Development

Effective PD focuses on professional learning that results in teachers changing their practices to improve the implementation of a curriculum. There are shared features of effective PD, which include active learning, content focus, collaboration, modeling, reflection, and sustained duration (Darling-Hammond et al., 2020; Kennedy, 2016). Effective professional development is needed in the local district that is the focus of this study to support their shift in instructional practices.

As previously noted in this literature review, PD is a valuable tool that can assist science teachers in shifting their instruction to inquiry-based modalities. The results from various studies have concluded that scientific inquiry must be a central part of science teachers' professional education and that teachers need quality PD focused on inquiry instruction. Multiple research studies include a recommendation for PD activities throughout the academic year focused on content and instructional practices (Capps & Crawford, 2013; DiBiase & McDonald, 2015; Kazempour & Amirshokoohi, 2014; Lakin & Wallace, 2015; Lebak, 2015; Lotter et al., 2014; Oppong-Nuako et al., 2015; Silm et al., 2017; Smart & Schools, 2016; Wong, 2016). This PD plan will be focused on the needs of the teachers and will begin with training teachers how to align the curriculum with the NGSS using anchoring phenomenon. Developing a PLC where teachers can collaborate three times a year will follow this training, and teachers can share their successes and challenges in implementing the FOSS curriculum.

Effective PD should focus on the content the teacher is teaching (Darling-Hammond et al., 2020). The middle school teachers implementing the FOSS curriculum were observed teaching a variety of science content. The curriculum at the middle school includes all three science content areas: life, physical, and earth. Darling-Hammond et al., (2020) and Kennedy (2016) concluded that to improve student achievement, the PD must include content that the teachers are responsible for teaching.

Another feature of PD is collaboration. It is important for grade-level teachers from different middle schools to meet and share best practices. Research has shown that there needs to be a system in place to support PD (Dogan et al., 2016; Darling-Hammond et al., 2020; Ndunda et al., 2017). A professional learning community (PLC) can be developed as a way of supporting and improving teacher content knowledge and skills. PLCs can focus on PD and build respect, trust, and collegiality (Carpenter, 2015; Dogan et al., 2016; Woodland, 2016). A PLC normally focuses on a specific problem for teacher collaboration and can assist in shifting teaching practices. If a PLC is formed at the middle school level, the focus could be to explore the challenges and successes of the FOSS curriculum. Collaboration and teamwork can produce a positive outcome for PD. Creating a PLC can help develop a community where teachers support one another.

Modeling is another feature of effective PD. As part of this research project, I will recommend PD time for teachers to observe their colleagues' teaching. Five teachers indicated in the interviews that they thought observing one another implementing FOSS lessons would be beneficial. Modeling of effective instruction of science content can assist teachers in obtaining a clear vision of what best practices look like (Darling-Hammond et al., 2020). In the local district certain teachers who have mastered certain investigations could serve as models for other teachers.

The frequency of the PD plan’s occurrence will be three times per year. However, there will also be documents developed on-line so teachers can have a venue to share ideas continuously. In addition to the 3 PD days, a PLC will be established to focus on curriculum alignment and sharing of experiences and challenges implementing the FOSS curriculum. Research on PD indicates that a shared vision, support from leadership, collaboration, and a focus on student work are necessary to sustain the PD (Darling-Hammond et al., 2020; Kennedy, 2016; Whitworth & Chiu, 2015).

Formative Assessment in Science Notebooks

Formative assessment is a method of assessing student work to inform instruction. There are different methods of formative assessment that are used in the science classroom to provide the teacher with a general sense of student understanding before administration of a summative assessment (McGlynn & Kelly, 2017; Schneider & Johnson, 2018). Formative assessment in the science classroom can be in the form of feedback to students and/or questions about their work completed.

One way by which formative assessment can be accomplished, is using science notebooks. Formative assessment can involve a teacher examining notebook entries on a regular basis in order to determine where students are in their science content and understanding what they can do by way of science practices. Formative assessment is often used to establish where a learner's understanding is on a particular topic, and it can thus help an educator focus on specific instructional sequences. A connection has been made between science notebooks as a source of formative assessment where teachers can provide useful feedback that can drive instruction. (Frisch, 2018; Kloser et al., 2017; Roberson & Lankford, 2010; Ruiz-Primo & Li, 2013; Schneider & Johnson, 2018; Shelton et al., 2016; Sparks, 2016). Teachers can assess notebooks and provide feedback in numerous ways.

Teachers can design a rubric or a checklist to formatively assess notebooks. Students can also be encouraged to self-assess their science journals. A rubric can be designed with developmental stages for each feature (Schneider & Johnson, 2018). One study completed by Huerta et al. (2014) supported the use of a notebook rubric to measure the scientific academic language and conceptual understanding. Many researchers agree that a notebook rubric should focus on communication rather than on English writing conventions (Huerta et al., 2014; Schneider & Johnson, 2018). The science notebook can be assessed formatively by asking questions about important parts of the notebook such as predictions, observations, drawings, and data collected.

The science notebook can provide opportunities for students to write about science content in addition to demonstrating their ability to perform the 8 NGSS science practices. Lindquist and Loynachan (2016) shared their experiences implementing science notebooks into a fifth-grade classroom. They supported the notion that science notebooks serve as a tool for students to write about science content and as a method for teachers to perform formative assessments. The formative assessment can be in the form of sticky notes probing for students thinking about science. Morabito (2017) supported the idea that notebooks serving as a tool for engaging students in inquiry-based learning. Shelton et al., (2016) investigated drawing and writing in science notebooks and how formative assessment could drive instruction. All these studies support the formative assessment techniques where teachers can use the content of the notebooks to drive future instruction. My observations of the participants supported the studies on utilizing notebooks in the classroom. Student notebooks were a form of formative assessment where students were writing in their science notebooks and making sense of science content.

Formative assessment is meant to inform instruction and scaffold learning for students (Huerta et al., 2014; Lindquist & Loynachan 2016; Morabito, 2017; Shelton et al., 2016). This type of evaluation is essential in assisting students in making sense of science concepts. Teachers can use students' notebooks to determine concepts students are grasping versus those that require further instruction. A few studies have been conducted on the type of feedback teachers can give to students. Science notebooks reveal information about student observations and reasoning about an investigation (Campbell & Fulton, 2014; Ruiz-Primo, 2013; Schneider & Johnson, 2018; Shelton et al., 2017; Sparks, 2016).

Effective Feedback in Science Notebooks

There are different strategies teachers can use to evaluate science notebooks, but many teachers agree that the feedback should be purposeful and performed regularly (Mallozzi, 2013; Ruiz-Primo & Li, 2013; Schneider & Johnson, 2018; Sparks, 2016). Teachers should also have a goal in mind when assessing science notebooks (Campbell & Fulton, 2014). This goal could be to examine a specific aspect in the notebooks like the focus question or the procedural summary. The feedback given should help students advance their scientific thinking and academic language as well as communication (Schneider & Johnson, 2018).

Feedback in notebooks can help students think about their own thinking and can help teachers plan instruction (Fulton, 2017; Campbell & Fulton, 2014; Kloser et al., 2016; Mallozzi, 2013; Ruiz-Primo & Li, 2013; Shelton et al., 2016). Feedback is critical to the success of student notebooks. While teachers are assessing science notebooks, they can provide feedback, which can assist students in their understanding of science content and their science practice skills. Teachers can analyze the students' observations and drawings to interpret their work. The feedback provided can be in different forms, like sticky notes or a rubric, or the embedded assessment included in the FOSS modules. The feedback provided can help determine what a student has learned, and the notebook can inform instruction.

Ruiz-Primo and Li (2013) examined 26 elementary and secondary school classrooms use of notebooks. This study focused on the different types of notebook entries that students were completing and produced data that were similar to the data I was collecting. The feedback teachers provided was examined by me as the researcher and provided insight into student learning, collectively, and individually. The Ruiz-Primo and Li (2013) study recommended that more data be collected and that teachers begin utilizing feedback to plan instruction. Kloser et al. (2017) supported the Ruiz-Primo and Li study by concluding the formative assessments based on notebooks are potent tools for informing instruction and engaging students in the scientific processes.

Science notebooks can increase student engagement with the science processes (Fulton, 2017; Sparks, 2016). Fulton (2017) examined whether science notebooks assisted students in engaging with the science content. The researcher gave 36 high school students pre- and posttests to assess their progress. The goal of the study was to discover if the science notebooks used daily increased engagement and achievement. The researcher developed a rubric to determine if specific notebook components were present. The results indicated that the science notebooks are a valuable tool in providing opportunities for students to strengthen writing skills and science process skills. Sparks (2016) found an increase in student engagement when they completed science investigations and used science notebooks.

Science notebooks give students a means for recording their questions, developing hypotheses, making observations, collecting data, drawing conclusions, and engaging with the language of science (Fulton, 2017; Campbell & Fulton, 2014). Notebooks reveal students thinking about a particular investigation and can reveal information about what they have learned and what misconceptions may linger. The feedback teachers provide can be one form of formative assessment that communicates to learners what they know and that can help drive instruction.

Writing in Science

Earlier in this work I discussed the importance of promoting scientific literacy using inquiry-based instruction as an important skill for 21st century learning. An important part of inquiry and of student science content learning is the oral and written discourse that focuses the thinking of students on what evidence they have for what they know and what they still need to learn and how this content knowledge connects to bigger ideas in the world (NRC, 2014). Fulton et al., (2018) supports writing and discusses how the Common Core Standards in Massachusetts calls for it to occur consistently. The science notebook acts as a vehicle for the evidence of student learning through their writing. Students record their data and their thinking about science phenomena into their journal. Using the science notebook can help build skills in reasoning and writing and bridge the gap from science to literacy development.

Scientifically literate students can communicate their ideas through writing or speaking. Writing in science can assist students to understand questions, claims, scientific reasoning, evidence, and relationships in science. Research indicates there is a lack of writing tasks in science classrooms (Demirdag, 2014; Fulton et al., 2018; NRC, 2014). The science notebook can serve as a means of writing for students in the science classroom. The integration of writing in science class provides opportunities for students to understand and learn science content (Demirdag, 2014; Huerta et. al., 2014, Lindquist & Loynachan, 2016; Schneider & Johnson, 2018; Shelton et al., 2016). Writing in the science notebook can be a method for students to develop literacy skills and construct their scientific content knowledge.

Teachers can utilize different strategies to encourage content writing in the notebooks. Students can begin by writing a focus question or problem they will solve for a given lab that week. This open-ended question can prompt thinking and ideas that students may have. Students should be encouraged to record their prior knowledge about the science content (Fulton, 2018). Next, students can conduct and experiment and collect data. Students can be taught how to organize these data into a chart or a graph. Once the evidence is collected, students can reflect on what they learned and make connections to the science content. Writing skills in science helps students to make sense and communicate science concepts (Demirdag, 2014; NRC, 2014).

Science writing can assist students in their vocabulary development and can help with content vocabulary. The science notebook can promote critical language skills among students. Students begin discussing and using the content vocabulary in their writing. Writing can advance scientific knowledge, academic language, and literacy development (Schneider & Johnson, 2018).

Science notebooks serve as a useful tool for engaging students in authentic inquiry-based science while developing writing skills. Notebooks support development of literacy-based skills through authentic activities (Demirdag, 2014; Huerta et al., 2014; Lindquist & Loynachan, 2016; Morabito, 2017; NRC, 2014; Shelton et al., 2016). Students need time built into their lessons to write and process their ideas about science. The science notebook connects to the NGSS scientific practices and relates directly to the real work of scientists.

Levels of Scientific Inquiry

Inquiry-based learning differs in the amount of autonomy given to the students and ranges from teacher-directed to guided inquiry and finally student-directed open inquiry (Artayasa et al., 2018; NRC, 2015). Students need time to practice their inquiry-based skills and build their way up to an open inquiry project. Using the different levels of inquiry as a continuum the classroom can shift from teacher-centered to student-centered where students are responsible for their own learning. Inquiry can foster the learning process for students to develop logical reasoning and problem-solving skills.

Several studies support the effectiveness of the different levels of inquiry-based learning as an instructional approach in which students gain a better understanding of science content (Andrini, 2016; Artayasa et al., 2018; Hardianti & Kuswanto, 2017; Zion & Mendelovici, 2012). Recent studies have also concluded the implementation of the three types of inquiry has proven effective to enhance scientific reasoning (Arslan, 2014; Fuad et al., 2017; Llewellyn, 2013; Pedaste et al., 2015; Steinberg & Cormier, 2013; Yanto et al., 2019; Zion & Mendelovici, 2012).

Structured or direct inquiry is a lower level of inquiry in which students investigate a teacher presented question and follow a prescribed procedure. Students receive explicit step-by-step guidelines at each stage leading to a predetermined outcome (Artayasa et al. 2018; Yanto et al., 2019; Zion & Mendelovici, 2012). The hands-on investigations help students develop basic inquiry skills like observing, making hypotheses, and collecting and organizing data. In direct inquiry, the teacher is directly providing and explaining science content knowledge using demonstrations and non-student activities. According to studies conducted by Artayasa et al. (2018) and Zion & Mendelovici (2012), direct inquiry has the least effect on student content understanding.

In guided inquiry, the teacher presents the students with a problem to investigate and the students explore the science phenomenon. The purpose of guided inquiry is for students to be involved in the use of scientific inquiry processes (observing, inferring, formulating explanations, making predictions, collecting data, and analyzing data) to solve a problem posed by the teacher (Arslan, 2014; Artayasa et al., 2018; Hassard & Dias, 2013; Risman & Santoso, 2019;). Students can be seen working collaboratively to decide what process to follow and what solutions should be targeted. This type of teaching methodology can be challenging for teachers who are teaching traditional lab experiments that are not student-centered and do not allow for ample exploration opportunities. In guided inquiry, the teacher poses the question to the students and the students lead the inquiry process by making decisions and arriving at a conclusion. Most of the FOSS curriculum is focused on guided inquiry, which allows for some structure in the investigations. Students are presented with a focus question that they will investigate and gather evidence for the science concepts.

Open inquiry is the highest level of inquiry and reflects the work performed by scientists. This type of inquiry demands higher-order thinking abilities (Fuad et al., 2017; Zion & Mendelovici, 2012). Open inquiry-based instruction is more complex, and students are self-directed. Students can be seen selecting a question and approach and collecting evidence for the question posed. Multiple studies have examined the different types of inquiry implemented in the classroom discovering open inquiry yields higher student content understanding and more critical thinking skills (Fuad et al., 2017; Zion & Mendelovici, 2012). This type of inquiry can be very difficult for a teacher to implement and should only occur once a teacher is comfortable with inquiry-based teaching. Open inquiry requires a great amount of independent learning from the student. Open inquiry is common in science fair type of situations where students develop a question and conduct their own investigation.

There have been numerous studies conducted examining a teacher’s view of inquiry. In many of these studies and observation checklist was used to determine the level of inquiry happening in the classroom (Akben, 2019; Zion & Mendelovici, 2012). In one study, 25 qualities of inquiry in the classrooms were used during an interview process (Akben, 2019). The study concluded most textbooks the teachers used centered on structured inquiry limiting student's ability to acquire science skills (Akben, 2019). Zion and Mendelovici (2012) completed a study where teachers were moving their instruction toward open inquiry. The challenge noted in this study was teachers needing a framework model to support them as they emphasize different levels of inquiry. The researchers concluded that learning through inquiry should be a gradual process and is a critical step in developing scientifically literate students (Zion & Mendelovici, 2012). Lotter et al., (2014) and Crawford (2012) had similar conclusions from their studies: inquiry-based teaching requires significant professional development and support if it is to be effective.

Inquiry is a more innovative teaching method in which students can develop their reasoning skills (Yanto et al., 2019). Reasoning includes linking evidence and facts to make logical conclusions about science phenomenon. The Yanto et al. (2019) study is supported by the results from Hardianti and Kuswanto (2017), Zion and Mendelovici (2012), Llewellyn (2013), and Arslan (2014) that the three inquiry levels have significant outcomes on increasing the students' learning outcomes as well as their critical reasoning skills.

Curriculum Alignment with the NGSS

The NGSS are a new set of K-12 science standards that were developed by the states. NGSS has identified scientific and engineering practices, crosscutting concepts, and core ideas in science that students should in order to prepare for success in college and the 21st century careers (NGSS, 2014). Future jobs will require skills in science, technology, engineering, and math. The NGSS provides a strong science education that includes a clear vision for teaching and learning. The NGSS equips students with the ability to think critically, analyze information, and solve problems.

Massachusetts adopted the NGSS but the NGSS does not prescribe specific curriculum materials nor a scope and sequence. The vision for science teaching in the NGSS requires a major change from traditional science teaching. Teachers must reconsider the science content and how ideas fit together (Reiser, 2013). According to Achieve (2015), in order to implement standards effectively materials need to provide an expansive range of supports that are the best way to engage students. Science instructional materials are a critical component for improving science education outcomes (NRC, 2015). Based on this recommendation by Achieve (2015), NRC (2015), and the NGSS (2014) the LPS school district adopted the FOSS curriculum for grades six to eight. The district science coordinator established a committee of teachers to pilot the FOSS program. It was discovered the FOSS would align with the needs of the district. Complete implementation of FOSS began a year after the pilot program in 2014. Now that the curriculum has been adopted it is important to ensure the FOSS aligns with the state standards (NGSS).

The number of changes called for by NGSS called for the local district to determine what aspects of the NGSS were most relevant to their curriculum materials and where support was needed. Several studies have examined the importance of implementing meaningful curriculum materials to support teaching and learning (Reiser, 2013; Smart & Schools, 2016). Teachers need informative educative science materials that support teachers in developing subject and pedagogical matter content knowledge, and inquiry-based practices to engage students in the science content (Reiser, 2013; Smart, 2016). A study conducted by Roseman et al., (2017) supported the idea that curriculum materials should support student and teacher learning. The LPS school district adopted the FOSS curriculum to shift the teaching and learning to be more inquiry-based. The FOSS curriculum aligned with the three core dimensions included in the NGSS: core ideas, crosscutting concepts, and science practices.

Once the decision had been made in the local district to implement FOSS, a committee of teachers representing each middle school met to align the specific FOSS units to specific grade levels. The district decided to include the three domains of science, Earth, Physical, and Life, into each grade level. This decision was also based on the recommendation of the NGSS. The FOSS curriculum includes core ideas, engaging in science and engineering practice, and exposing crosscutting concepts (FOSS, 2020).

Once the LPS district had adopted FOSS the curriculum, the curriculum committee reconvened to discuss which NGSS standards may be missing from FOSS and how to implement those standards into the curriculum. A spreadsheet was made to note these discrepancies. It has now been five years since the FOSS has been implemented and the standard alignment should be revisited.

Project Description

Implementation of this professional development program will take place over three days offered in September, January, and June, along with monthly PLCs after school. This schedule will allow a consistent meeting time for the teachers. The full day professional development will occur at the professional development office and each of the PLC meetings will occur at one of the middle schools. Middle school teachers will be asked to volunteer to host the PD at their schools. Changing location each month will allow for more teachers to attend if traveling is a concern. The full-day PD training will be from 8 am to 3 pm for three days during the week before school starts in August, for one day in January, and for one final day June. Also, after-school meetings will be scheduled monthly throughout the year for additional support. During the full day professional development, teachers will be given a half-hour lunch break. The decision about where the PD will happen will be advertised two weeks before the session.

I plan to implement a PLC among middle school science teachers. I will use the research conducted by Darling-Hammond et al., (2020) to develop the PLC. I will have teachers develop a shared vision to improve teacher collaboration to increase student achievement. The ultimate goals for the three-day PD will be for teachers to discuss the FOSS curriculum and align to the NGSS, determine what supplemental lessons are needed, and if there were additional resources being used. The PLC will allow consistent collaboration among science teachers. A second focus of the PLC will be the science notebooks. I will encourage teachers to share their assessment and feedback methods of the science notebooks. How are the teachers using the notebooks to drive instruction? What kind of feedback is being provided? Any shared items will be saved in the appropriate Google folder so that all teachers can access them at any time throughout the year.

Potential Resources and Existing Supports

Implementing this professional development program requires a few resources and supports for the plan to be successful. There are 40-targeted teachers among nine middle schools that will be involved in the PD. The project (Appendix A) will include three days of professional development for the lead science teachers in the building and after school study group sessions open to all middle school teachers. I will be assisting the science curriculum coordinator in coordinating the PD days and the PLC agendas. I have experience with the FOSS curriculum and curriculum alignment.

The middle school teachers already have FOSS curriculum guides as well as the NGSS. I will have hard copies of the new NGSS standards as a resource for them. Teachers will need their laptops to access Google documents and their FOSS modules. I will have folders and specific templates readily available on Google for teachers to record the substance of their work. I will make available large post-it paper, and markers for the individual groups to record questions that may arise. These resources are all available through the school system and at the central office where professional development normally occurs. Teachers will be asked to bring various student work samples, lesson plan ideas, and lab notebook rubrics to share with colleagues. These items will be needed for the full day PD as well as for the PLCs.

Another resource for this plan will be the districts funds for PD activities and staff development throughout the year. The district has hired lead science teachers for each middle school. The lead teachers are responsible for attending PD sharing the information with the other science teachers in their buildings. With the approval of the science curriculum coordinator, this 3-day PD opportunity will be used to replace the normal PD during the year. The district will also serve as a resource for a space to conduct the PD with the lead science teachers. The PLCs will be held at different middle school in order to increase the participation across the district.

Potential Barriers

A potential barrier to the implementation of this professional development plan will be adequate time for the PD as well as funding for the PD. My suggestion is that the professional development be scheduled 3 times during the year for a full day. This could pose a problem should substitutes and funding for them be unavailable. I propose the first PD occur before school begins in August and the final one in June as soon as school ends. This will help alleviate the problem with substitutes. The after-school sessions will run from September to June. The science department has allotted professional development funds, and my goal is to tap into that resource through the science curriculum coordinator. I will also suggest that a consistent time once a month is scheduled after school for teachers to share implementation ideas.

A solution to the availability of substitutes will be to utilize the lead science teachers from each middle school to the 3-day professional development training. These teachers can then report back to the other science teachers in their building about what occurred during the professional development. This could occur on the already scheduled half days that occur once a month. This dissemination of information could occur during the scheduled early release days scheduled by the district. A compromise will be for all teachers to be able to attend the final professional development in June. All teachers will also have the opportunity to attend the after-school study sessions.

Roles and Responsibilities

This professional development program was designed with input from the science curriculum coordinator, and its goal is for me to assist in delivering the training. The main training will happen during the full PD days. Teachers will learn how to align the current science curriculum to ensure all standards are being taught. This will provide an opportunity to add in supplemental lessons where they are needed. I will work with the science curriculum coordinator to deliver this training. The lead science teachers will be responsible for sharing the information with the other science teachers in their buildings. It will be possible once the PLC is established that the teachers can maintain Google sharing and meetings throughout the year. The training will be organized in a way that the teachers can sustain the sharing of ideas on their own and among themselves.

All middle school lead science teachers in grades 6 through 8 will be expected to attend the 3-day professional development training. Their role in the PD will be to actively participate and share their experiences with the FOSS curriculum. The lead teachers will also communicate information back to the other teachers in their buildings. All middle school science teachers will be expected to attend the after-school PLC sessions. This training will be for teachers who have taught FOSS for at least three years. The activities from the sessions will involve teachers sharing what supplemental resources they use for specific FOSS units and share best practices for the current investigations they implement. Teachers will also be expected to share how they are using science notebooks in the classroom. Do they use a rubric for formative or summative assessments? How do they provide feedback to students on their progress with learning lesson content? I will recommend that teachers new to FOSS implementation have separate training.

Project Evaluation Plan

The project evaluation process will begin by reviewing feedback from the teachers on a survey they receive at the end of every PD session and PLC monthly study group (Appendix A). This formative feedback will help determine the effectiveness of the current PD and what is needed moving forward with the FOSS curriculum. This survey will be available via Google forms. The evaluation seeks to gather information about the goals of this plan: learn and use collaboration strategies in science instruction, streamline different methods for assessing science notebooks, update the curriculum map to align with NGSS and add in supplemental lessons.

There will also be a summative evaluation conducted at the end of the year to help determine the effectiveness of the PD and to gather some recommendations for moving forward with the FOSS curriculum. I will also monitor attendance at the full day and after school sessions to determine effectiveness of the sessions.

The stakeholders for this professional development plan include the LPS superintendent, assistant superintendent for curriculum, the science curriculum coordinator, the middle school teachers, and the middle school students. I have worked very closely with the science curriculum coordinator and have shared with her my results from the study and the concerns teachers have expressed. I shared with her my professional development plan, and she supports the plan. In 2014, the LPS approved the adoption of the FOSS curriculum for Grade 6 through 8. This adoption represented a major financial investment for the district. All the stakeholders wanted to see the FOSS program succeed, and it was essential that the curriculum be implemented consistently among all the middle schools in the district. For the FOSS program to be successful, there needed to be consistent communication and collaboration among teachers.

The teachers and students are also stakeholders in this professional development plan. As previously stated, the vision for teaching and learning in the science classroom has changed since the NRC recommended there be a shift from traditional teaching practices to more inquiry-based instruction. This recommendation prompted the release of the NGSS in 2013; however, how to implement the standards was left to individual towns and cities to figure out.

The LPS district has adopted an inquiry-based curriculum through FOSS, and this professional development will assist teachers in achieving all standards using a hands-on approach. Teachers are more likely to participate and engage in a professional development plan that is based on their needs (de Groot-Reuvekamp, Ros et. al, 2018). During my interviews with teachers, I was able to listen to their needs and create a professional development plan with their needs in mind. The project evaluation will be an ongoing effort to allow enough time to monitor the plan I have put in place for the district.

Project Implications, Including Social Change

It has been recommended by the NGSS (2016) and the NRC (2013) that science practices in the classroom be more inquiry-based. The NGSS released new standards that centered on cross cutting concepts, science practices, and coherence between grade levels (Reiser, 2013). The NGSS released the standards, however, that left it up to individual cities and towns to implement the standards. The local district has implemented the FOSS curriculum and the research from this study confirms there is a need for PD to address the curriculum re-alignment, development of a notebook rubric, and increase collaboration among middle school science teachers to discuss challenges they are experiencing. Research further supports the need for sustained, content-focused, collaborative PD for addressing the needs of the teachers (Darling-Hammond et al., 2017). The PD will include 3 full days for the lead science teachers and monthly study groups for all the science teachers under the organization of a PLC.

Local Community

In 2014, the LMS school district adopted the FOSS curriculum for Grades 6 through 8. The goal of adopting the FOSS curriculum was to assist teachers in shifting their instruction to embody inquiry-based concepts. As well, a vertical science team was established to align the FOSS with the NGSS at each grade level. A decision was made to integrate the three strands of science—Earth and Space, Physical, and Life—into each grade level. During the first year of implementation, professional development was offered where FOSS demonstrated specific modules for teachers.

In speaking with the science curriculum coordinator, it became clear there was a need for more collaboration among middle school science teachers. This idea for collaboration was supported by the interviews I had with various science teachers at different middle schools. Looking at the CBAM Levels of Use, 13 of the 14 teachers interviewed were in the refinement stage, indicating they were comfortable implementing the FOSS modules and were looking to make it better with supplemental lessons and realignment to the NGSS. The teachers all expressed interest in professional development where they could share curriculum ideas.

This professional development program was developed to assist teachers in ensuring all NGSS standards are being covered in Grades 6 through 8. This program will hopefully increase collaboration between the eight middle schools to ensure that all the students are receiving the same quality instruction. The project component of this work includes monthly after-school study group sessions with focuses suggested by the teachers as well as three full professional development days. The focus of the full-day professional development will be to verify all the NGSS standards are being covered in grades six to eight and to share supplemental lesson ideas to accompany the FOSS modules.

Larger Context

For decades, inquiry-based instruction has been recommended to play a central role in high-quality science teaching and learning (NRC, 2015; & NSTA, 2016). Identifying curriculum materials and programs that will assist teachers in shifting their instruction is important.

This study can contribute to districts deciding if the FOSS curriculum is an appropriate way to shift instruction to be more inquiry-based. The project deliverable that was developed for this project study can provide administrators with information to improve the current implementation of the FOSS curriculum. The results from this study provide information about the benefits and challenges teachers had shifting instruction. This information could help other districts trying to align with the NSTA recommendations.

Conclusion

The overall goal of this project is to provide training on re-aligning the FOSS curriculum with the current NGSS standards add in supplemental lessons not included in FOSS and address the need for consistent collaboration with other teachers throughout the district. The professional development will offer time for teachers to collaborate on supplemental lessons and share ideas about formative assessments, notebook use, and effective writing in science. In section 3 and in Appendix A, I have outlined the project and described the literature that supports my ideas in the PD plan. In Section 4, I described the strengths and limitations of the project, recommendations for alternative approaches and implications, application, and directions for future research.

Section 4: Reflections and Conclusion

Introduction

In this section, I will describe the strengths and limitations of the proposed PD project and recommend ways in which the project's limitations can be resolved. I will also discuss what I have learned as a result of designing this project study in the areas of scholarship, project development, and evaluation, as well as the importance of leadership and change. Finally, I will describe the project's implications and possible topics for future research.

Project Strengths and Limitations

The goal of this project is one that has been shared with the LMS and the various teachers cited throughout this work, namely, to understand the challenges and benefits inherent in the implementation of the FOSS curriculum. The FOSS curriculum was adopted as a means of assisting teachers in transforming their instruction such that it becomes structured around inquiry. Scientific inquiry is advocated in all of the current national and state standards and is reinforced by current research (Achieve, 2015; Lead States, 2013; NRC, 2014, NSTA, 2016). One strength of this project is that the findings from the research study and current literature were used to design the 3-day PD and the PLC. Another strength of the project is that there were two methods for data collection, and the resulting themes from the observations and interviews reflected similar needs for teachers in the local district.

Having data from the observations and the interviews, which included the LoU and SoC of the FOSS curriculum, helped structure the PD to meet the needs of the teachers. Multiple sources of data (Creswell, 2012) revealed in the findings the challenges teachers were experiencing which guided the direction of the project. The project study of this work is 3 days of professional development throughout the year and after school professional development sessions meant to assist science teachers in sharing their curriculum ideas for enhancing FOSS and realigning the FOSS to the NGSS.

One strength of the program was that the teachers identified the stages of concern and level of use from the CBAM. Teachers were found to be at a consistent level of use, and all had the same stages of concern. All 14 teachers indicated that their stage of concern was collaboration, and 13 out of 14 were at the refinement level of use. Teachers were at a stage of implementing the curriculum where they were looking to make it better, a goal that could be accomplished by effective collaboration. This information was used to design the PD and the PLC. Designing PD that is based on the needs of the teachers provides more of an opportunity for teachers to connect to the practice and supports (Darling-Hammond et al., 2017).

Teachers who were observed had shifted their instruction to the FOSS investigations. Teachers were consistently using the materials provided by FOSS and grateful for those resources. Consistent with the literature was the use of science notebooks in the classroom as students completed individual investigations. Teachers had specific systems in place to assist students with their writing in science. This project will address the concerns about notebook usage and designing a rubric for formative assessment. This becomes a strength of the project because again the PD and PLC were based on the needs of the teachers.

Another strength of this program is that the FOSS curriculum has not been re-aligned since its implementation in 2014. This program provides the opportunity for the district to involve teachers in the re-alignment of FOSS to the NGSS and allows for teachers to share in what supplemental lessons are needed. Teachers being involved in this process provided authenticity and ownership of their ideas.

An additional strength is the project that was developed answers the need for more consistent collaboration among teachers to share curriculum ideas. There were many challenges to implementing FOSS, including content alignment, supplemental lessons, time for assessing notebooks, and time to prep materials. The project component of this work is a 3-day professional development sequence occurring throughout the year as well as monthly after-school meetings. The ultimate goal is to create a professional learning community where teachers can support one another with the implementation of FOSS. The PLC is designed to include the topics teachers expressed to be of the most importance.

A final strength is this project study draws from the current literature and feedback given by the teachers in the local district. Yin (2017) stated that four to six cases were needed to create theoretical replication. I observed 14 science teachers in the district, which represents approximately one-half of middle school science teachers in the district. The results were consistent in that teachers shared there was not currently enough collaboration and sharing of supplemental lessons in the local district. The interviews indicated collaboration was needed to discuss curriculum alignment, student work, notebook assessment, and material management. This finding is in alignment with the research on the importance of collaboration in order to shift instructional practices to being more inquiry-based (Darling-Hammond et al., 2020; Kennedy, 2016). A PLC will be developed to support teachers using the FOSS curriculum and support them in addressing their challenges (Carpenter, 2015; Dogan et al., 2016; Woodland, 2016).

Another limitation of the project study is the maintenance of the plan. The intent of the project study is to bring the middle school science teachers together more consistently in order to sustain and improve the implementation of the FOSS curriculum. This consistent collaboration will develop a community among teachers where their ideas are valued. Even if the professional development is implemented, there is no guarantee that the PLC will be maintained in subsequent years. However, it is evident from my interviews with teachers they are seeking this type of support.

Recommendations for Alternative Approaches

The following recommendations are based on alternative approaches to address the problem. The first recommendation is for the researcher or curriculum coordinator to conduct observations and interviews for teachers implementing FOSS for the first year. The needs of these teachers may be the same as the veteran teachers in my study. It would be of interest to discover if separate professional development is needed for the new teachers. Accepting this recommendation would provide a clearer understanding of the needs of the first-year teachers to the science curriculum coordinator.

A second recommendation would be to conduct observations and interviews focusing on the ELL and special education populations. This would provide a deeper understanding of the topics necessary at the professional development sessions. This could involve creating lesson plans to differentiate the FOSS lessons for special populations, which, in turn, would increase access to the science content.

For this study I only used teachers in the observations and interviews. I could interview principals and the science curriculum coordinator about what they think the benefits and challenges are implementing FOSS. It would be interesting to determine if these findings align with what the teachers are seeking. This data could add to the challenges and experiences of implementing the FOSS curriculum.

Scholarship, Project Development, and Leadership and Change

Scholarship

As an educator I have always believed in being a life-long learner. Engaging in life-long learning can help in the ever-changing world of education. The students we are teaching change every year change and educators have to adapt their lessons to meet the needs of diverse students. The goal of implementing FOSS was to assist the science teachers in shifting their instruction to be more inquiry-based. It became very clear from my interviews and observations that the science classroom is a different place than it was five years ago. I learned from my data collected to design a project that was focused on the needs of the teachers and that supplemental lessons were needed to meet all of the NGSS standards.

Inquiry-based instruction has always been important to me and I was very interested in whether or not FOSS was assisting teachers in shifting their instruction. As I began my research, I discovered a lot about inquiry-based instruction and the challenges involved with shifting instruction. I decided on this topic because I believed it would also impact the teaching at the high school level. I discovered a lot about my own teaching and the needs of the students in my district. Inquiry instruction needs to be purposeful and a student need time to explore with science phenomenon and construct their own meaning of science concepts.

During this time that I worked on this project, I believe that I demonstrated a great deal of growth as a scholar and as a leader in the local district. The teachers appreciated that I was listening to their concerns and that through effective professional development we would be able to move forward with FOSS and make it even better for our diverse student population. The evaluation for this professional development plan will be in the form of teacher feedback for future sessions. I will adapt my recommendations for the professional development sessions based on the needs of the teachers, making the PLC more authentic.

Analysis of Self as a Scholar

When I began this doctoral journey, I was a middle school teacher implementing the FOSS curriculum like the participants in my study. This changed halfway through my journey, which turned out to be beneficial to my study. I was able to take everything I knew about the curriculum and discover what the real challenges and benefits teachers had with implementing FOSS. Not teaching the FOSS curriculum meant I was not invested personally and could be objective I also had built a lot of positive trusting relationships with the participants I would be observing and interviewing. The teachers trusted that I had their best interest in mind. Discovering what was being taught at the middle school level helped me with, and how I teach ninth grade students. I gained insight into what the middle school students were learning and incorporated this into my own teaching.

When I embarked on this doctoral journey, I knew there would be several challenges I would have to overcome. I am a full-time teacher and mother of two teenagers. I also did not expect this journey to take six years and it pushed my limits in a number of ways. I do feel my work will benefit the school system overall and help them move forward with the FOSS curriculum.

Through this Ed. D. program, I have been challenged by the rigorous course work and been challenged to write in a scholarly manner. I have extensively researched inquiry-based science instruction and all the components that are involved with providing the best instructional practices. The research and information I have gathered from this study will help me shift my own instructional practice to be more inquiry-based. I have begun to share my experiences and knowledge with my colleagues at the high school and I have a new level of credibility as they see me as a lifelong learner. I have begun using my knowledge of inquiry-based instruction to develop curriculum at the high school.

Analysis of Self as a Practitioner

As an educator, I believe we can always learn something new and contribute to the field of education. I often take on the role of a lead science teachers and mentor new teachers as they embark on their teaching careers. I had an invested interest in finding out more about inquiry-based learning and how the implementation of the FOSS curriculum was going at individual schools. At the high school I am always looking for ways to integrate inquiry-based lab into our lessons. Observing and interviewing teachers gave me some ideas for my own classroom.

The biggest learning for me throughout this journey has been about science notebooks and their importance in an inquiry-classroom. Notebooks can be used to shift the learning to students so that the students have to demonstrate knowledge and write about what they are learning. Students often draw, create diagrams and explain their thinking. When this happens in a notebook, there is a certain ownership that students have. The journal becomes very authentic for students. I have brought this learning to the high school where I teach.

As a practitioner, I will take what I have learned through this process and share this with teachers I work with. I have knowledge of what the eighth-grade students are being taught and we can continue that at the high school level. As a leader in my building, I will share what I have learned and make a positive impact for other learners and educators in my district.

Analysis of Self as a Project Developer

I developed a project for the local district to increase professional learning centered on inquiry-based instruction. I wanted to ensure the project reflected what I had learned from the classroom observations and one-on-one interviews and the needs of the teachers. The project I developed could assist the middle school teachers in improving the implementation of FOSS by sharing ideas and collaborating. I learned a lot about the needs of the teachers and about the best methods to align curriculum. It is important to evaluate what standards are being covered and what gaps exist. I have been able to use this knowledge and assist in creating the curriculum map for the freshman science course.

PD is not new to the district; however, this PD is designed to incorporate the findings from my study. This project incorporates research strategies on how to build an effective professional learning community. The ultimate goal of science in the district is to improve student learning with more inquiry-based instruction.

Project Development

I embarked on this doctoral journey with a clear understanding of inquiry-based learning and how important professional development was for teachers. Scientific inquiry and the important use of notebooks became a focus of my research. As the results of my research unfolded through interviews and observations, I gained a much deeper understanding into the benefits and challenges teachers faced shifting their instruction to be more inquiry-based. I developed a professional development program to assist teachers with their shift in instruction.

Professional development, inquiry-based instruction, and notebook use became key topics my research and my recommendation for a PLC for middle school science teachers. As a result of my research, I grew as a scholar and was able to hone my knowledge base so that I now have a deeper understanding of professional development and how to develop a PLC that will lead to better teacher outcomes. Based on my interviews and observations, the PLC needs to focus on material management, notebook usage, and development of formative and summative assessments.

It is possible that the teachers included in this study were able to reflect on their own instructional practices as a result of our conversation. This study may have helped them individually as they shared their best practices with me. I also feel the teachers will feel ownership to their ideas being part of my professional development plan. The professional development plan for this project study was solely based on the needs of the teachers expressed during the interviews.

During this time that I worked on this project, I believe that I demonstrated a great deal of growth as a scholar and as a leader in the local district. The teachers appreciated that I was listening to their concerns and that through effective professional development we would be able to move forward with FOSS and make it even better for our diverse student population. The evaluation for this professional development plan will be in the form of teacher feedback for future sessions. I will adapt my recommendations for the professional development sessions based on the needs of the teachers, making the PLC more authentic.

Leadership and Change

I have been the lead science teacher for my academic team at the high school for the past three years. Part of this responsibility is to align our curriculum with the NGSS standards as well as what the students are learning at the middle school level. This experience collecting data from middle school science teachers and then developing a project plan has helped me with this leadership role. I learned how to listen to the feedback from teachers and use my research of the literature related to inquiry-based learning to develop a project. This experience has opened my eyes to the needs of the teachers in the middle school and how this affects the high school students I teach. Students need to be engaged in the science content as much as possible. If this engagement in science practices starts in the younger grades, the students will be more prepared for high school science courses.

I have had the opportunity to speak with the district curriculum coordinator about my PD ideas and will have an opportunity to prepare and present my findings to the middle school science teachers. I have also presented my findings to my colleagues at the local high school. My data and knowledge about inquiry-based instruction has helped me shift instruction at the 9th grade level to be more inquiry-based.

Completing this research on inquiry-based instruction has allowed me to develop and facilitate a successful science camp in my district. I was able to use my knowledge and research to assist teachers in designing their science programs. All of the workshops offered for the students were hands-on and inquiry-based. Students could be seen solving problems, completing science challenges, and coding robots.

Reflection on Importance of the Work

As previously discussed, one of the most important aspects of what I learned during the interview process and development of this project involves the concerns and needs that teachers have for consistent professional development in the implementation of the FOSS curriculum. Professional development needs to occur regularly throughout the school year and must provide support in the areas of materials management, notebook assessment, and collaboration on supplemental lessons not included in the FOSS modules. The study I developed is important to the middle school science teachers and the administration that has purchased the FOSS curriculum.

There was evidence from the interviews that each teacher interviewed is at a level of use with FOSS where they want to move forward with FOSS implementation. However, supplemental lessons and ideas are needed to ensure there is complete alignment to the NGSS. Teachers interviewed also indicated that their stage of concern was collaboration. Teachers at the middle school level often teach in isolation because there is no other science teacher at their school with whom to meet and plan. This project will allow such interaction on a regular, consistent basis.

Implications, Applications, and Directions for Future Research

The goal of this project study was to provide middle school science teachers with the necessary professional development needed to sustain the newly implemented FOSS curriculum. The intention of implementing FOSS was to assist teachers as they shift their instruction to be inquiry-based. An inquiry-based science curriculum is what the NRC has been recommending with the implementation of the NGSS. An inquiry-based science curriculum promotes problem solving in developing students for the 21st century.

All of the teachers interviewed for this study indicated they wanted more consistent collaboration for science vertical team planning. They agreed the FOSS curriculum was successful in helping them shift their instruction; however, the teachers needed sustained professional development to continue implementing the curriculum effectively. Collaboration is a part of refinement stage and all part of the change process, as outlined by CBAM (2016).

Another contribution that this study makes to positive social change is at the organization level. This study has the potential to improve the resources and supplemental lesson teachers are seeking. The on-line platform I am organizing will allow all teachers a resource for scaffolding and differentiating lessons.

The last contribution that this study makes is increase in teacher collaboration. It is important for teachers to be given time to collaborate with one another about best instructional practices. Through my professional development plan teachers will be able to share how they are implementing FOSS and discuss which standards may be missing from the FOSS modules. This alignment will help with the addition of supplemental lessons for each grade level. Teachers will have time to share and evaluate student work, design formative assessments centered on FOSS, and design rubrics for notebook assessment. Ultimately this will assist in the teaching methodology occurring at the high school level.

Future research should continue to explore the challenges and successes of teachers implementing the FOSS curriculum. It was discovered during the interviews with teachers that a main concern was on using the FOSS to teach to the ELL and special education students. I would like to explore this more and determine ways that FOSS can be differentiated to meet the needs of those student populations. I would recommend more in-depth conversations with the teachers and time to plan these lessons. According to CBAM (2016), change is a process that takes time and can change depending on the needs of the teachers. The Levels of Use and Stages of Concern should be revisited every year to assess the current needs of teachers. Teachers need sustained support as they continue implementing the FOSS curriculum.

Conclusion

The most recent vision for science teaching and learning was established in the framework for K-12 science (NRC, 2014) and was the focus in the NGSS 2013. This vision requires a shift in traditional science teaching to a more hands-on student-centered approach. This new approach is what is needed to make teaching and learning more meaningful and productive for students. A local district has adopted the FOSS curriculum as a means to meet the demands of the NGSS. This study utilized the CBAM framework to identify the stages of concern and levels of use teachers experienced with shifting their instruction practice to be more inquiry-based using the FOSS curriculum.

The 14 teachers who were interviewed indicated they were fully implementing the FOSS modules and were ready for some additional professional development to enhance the current curriculum. The teachers had a vested interest in FOSS and the activities included in the modules and investigations. I observed that there were some inconsistencies in how notebooks were being assessed and some difficulty with the management of materials. I was able to meet with the science curriculum coordinator to discuss my findings and share my professional development plan.

The professional development that I created represents the needs of the teachers interviewed. Teachers shared their need for more collaboration at the vertical level. Many teachers in individual middle schools did not have another teacher with whom to plan science lessons. Interviews revealed that the teachers were all implementing the FOSS modules consistently according to the district curriculum guide. I observed the same FOSS modules being implemented at the same time at different middle schools. The teachers all agreed that the FOSS curriculum was helping to shift instruction to be more students-centered; however, teachers needed more support by collaborating with teachers throughout the year. Moving forward with the FOSS curriculum, it will be essential to realign the standards with FOSS and determine what lessons need some revamping.

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Appendix A: The Project

Introduction

Results of findings gathered from observations and one-on-one interview with middle school science teachers guided the direction of this project. Teachers employed at six of the nine middle schools in a local district shared their experiences with shifting their instruction to be more inquiry-based implementing the FOSS curriculum. A review of findings revealed that the district might benefit from greater consistent collaboration among teachers where time is committed to teachers sharing curriculum ideas.

Professional learning communities (PLC) are a group of educators working collaboratively and consistently toward a common goal like student achievement (Woodland, 2016). A PLC can be developed as a means of supporting and improving teacher knowledge and skills. PLCs can focus on PD and build respect, trust, and collegiality (Carpenter, 2015; Dogan, 2015; Woodland, 2016). Creating a project learning community among the middle school science teachers can help develop a community where teachers support one another.

Purpose

The purpose of this project is to provide ongoing support for teachers implementing the FOSS curriculum. The goals of the project are: first to learn and use collaboration strategies during the academic year, second to develop a common lab rubric for all teachers to use, third is for teachers to create a current curriculum map that is aligned to the NGSS, and fourth to model and encourage teacher observation of FOSS investigations. The professional development will be three full days throughout the school year (September, January and June) for the lead science teachers as well as 1.5-hour afternoon sessions once a month. The outcomes of my study indicated that teachers are in need of ongoing professional development to share ideas and lessons that will compliment FOSS as well as align the FOSS to the NGSS. Teachers also expressed a need to develop a common rubric for their science notebooks. I met with the Science Curriculum coordinator and she supports this plan. All the professional development will be intended for the 6-8th teachers that have been implementing FOSS for at least a year.

Stated Goals and Objectives:

1. To facilitate and encourage collaboration among middle school science teachers to share supplemental lesson plans and curriculum ideas aligned with FOSS.
2. To create a common rubric, assess the science notebooks.
3. To create a curriculum map for all 6-8th grade science teachers to access that will display supplemental curriculum ideas and be aligned to the FOSS curriculum.
4. To provide opportunities for teachers to observe their colleagues implementing FOSS lessons and time to reflect on these observations.

Implementation Schedule

Professional Development Workshop (September, January and June):

This professional development will be offered to the teachers serving as lead science teachers in each middle school. It will be the responsibility of the leads to disseminate the information from the trainings to the rest of the teachers in their schools. The PLC will be developed as another means of continuing the PD work and increasing collaboration among the teachers. The rationale behind this is funding. The LPS is a large school district with over 40 science teachers.

Session 1: 8:00 a.m. – 2:30 p.m.

Research Background, Curriculum Alignment: NGSS and FOSS

Proposed Time: September (shortly before school starts)

Duration: 6 hours

The goal of the first session will be to provide teachers with the background to my research and begin to update the science curriculum map and standards aligned to FOSS. The teachers will identify any gaps and/or supplemental lessons that are needed. The lead teachers will share this information to the other science teachers during early release days and the information will be part of the once a month after school agendas.

The second goal of this professional development will be to create a Google document folder that will contain the information for each grade level. Each folder will have the curriculum map aligned with FOSS as well as other resources developed during the professional development throughout the year.

Session 2: 8:00 am – 2:30 pm

Sharing Curriculum Ideas across disciplines

Proposed Time: January after second marking period

Duration: 6 hours

The goal of the second session will be to continue the work from September professional development. Teachers will continue and confirm the curriculum alignment and continue sharing supplemental lesson ideas.

The second goal will be to receive feedback on the Google document that has been created and adjust accordingly.

A third focus for this professional development will be to share rubrics and lesson plan ideas aligned with FOSS specifically on the Launch, Explore, Summary portion of a lesson.

Session 3: 8:00 am – 2:30 pm

Review of the work completed and Plan moving forward

Duration: 6 hours

Proposed time: June (once school is out of session)

All middle school science teachers will be invited to this professional development at the end of the school year. This PD will be designed to review the after-school sessions and the work the Lead Science teachers had participated in. This session will help set goals for the following years PLC.

Agenda Session 1
(Lead Science Teachers)

8:00 am – 9:00 am	Introduction to goals of PLC – discuss background of research and needs of teachers Teachers will learn about aligning of FOSS curriculum using the new NGSS standards. We will spend time learning how to set up the Google folders for each grade level. Discussion about importance of curriculum mapping and samples of what this could look like. Resources needed: Teachers will bring laptops and FOSS curriculum materials. I will need a laptop, projector, curriculum alignment template and NGSS standards.
9:00 am – 12:00 pm	Breakout Sessions by grade level (6,7, and 8) ❖ Review of the NGSS standards and current FOSS pacing. Use Google Documents to create working document. ❖ Discuss any standards missing and adjust pacing. Resources needed: Teachers will bring laptops and FOSS curriculum materials. I will need a laptop, projector, curriculum alignment template and NGSS standards.
12:00 pm – 12:30 pm	LUNCH

12:30 pm – 1:30 pm	Open Discussion: Establishing the importance of teachers observing other teachers ❖ Observing as a form of professional development ❖ Observation protocol (Appendix F) ❖ Obstacles to observing teachers Resources needed: Teachers will bring laptops and FOSS curriculum materials. I will need a laptop, projector, curriculum alignment template and NGSS standards.
1:30 pm – 2:30 pm	Update on consumable materials needed for next FOSS unit for grade 6-8. ❖ Google Docs for teachers to input needed materials

Agenda Session 2 (Lead Science Teachers)

8:00 am – 9:00 am	Review of the established PLC (after school session topic rubric sharing, Launch, Explore portion of FOSS) Resources needed: Teachers will bring laptops and FOSS curriculum materials. I will need a laptop, projector, curriculum alignment template and NGSS standards.
9:00 am – 12:00 pm	Breakout Sessions by grade level (6,7, and 8) ❖ Science and Engineering Practices Think, Pair, Share activity. ❖ Launch activity (KWL and See, Think, Wonder) ❖ Explore discussion ❖ Supplemental Lessons to FOSS modules Resources needed: Teachers will bring laptops and FOSS curriculum materials. I will need a laptop, projector, curriculum alignment template and NGSS standards.
12:00 pm – 12:30 pm	LUNCH
12:30 pm – 1:30 pm	It will be recommended that teachers observe one another teaching FOSS lessons. During this session teachers will revisit and reflect on this process. Resources needed: Teachers will bring laptops and FOSS curriculum materials. I will need a laptop, projector, and observation protocol templates (Appendix F)

1:30 pm – 2:30 pm	Update on consumable materials needed for next FOSS unit for grade 6-8. ❖ Google Docs for teachers to input needed materials

Agenda Session 3 (Lead Science Teachers)

8:00 am – 9:00 am	Review of after school sessions ❖ Sharing of ideas ❖ Ideas moving forward Resources needed: teacher laptops and projector
9:00 am – 12:00 pm	Breakout sessions by grade level ❖ Formative assessment discussion ❖ Importance of Writing in Science ❖ Notebook Rubric samples (teachers will bring and share) Resources needed: Teachers will bring laptops and FOSS curriculum materials. I will need a laptop.
12:00 pm – 12:30 pm	LUNCH
12:30 pm – 1:30 pm	Teacher to teacher observations ❖ Have any teachers observed colleagues? ❖ What is needed to move forward with this? Resources needed: teacher laptops and projector
1:30 pm – 2:30 pm	Discussion of the summary portion of the lesson ❖ Teacher activity to share methods to summarize FOSS investigations

	❖ Google sheet for teachers to input needed materials Resources needed: teacher laptops and projector

Part 2: I would like to recommend that there be 1.5 hour after school meetings scheduled every month for all science teachers to participate in. These can be hosted by different middle schools in the district. The goal of these sessions is to provide the ongoing support and collegiality teachers suggested during my interviews. There will be a focus each month and teachers can decide which ones would benefit them the most.

Monthly PLC themes:

September: Setting up notebooks

- Different ways to set up notebooks (bring samples).
- Importance of writing in science (article or book suggestion).

October: Formative assessment of science notebooks.

- Bring rubrics to share - options

November: How do we launch a FOSS lesson? Is it just the focus question? What else do teachers do to launch the lesson – bring examples?

December: Break out groups – teachers model an investigation – focus on the explore portion of the lesson – What does this look like in the classroom?

January: Full Day Professional Development for the lead science teachers

January: Effective Feedback in Notebooks

- Bring work samples of notebooks to share – how do we provide feedback? What do we do with the feedback?
- Activity on what we notice about student work.

- How do we give feedback in the notebook? (review again in April)

February: Revisit supplemental lessons and update – ongoing but time to review

March: Misconceptions? How do we re-teach these concepts.

April: Summary portion of the lesson – how we summarize the lesson for the day – What if investigation goes more than a day?

May: Review of feedback – Reflection: What have we changed? What's next?

- Bring work samples
- Goals for next year with FOSS implementation
- Topics we could focus on next year.

Common Documents on Google:

- Folder for rubric choices (approved by district).
- Folder on setting up a notebook, binder, copied sheets (School X as a model)
- NGSS Standards aligned with FOSS by grade level.
- Document for standard, FOSS, supplemental ideas to enhance investigation (explore).
- Folder on formative and summative assessment ideas.
- Launch ideas for lessons.
- Summary ideas for lesson.

Materials Needed:

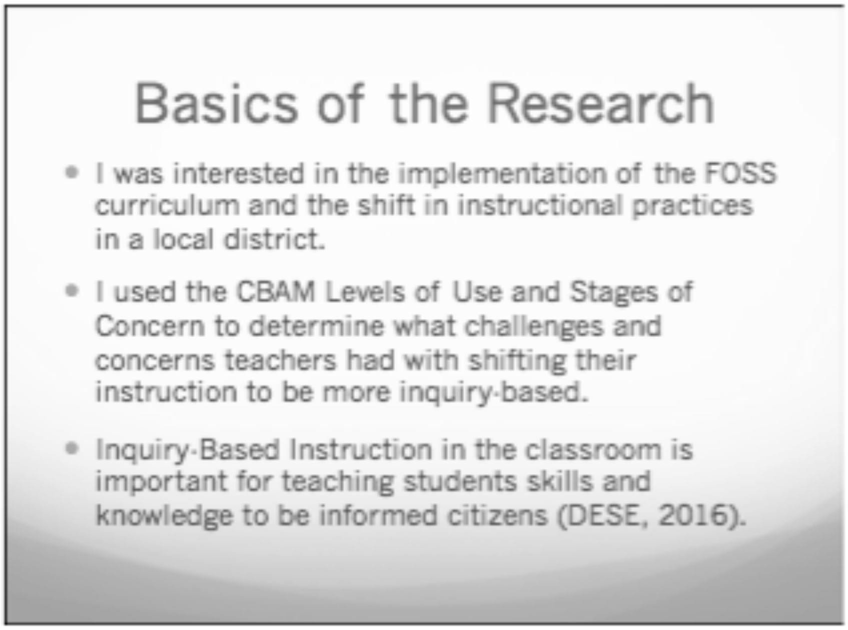
- Sign-in sheets
- Name Tags

- Power Point presentations
- Agendas
- NGSS standards
- Projector
- Laptop
- FOSS curriculum units – Fossweb.com
- Consumable material list for each FOSS unit 6-8

Power Point Presentation

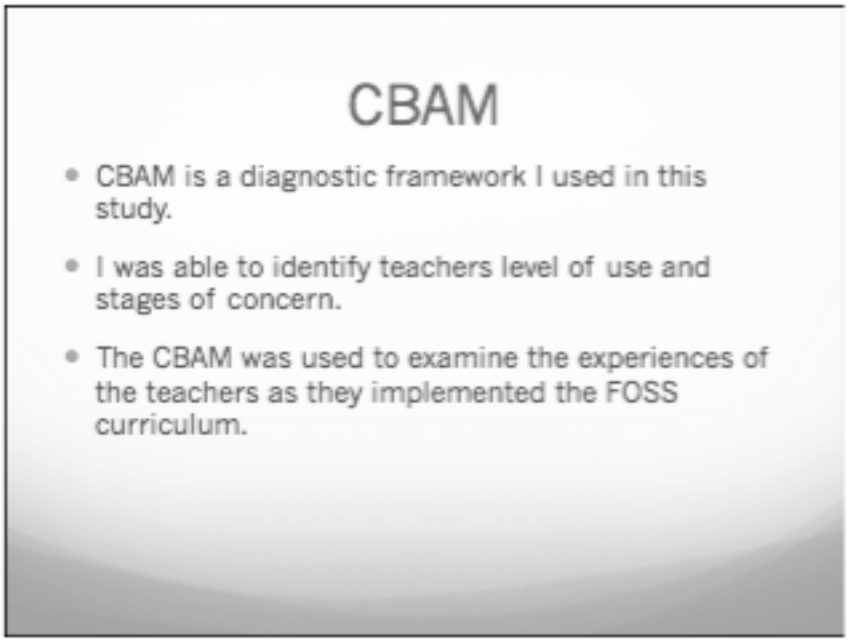
Background to Research

Session 1 – Science PLC



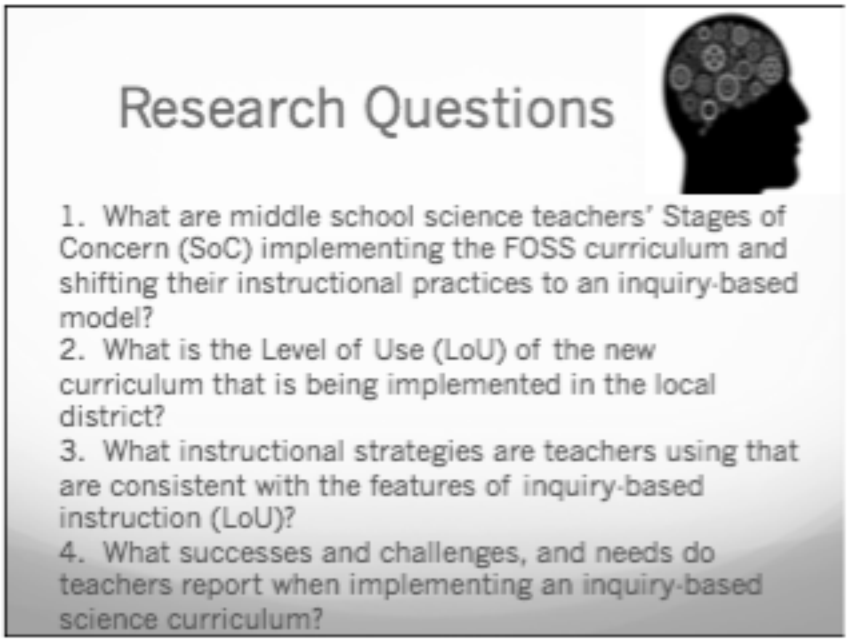
Basics of the Research

- I was interested in the implementation of the FOSS curriculum and the shift in instructional practices in a local district.
- I used the CBAM Levels of Use and Stages of Concern to determine what challenges and concerns teachers had with shifting their instruction to be more inquiry-based.
- Inquiry-Based Instruction in the classroom is important for teaching students skills and knowledge to be informed citizens (DESE, 2016).



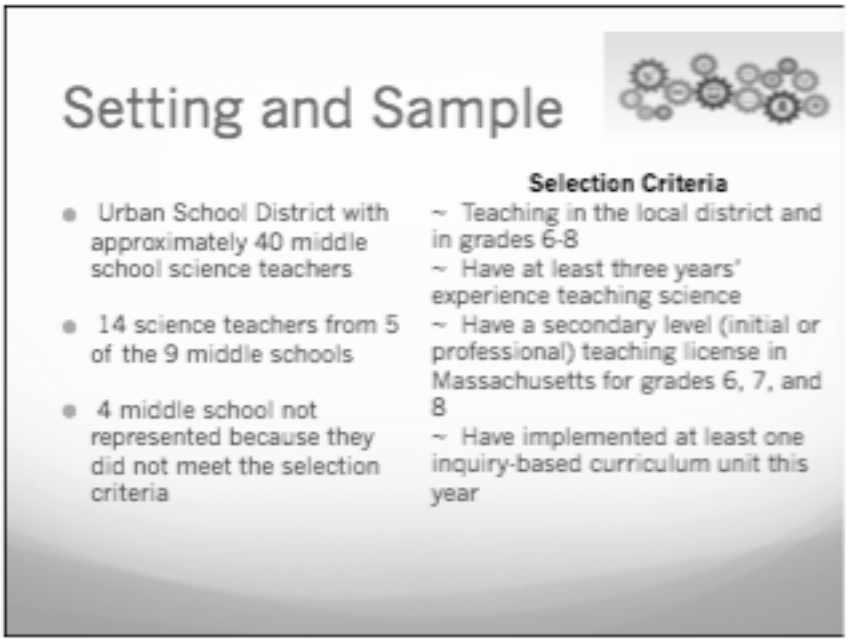
CBAM

- CBAM is a diagnostic framework I used in this study.
- I was able to identify teachers level of use and stages of concern.
- The CBAM was used to examine the experiences of the teachers as they implemented the FOSS curriculum.



Research Questions

1. What are middle school science teachers' Stages of Concern (SoC) implementing the FOSS curriculum and shifting their instructional practices to an inquiry-based model?
2. What is the Level of Use (LoU) of the new curriculum that is being implemented in the local district?
3. What instructional strategies are teachers using that are consistent with the features of inquiry-based instruction (LoU)?
4. What successes and challenges, and needs do teachers report when implementing an inquiry-based science curriculum?



Setting and Sample

- Urban School District with approximately 40 middle school science teachers
- 14 science teachers from 5 of the 9 middle schools
- 4 middle school not represented because they did not meet the selection criteria

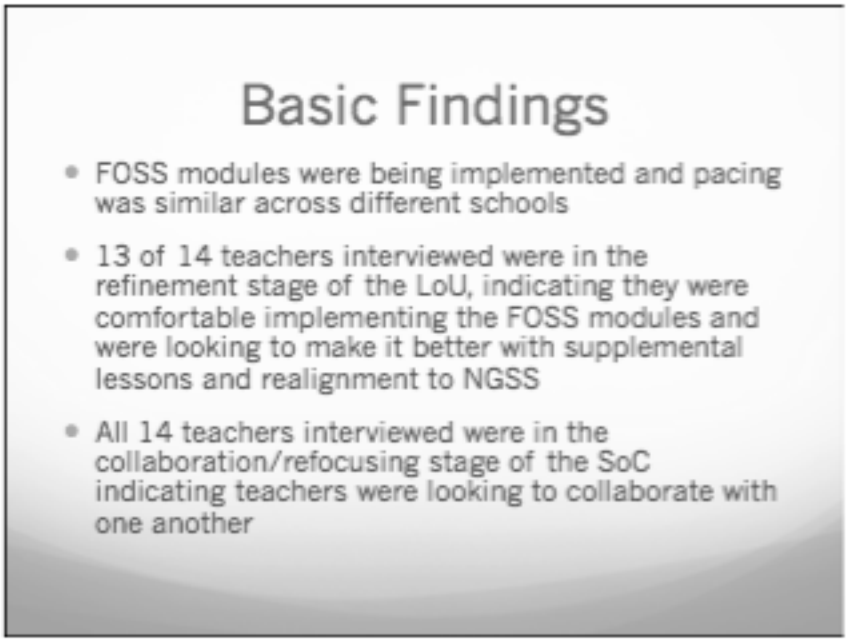
Selection Criteria

~ Teaching in the local district and in grades 6-8

~ Have at least three years' experience teaching science

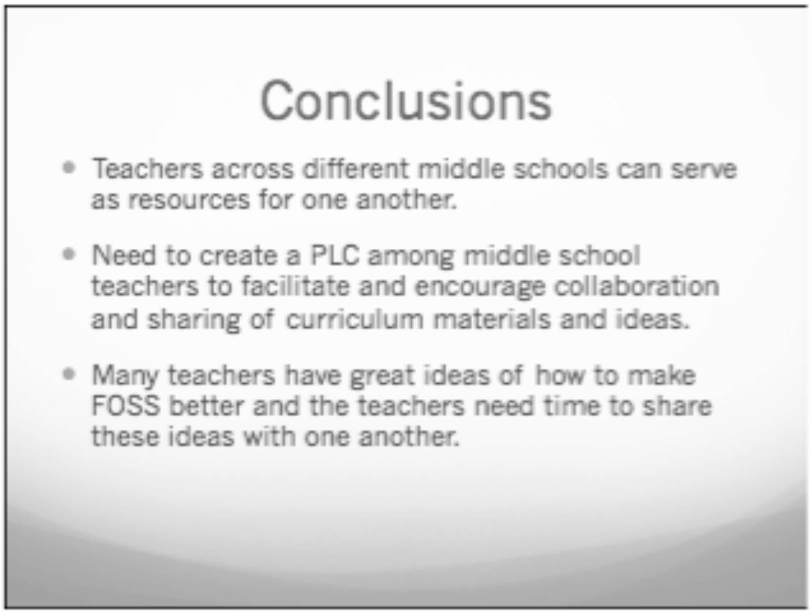
~ Have a secondary level (initial or professional) teaching license in Massachusetts for grades 6, 7, and 8

~ Have implemented at least one inquiry-based curriculum unit this year



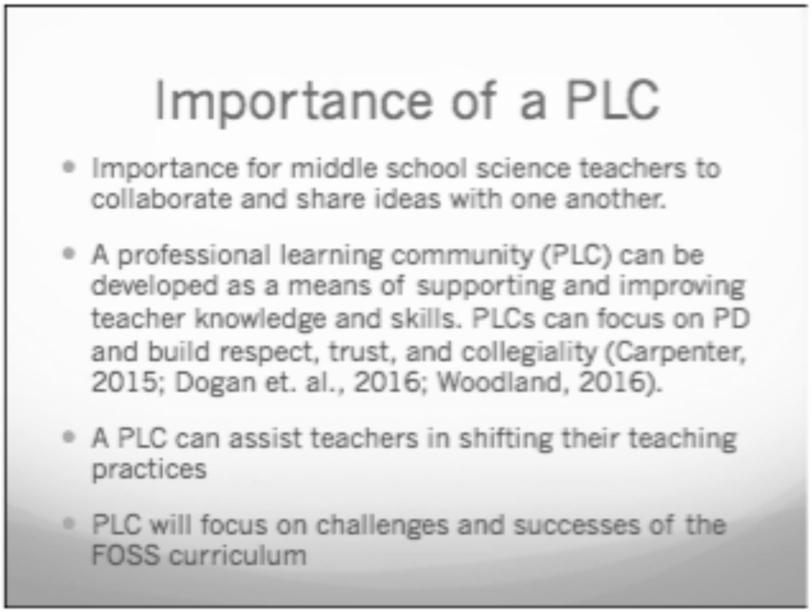
Basic Findings

- FOSS modules were being implemented and pacing was similar across different schools
- 13 of 14 teachers interviewed were in the refinement stage of the LoU, indicating they were comfortable implementing the FOSS modules and were looking to make it better with supplemental lessons and realignment to NGSS
- All 14 teachers interviewed were in the collaboration/refocusing stage of the SoC indicating teachers were looking to collaborate with one another



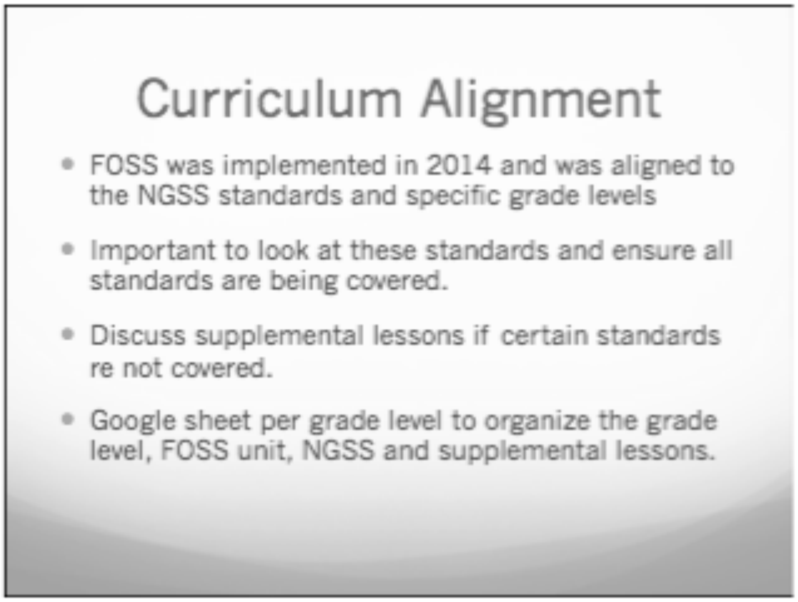
Conclusions

- Teachers across different middle schools can serve as resources for one another.
- Need to create a PLC among middle school teachers to facilitate and encourage collaboration and sharing of curriculum materials and ideas.
- Many teachers have great ideas of how to make FOSS better and the teachers need time to share these ideas with one another.



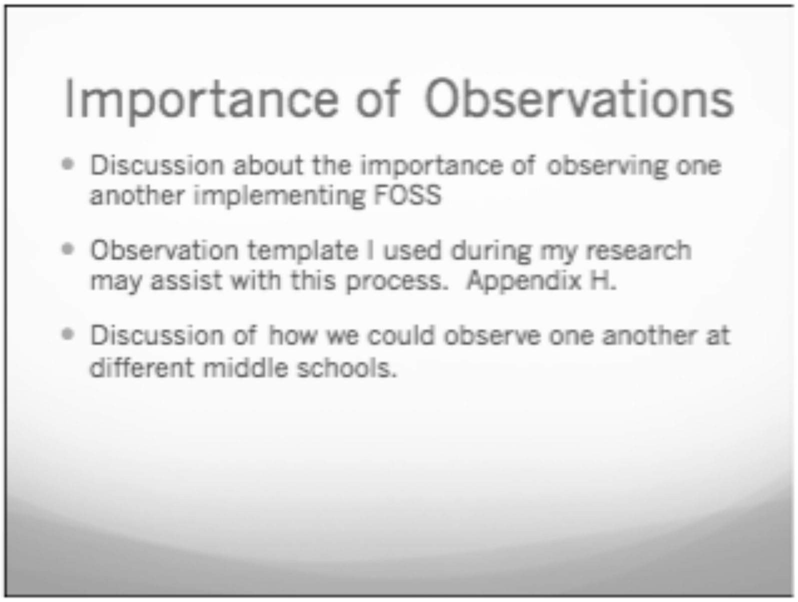
Importance of a PLC

- Importance for middle school science teachers to collaborate and share ideas with one another.
- A professional learning community (PLC) can be developed as a means of supporting and improving teacher knowledge and skills. PLCs can focus on PD and build respect, trust, and collegiality (Carpenter, 2015; Dogan et. al., 2016; Woodland, 2016).
- A PLC can assist teachers in shifting their teaching practices
- PLC will focus on challenges and successes of the FOSS curriculum



Curriculum Alignment

- FOSS was implemented in 2014 and was aligned to the NGSS standards and specific grade levels
- Important to look at these standards and ensure all standards are being covered.
- Discuss supplemental lessons if certain standards re not covered.
- Google sheet per grade level to organize the grade level, FOSS unit, NGSS and supplemental lessons.



Importance of Observations

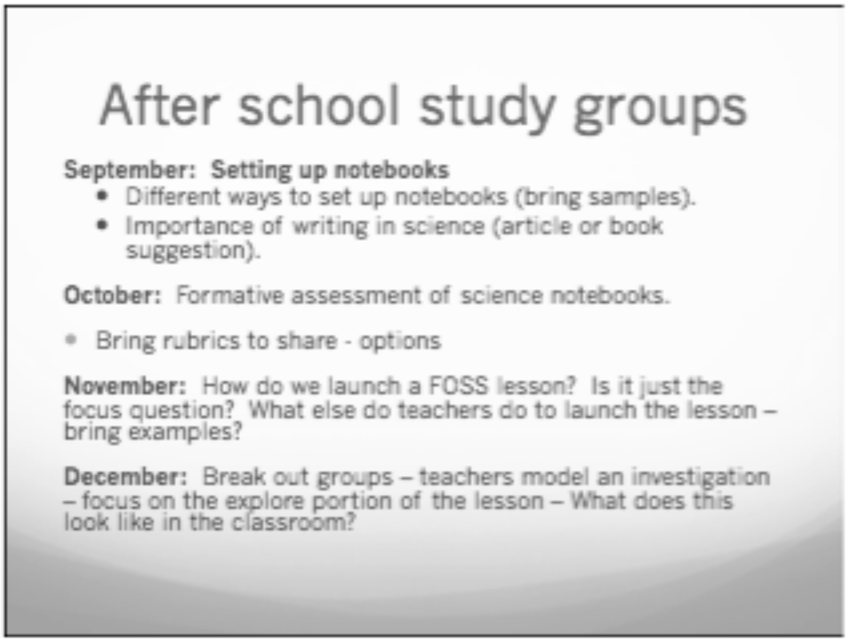
- Discussion about the importance of observing one another implementing FOSS
- Observation template I used during my research may assist with this process. Appendix H.
- Discussion of how we could observe one another at different middle schools.

Consumable Materials

- Google form will be used to assist teachers in re-ordering supplies.
- Other resources needed?

Background to Research

Session 2 – Continuing our work
Science Professional Development



After school study groups

September: Setting up notebooks

- Different ways to set up notebooks (bring samples).
- Importance of writing in science (article or book suggestion).

October: Formative assessment of science notebooks.

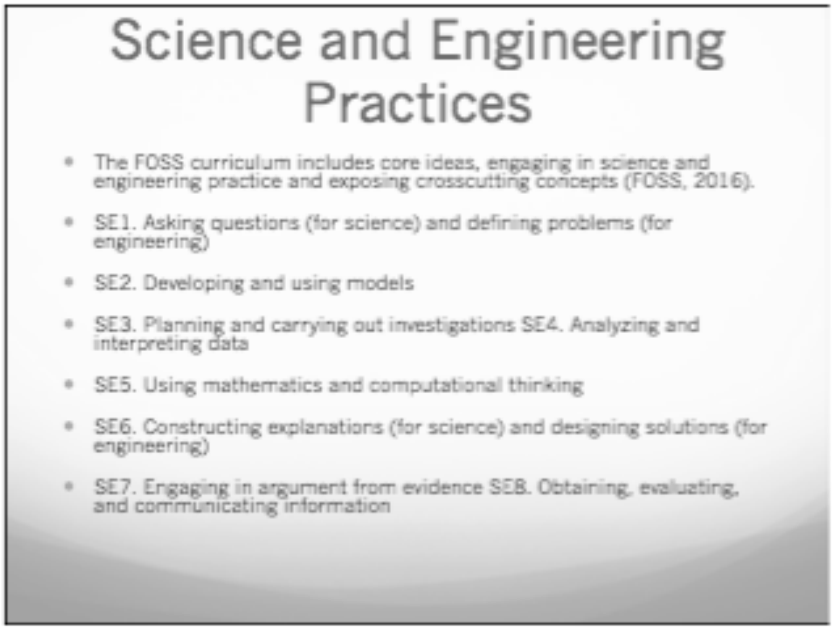
- Bring rubrics to share - options

November: How do we launch a FOSS lesson? Is it just the focus question? What else do teachers do to launch the lesson – bring examples?

December: Break out groups – teachers model an investigation – focus on the explore portion of the lesson – What does this look like in the classroom?

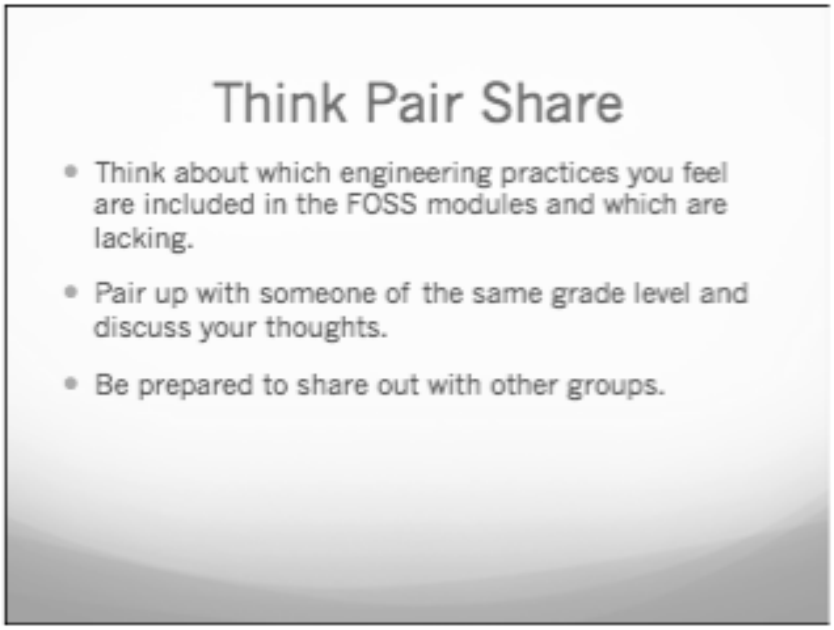
After school study groups

- Discussion of study group sessions. What worked? Changes? Teachers share and record ideas.
- Formative assessment and notebook rubrics – review samples -



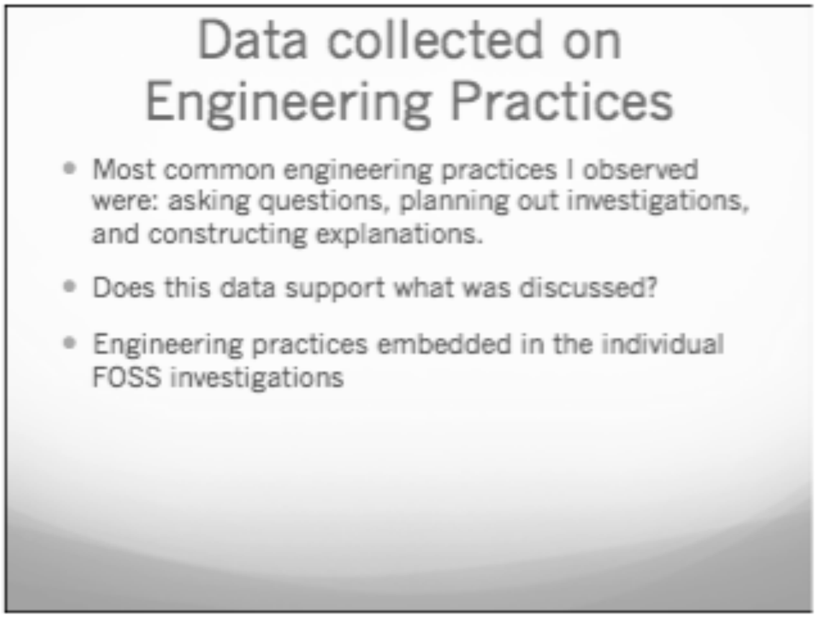
Science and Engineering Practices

- The FOSS curriculum includes core ideas, engaging in science and engineering practice and exposing crosscutting concepts (FOSS, 2016).
- SE1. Asking questions (for science) and defining problems (for engineering)
- SE2. Developing and using models
- SE3. Planning and carrying out investigations SE4. Analyzing and interpreting data
- SE5. Using mathematics and computational thinking
- SE6. Constructing explanations (for science) and designing solutions (for engineering)
- SE7. Engaging in argument from evidence SE8. Obtaining, evaluating, and communicating information



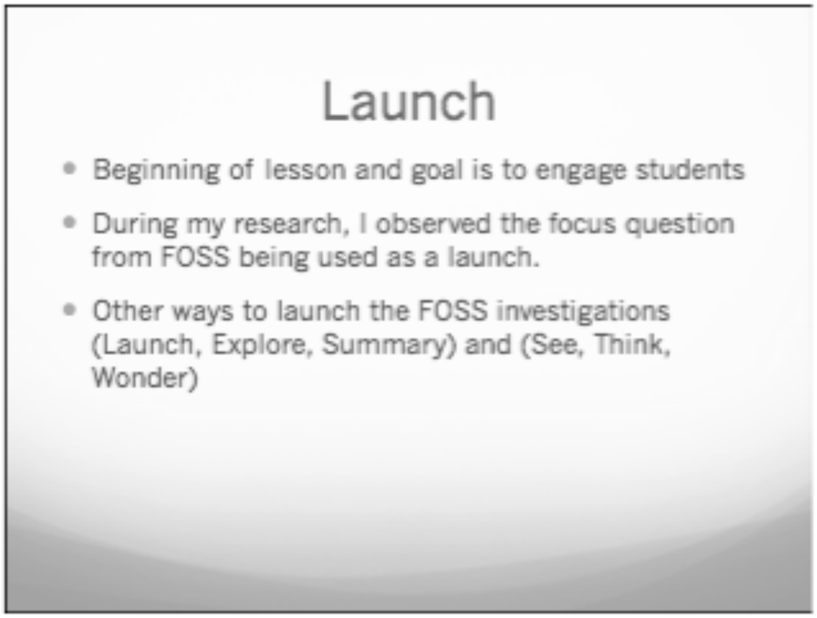
Think Pair Share

- Think about which engineering practices you feel are included in the FOSS modules and which are lacking.
- Pair up with someone of the same grade level and discuss your thoughts.
- Be prepared to share out with other groups.



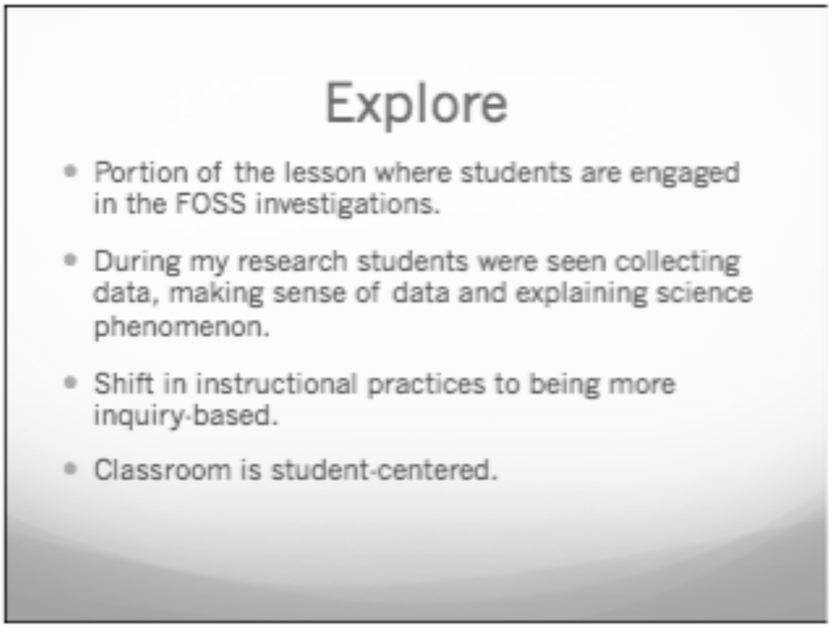
Data collected on Engineering Practices

- Most common engineering practices I observed were: asking questions, planning out investigations, and constructing explanations.
- Does this data support what was discussed?
- Engineering practices embedded in the individual FOSS investigations



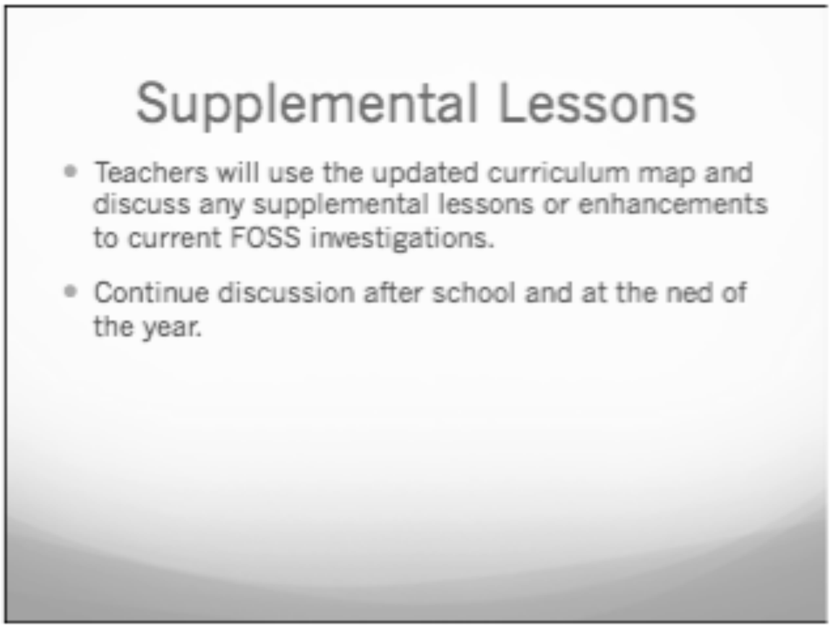
Launch

- Beginning of lesson and goal is to engage students
- During my research, I observed the focus question from FOSS being used as a launch.
- Other ways to launch the FOSS investigations (Launch, Explore, Summary) and (See, Think, Wonder)



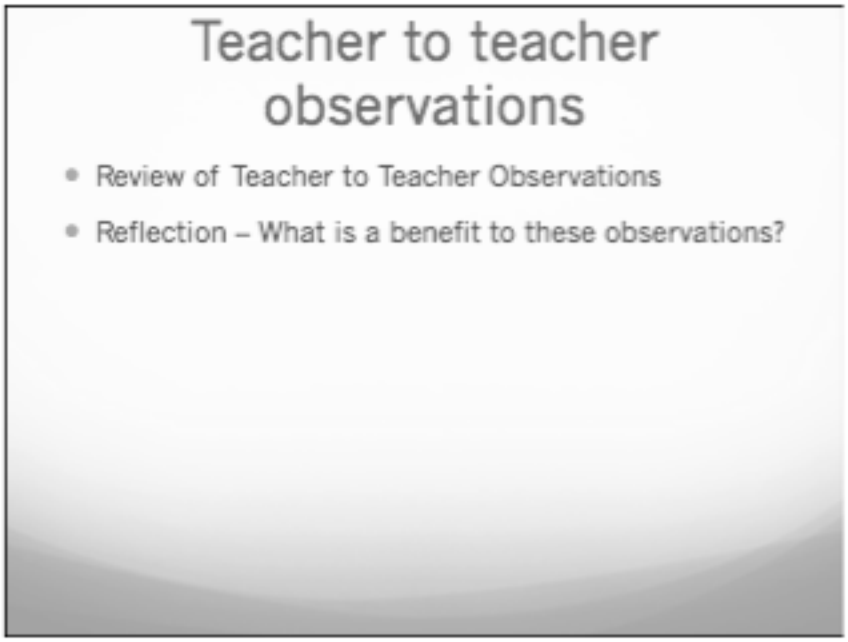
Explore

- Portion of the lesson where students are engaged in the FOSS investigations.
- During my research students were seen collecting data, making sense of data and explaining science phenomenon.
- Shift in instructional practices to being more inquiry-based.
- Classroom is student-centered.



Supplemental Lessons

- Teachers will use the updated curriculum map and discuss any supplemental lessons or enhancements to current FOSS investigations.
- Continue discussion after school and at the ned of the year.



Teacher to teacher observations

- Review of Teacher to Teacher Observations
- Reflection – What is a benefit to these observations?

Consumable Materials

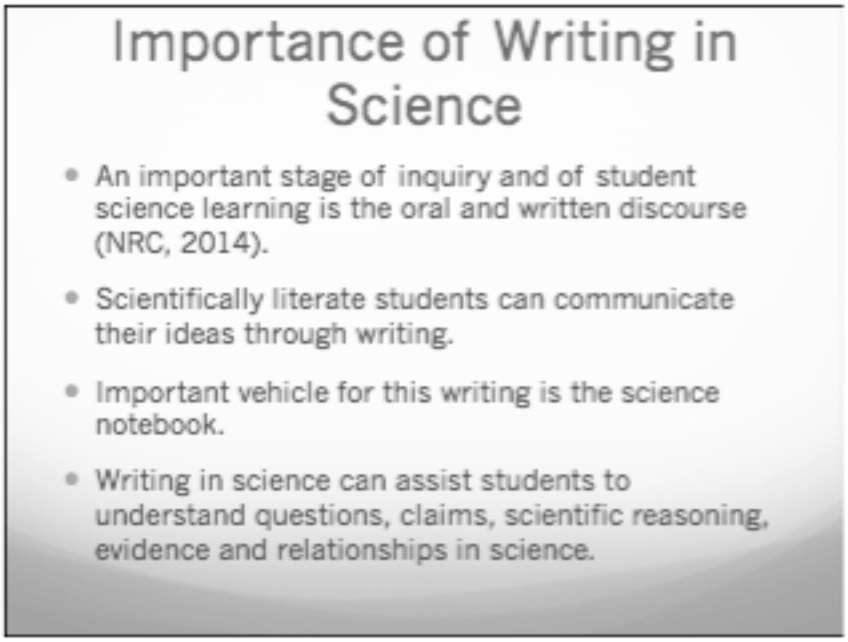
- Google forms update for next FOSS unit

Background to Research

Session 3 – Moving forward

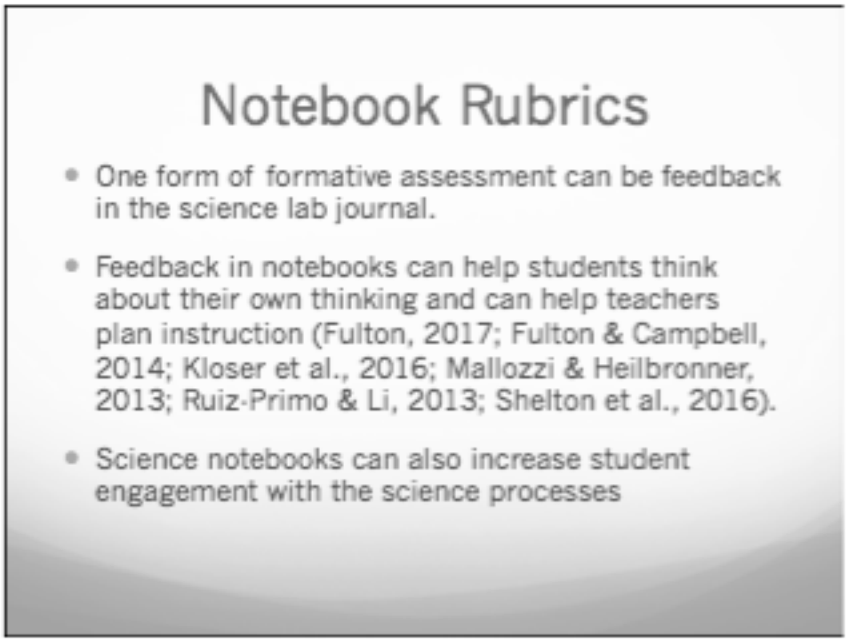
Review of After School Sessions

- Sharing of Ideas
- Ideas moving forward



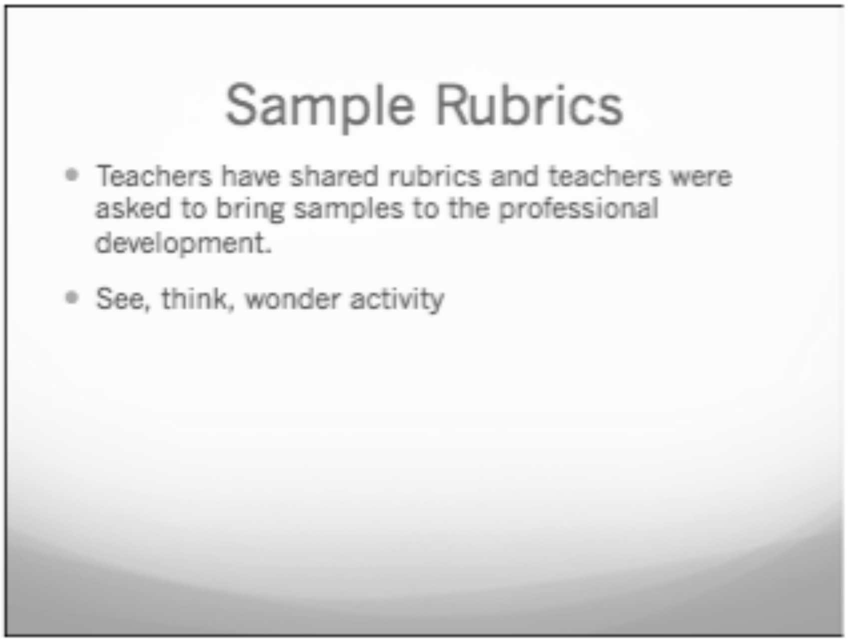
Importance of Writing in Science

- An important stage of inquiry and of student science learning is the oral and written discourse (NRC, 2014).
- Scientifically literate students can communicate their ideas through writing.
- Important vehicle for this writing is the science notebook.
- Writing in science can assist students to understand questions, claims, scientific reasoning, evidence and relationships in science.



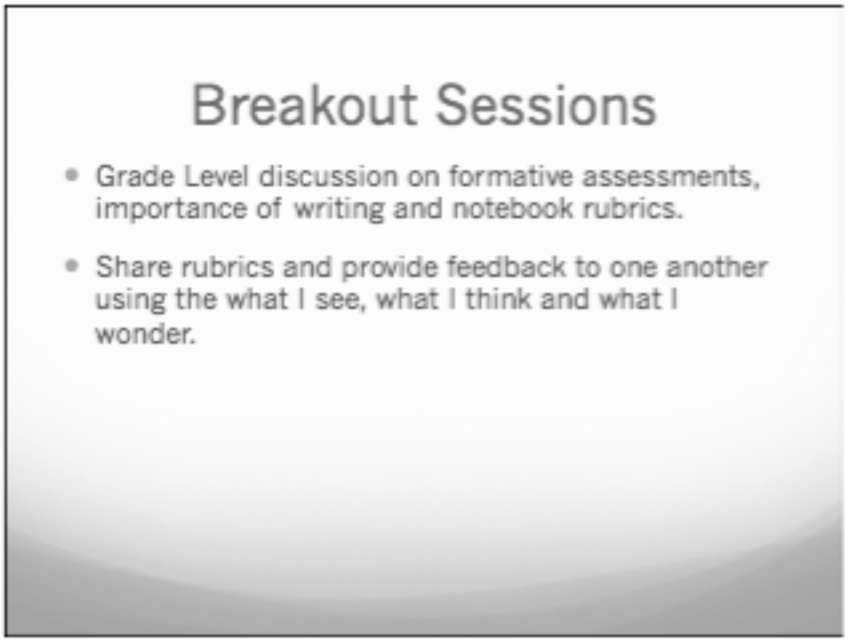
Notebook Rubrics

- One form of formative assessment can be feedback in the science lab journal.
- Feedback in notebooks can help students think about their own thinking and can help teachers plan instruction (Fulton, 2017; Fulton & Campbell, 2014; Kloser et al., 2016; Mallozzi & Heilbronner, 2013; Ruiz-Primo & Li, 2013; Shelton et al., 2016).
- Science notebooks can also increase student engagement with the science processes



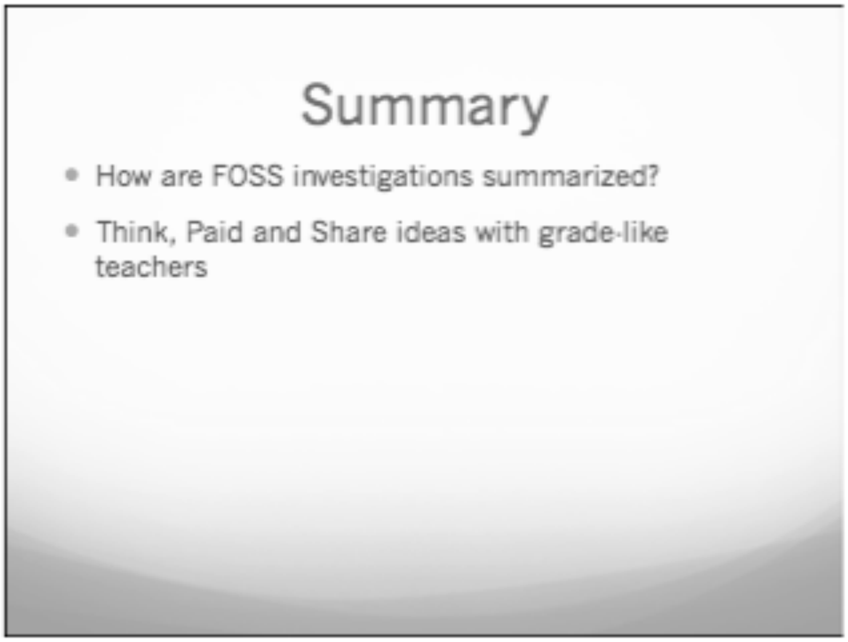
Sample Rubrics

- Teachers have shared rubrics and teachers were asked to bring samples to the professional development.
- See, think, wonder activity



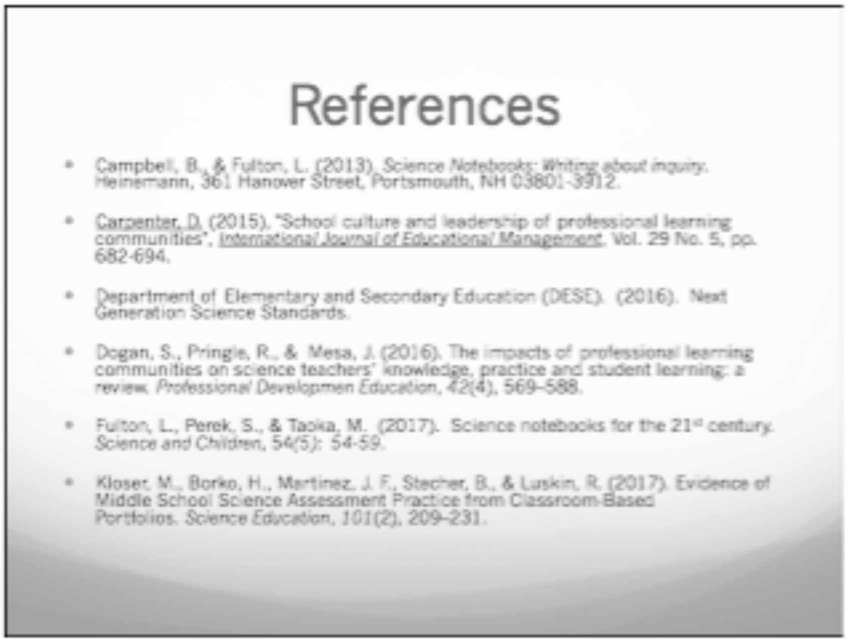
Breakout Sessions

- Grade Level discussion on formative assessments, importance of writing and notebook rubrics.
- Share rubrics and provide feedback to one another using the what I see, what I think and what I wonder.



Summary

- How are FOSS investigations summarized?
- Think, Paid and Share ideas with grade-like teachers



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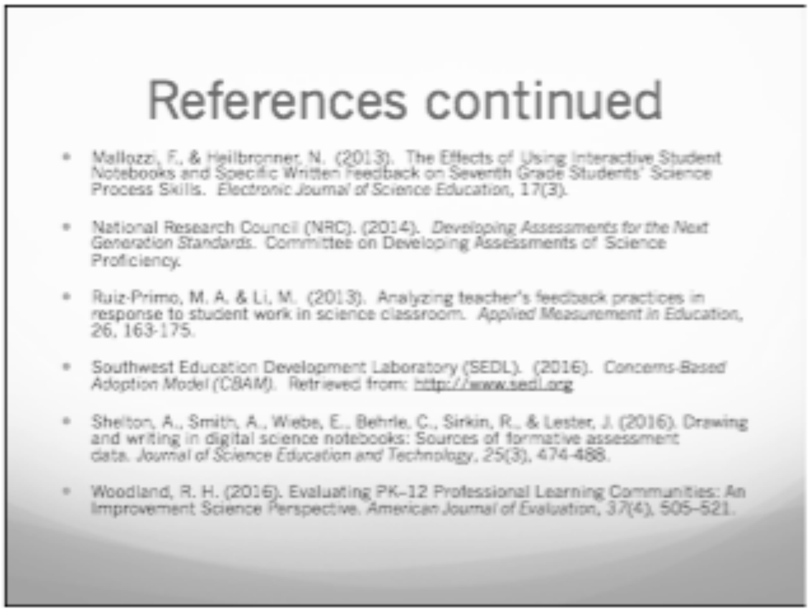

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PD Evaluation

This evaluation is designed to capture feedback regarding your participation in the 3-day PD trainings. There will be a second survey designed for the monthly study groups. I will prepare this as a Google Form so the data is easier to collect.

Directions: Using the scale below, indicate how you would rate each of the following.

0= NA 1= Strongly Agree 2= Agree 3= Disagree 4= Strongly Disagree	
Statement	Scale Number
1. The 3-day PD met my expectations and assisted me in re-aligning the FOSS curriculum to the NGSS.	
2. I have a better understanding of the Launch, Explore, and Summary lesson plan as it relates to FOSS.	
3. I was able to communicate the information from the PD to the other teachers in my building. I understand the goals of the PLC.	
4. The sessions were well organized and my ideas were heard.	
5. The Google Doc created is easy to use and will help organize our curriculum moving forward.	
6. I feel comfortable using the observation template (Appendix F) and look forward to observing my colleagues implementing FOSS?	

Other Questions:

1. What was the most effective part of this PD?
2. What was the least effective part of this PD?
3. What is one suggestion for future PD?

PLC Evaluation

This evaluation is designed to capture feedback regarding your participation in the monthly PLC. I will prepare this as a Google Form so the data is easier to collect.

Directions: Using the scale below, indicate how you would rate each of the following.

0= NA 1= Strongly Agree 2= Agree 3= Disagree 4= Strongly Disagree	
Statement	Scale Number
1. The PLC met my expectations and helped increase my collaboration with science teachers across the district.	
2. The goals of the PLC were clear.	
3. The material presented is something I can use in my daily instruction.	
4. The sessions were well organized and my ideas were heard.	
5. The Google Doc created is easy to use and will help organize our curriculum moving forward.	

Other Questions:

1. What was the most effective part of the PLC?
2. What was the least effective part of the PLC?
3. What are some other topics you would like included in the monthly PLCs?

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January 22, 2019

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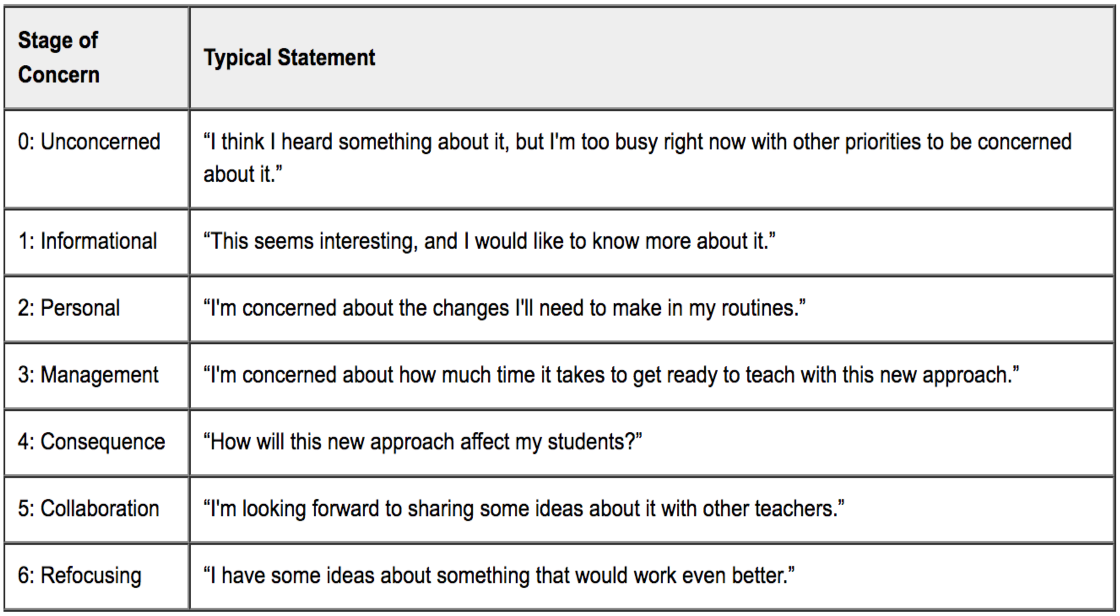
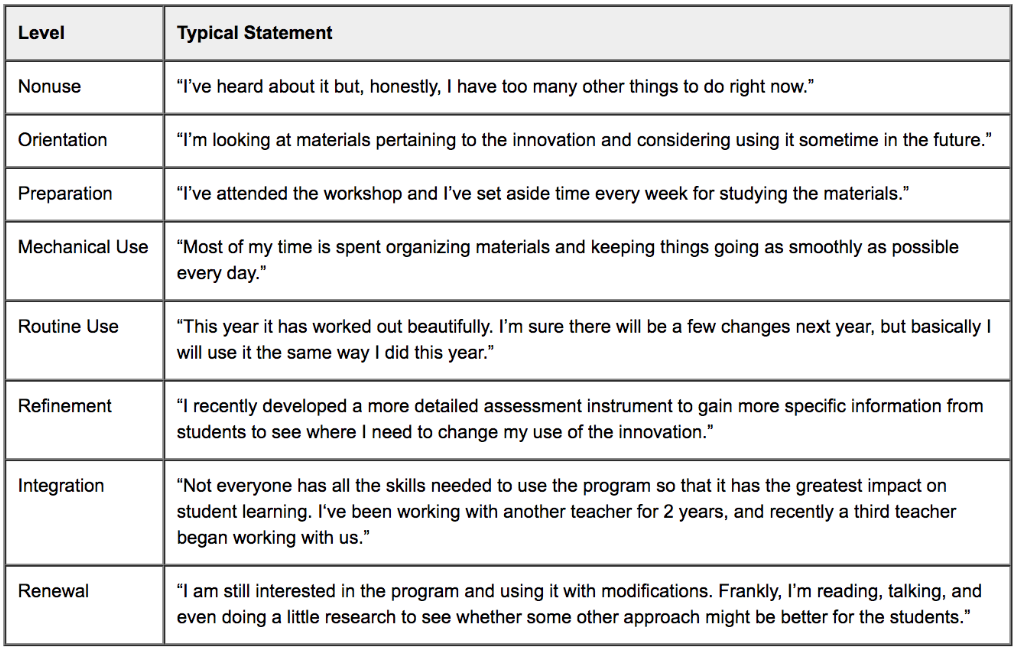
Appendix C: Stages of Concern



Stage of Concern	**Typical Statement**
0: Unconcerned	“I think I heard something about it, but I'm too busy right now with other priorities to be concerned about it.”
1: Informational	“This seems interesting, and I would like to know more about it.”
2: Personal	“I'm concerned about the changes I'll need to make in my routines.”
3: Management	“I'm concerned about how much time it takes to get ready to teach with this new approach.”
4: Consequence	“How will this new approach affect my students?”
5: Collaboration	“I'm looking forward to sharing some ideas about it with other teachers.”
6: Refocusing	“I have some ideas about something that would work even better.”

Figure C1. Stages of concern. Adapted from SEDL, 2016.

Appendix D: Levels of Use



Level	**Typical Statement**
Nonuse	“I’ve heard about it but, honestly, I have too many other things to do right now.”
Orientation	“I’m looking at materials pertaining to the innovation and considering using it sometime in the future.”
Preparation	“I’ve attended the workshop and I’ve set aside time every week for studying the materials.”
Mechanical Use	“Most of my time is spent organizing materials and keeping things going as smoothly as possible every day.”
Routine Use	“This year it has worked out beautifully. I’m sure there will be a few changes next year, but basically I will use it the same way I did this year.”
Refinement	“I recently developed a more detailed assessment instrument to gain more specific information from students to see where I need to change my use of the innovation.”
Integration	“Not everyone has all the skills needed to use the program so that it has the greatest impact on student learning. I've been working with another teacher for 2 years, and recently a third teacher began working with us.”
Renewal	“I am still interested in the program and using it with modifications. Frankly, I’m reading, talking, and even doing a little research to see whether some other approach might be better for the students.”

Figure D1. Levels of use. Adapted from SEDL, 2016.

Appendix E: Key Terms and Phrases for LoU and SoC

LoU 1 Routine	**LoU 2 Refinememt**	**LoU 3 Integration**	**LoU 4 Renewal**
Daily implementation, not changing anything, will use the same next year.	Vary instruction, making changes, adapt instruction, adjust	Teacher Collaboration	Replacing Curriculum with something else/better.
SoC 3 – Task	**SoC 4A – Consequence**	**SoC 4B – Collaboration**	**SoC 4C-Refocusing**
Not enough time Worry about resources and time to prep or grade	Affect the curriculum has on student learning	Working with others Opinions about FOSS	There is something better. Adding to the FOSS – supplemental lessons Curriculum alignment

Appendix F: Classroom Observation Log

The following template has been designed to align with the teachers Levels of Use with the NGSS eight science practices. The researcher/observer for this study will use this template as teachers are observed teaching a science lesson. How often does the teacher provide opportunities for the students to engage in inquiry-based science practices? What will be recorded? These data can provide evidence of an inquiry-based classroom. The observation log also allows for the observer to document the pacing and the script of the lesson.

Table F1

Science Practices Assessment Tool

Teacher/Grade	Science and Engineering Practices Codes SE1. Asking questions (for science) and defining problems (for engineering) SE2. Developing and using models SE3. Planning and carrying out investigations SE4. Analyzing and interpreting data SE5. Using mathematics and computational thinking SE6. Constructing explanations (for science) and designing solutions (for engineering) SE7. Engaging in argument from evidence SE8. Obtaining, evaluating, and communicating information			
Recording Time	5 E Component	Brief description of what teacher and students are doing	Science Practices Codes	Research Notes or Questions

Appendix G: 5 E Lesson Plan Template

The lesson plan template was used as part of the observation of a FOSS investigation. I took notes on the 5E parts of the lesson visible during my observation.

Teacher:
Date:
Subject / grade level:
Materials:
NGSS Standards
Content objective(s): **Language objective(s):**
Differentiation strategies to meet diverse learner needs:
ENGAGEMENT Describe how the teacher will capture students' interest. What kind of questions should the students ask themselves after the engagement?
EXPLORATION Describe what hands-on/minds-on activities students will be doing. List "big idea" conceptual questions the teacher will use to encourage and/or focus students' exploration

EXPLANATION

Student explanations should precede introduction of terms or explanations by the teacher. What questions or techniques will the teacher use to help students connect their exploration to the concept under examination?

List higher order thinking questions, which teachers will use to solicit *student* explanations and help them to justify their explanations.

ELABORATION

Describe how students will develop a more sophisticated understanding of the concept.

What vocabulary will be introduced and how will it connect to students' observations?

How is this knowledge applied in our daily lives?

EVALUATION

How will students demonstrate that they have achieved the lesson objective?

This should be embedded throughout the lesson as well as at the end of the lesson.

Appendix H: Interview Questions

Pseudonym:

Date: **Location:**

Time Start: **Time End:**

Thank you for letting me observe your class. It is always exciting to see other science classes. As part of the interview, I would like to ask a few questions related to the lesson I just observed and some general questions about your science classroom. Would you mind if I record the interview? Recording the interview will help me to ensure the accuracy of what we discuss and verify what I write down. I can assure you that all precautions will be taken not to disclose to anyone else any part of the data that are linked to your identity. If you have any questions please ask. I would like you to read this consent form and sign it before we begin. If you do not wish to answer any question or if you want to discontinue this interview at any point, feel free to do so. Do you have any questions you would like to ask before we begin?

These first sets of questions have to do with determining your stage of concern with implementing the FOSS curriculum.

1. How long have you been implementing the FOSS curriculum in your classroom?
2. Look at the Stages of Concern table. Do you have any concerns with implementing the FOSS curriculum? What are these concerns?
3. How do you think FOSS inquiry science affects the way you teach science? In what ways, if any, has it helped you shift your instructional practice?

4. In what ways do you feel FOSS is helping students learn science content and practices?

   The next few questions are about the Levels of Use (Appendix D).

5. Looking at these levels of use stages, where are you now in implementing science inquiry in the classroom compared to where you were when you first started using FOSS? Tell me about the difference in your instructional strategies? What do you attribute the changes to?
6. What do you know of the NGSS 8 science practices? Do you incorporate them in your FOSS lesson plans? Can you give an example?
7. Do you use science notebooks in the classroom? Can you provide an example for how they are used?
8. How do you think FOSS inquiry science affects the way you teach science? In what ways has it helped you shift your instructional practice?
9. What strategies from the district professional development do you utilize in your classroom? Which strategies do you find most effective when teaching inquiry-based lessons?

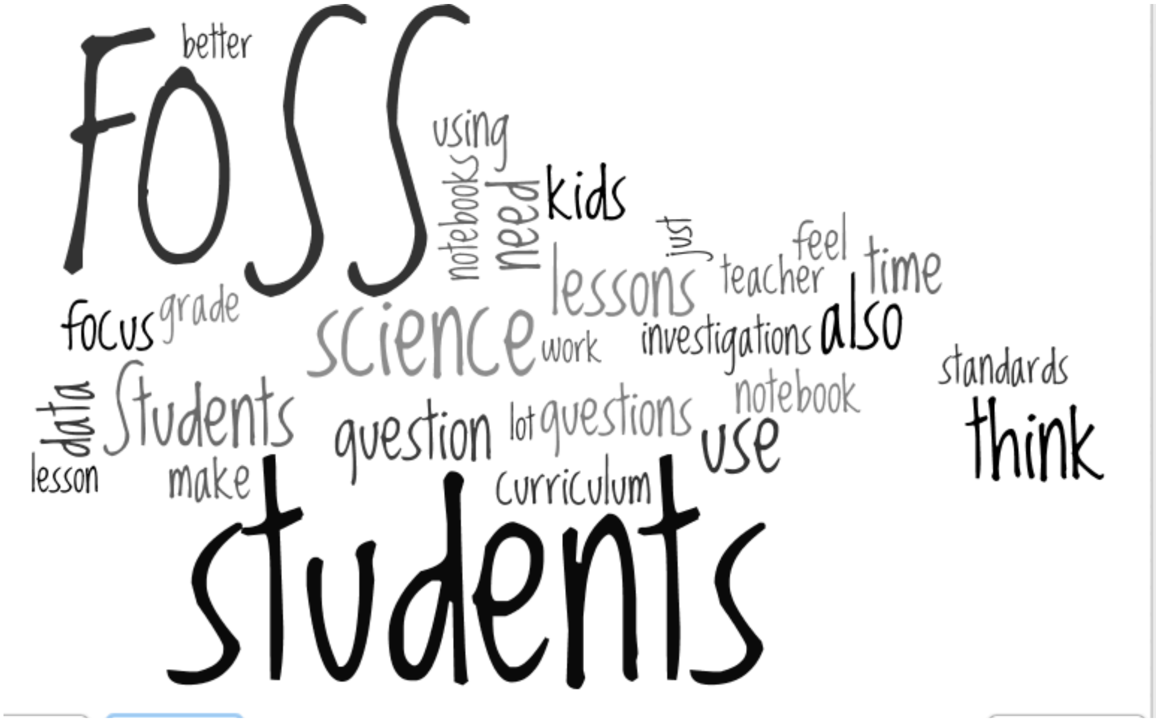
The next few questions are about your instruction during FOSS lessons.

10. How do you think students best learn science?
11. How do you plan for instruction?
12. What is the role of the student and teacher in your classroom?
13. Please describe a typical inquiry-based lesson in your classroom. If no inquiry has been implemented – what has hindered your implementation?

The last few questions are about your overall experiences with FOSS.

14. What have been the most challenging aspects of implementing FOSS?
15. What do you think could have been done to avoid those challenges?
16. What type of support do you need to move forward with implementing FOSS?
17. Please tell me about the biggest success that you have had implementing FOSS. What factors allowed you to succeed?

Appendix I: Word Cloud (Wordle)



Appendix J: Identified Codes, Categories, and Themes

Interviews	First Pass – Wordle and Open Codes	Second Pass Collapsed Codes	Third Pass Categories	Theme
	Students	Student and kids	Inquiry-Based Practices: notebooks, think, FOSS, investigation, student/kids	Teacher confidence in shifting Instruction: successes with FOSS implementation, student role and teacher role in the classroom, material management
	FOSS	Question(s)	Shift in instruction: challenges and successes	Teacher Response to Change: LoU and SoC
	Science	FOSS and investigation	Successes	Professional Development - challenges, needs, teachers collaborating, supplemental lessons, adapt instruction
	Notebook	Notebook (orange)	Challenges: time, materials, curriculum, standards, grade, management	Integration of inquiry-based instruction: material management, notebook usage and assessment, student centered, question, FOSS investigations, science practice and 5 E lesson plan
	Question	Professional development (yellow)	Professional Development - needs, teachers collaborating, supplemental lessons, adapt instruction	

	Think	Challenges (pink)	
	questions	successes (green)	
	Data	needs (blue)	
	Need	curriculum, standard and lessons	
	Time	student work	
	curriculum	Time	
	standards	SoC 3 Management	
	Focus	SoC 4A (Consequence), 4 B (Collaboration), 4 C (Refocusing)	
	Work	LoU 1(Routine)	
	Feel	LoU 2 (Refinement)	
	Using	LoU 3 (Integration)	
	Make	LoU 4 (Renewal)	
	Lessons		
	Better		
	Teacher		
	Investigations		
	Work		
	Grade		
	Also		
	Lot		
	SoC 3 (Management)		
	SoC 4A (Consequence), 4 B (Collaboration), 4 C (Refocusing)		
	LoU 1 (Routine)		
	LoU 2 (Refinement)		
	LoU 3 (Integration)		
	LoU 4 (Renewal)		
Observations	First Pass	Second Pass Collapsed Codes	Third Pass Evidence for which themes
	Identified 5 E (Engage, Explore, Explain, Evaluate and Elaborate)	Material usage	Teacher Confidence in Shifting Instruction: material usage,

			teacher role, and student role
	8 science practices	Student role	Integration of Inquiry-Based instruction: 5E, notebook usage, and 8 science practices
		Teacher role	
		Notebook usage	