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Elementary Teachers' Implementation of Inquiry-Based Instruction

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This is to certify that the doctoral study by

William Patrick Gray

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Walden University
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Abstract

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MA, University of Maryland Eastern Shore, 1995

BS, University of Maryland Eastern Shore, 1993

Project Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Education

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Abstract

A mid-Atlantic state has recently adopted the Next Generation Science Standards (NGSS) that require teachers to integrate inquiry-based instruction into the classroom. The problem at the local level is a new inquiry-based curriculum, based on the NGSS, is being mandated without identifying the instructional strategies teachers are using to implement the new standards. The purpose of this project study was to explore fourth- and fifth-grade science teachers' inquiry-based instructional strategies, why the strategies were chosen, and teachers' concerns about the implementation of the strategies. In this case study, the concern-based adoption model and self-efficacy were used as a conceptual framework to capture the experiences and perceptions of the participants' implementation of inquiry-based instruction. Data were collected, in the form of interviews, lesson plans, and classroom observations, from nine fourth- and fifth-grade elementary teachers in a rural, mid-Atlantic school system setting. The participants were interviewed about their implementation of inquiry-based instruction and classroom observations and documents were gathered to provide corroborating evidence. Open-coding strategies were used to analyze the data. The findings from this study supported the need for increased professional development for elementary teachers to implement inquiry-based lessons. Consequently, a professional development plan was developed to help address teachers' concerns by providing information on the implementation of a new inquiry-based curriculum, based on NGSS, and give voice to elementary science teachers. The results influence positive social change by supporting teachers' implementation of practices that support students' learning in science.

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Dedication

This work is dedicated to my family whose backing through this process was essential. My wife, Latrice, who has supported me unconditionally and endured countless nights with me on the computer and was always source of encouragement. My son, Patrick, and my daughters, Camille, Amber, and Taylor, who always kept a smile on my face and grounded me in my efforts. I want to thank my mom and dad for their inspiration and wisdom. And to the memory of my grandmother and grandfather.

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I would first like to thank my advisor and mentor, Dr. Crissie Jameson. From our first meeting as she took over for my former advisor, I knew I had found someone of like mind regarding what is truly important in education. Your time spent teaching, reviewing, editing, and talking with me are so appreciated and contributed so much to my professional growth. Your encouragement and motivation help me dig deeper and stay the course.

I wish to acknowledge Dr. Patrick that has been with me through every step and Dr. Robb that helped me reach the finish line.

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Section 1: The Problem

The Local Problem

The state of Maryland adopted Next Generation Science Standards (NGSS) in 2013 with the plan of full implementation in the school systems by 2018 (NGSS Lead States, 2013). NGSS was designed to help students understand science concepts through inquiry-based activities (Pruitt, 2014). Inquiry-based instruction is a student-centered approach in which teachers facilitate learning experiences allowing students to take an active role in their learning through experimentation and reflection (Nariman & Chrispeels, 2016). In East School District (a pseudonym), inquiry-based instruction will require a shift from current classroom practices to an inquiry-based pedagogy that may not have been part of teachers' formal training. The problem at the local level is a new inquiry-based curriculum, based on the NGSS, is being mandated without identifying the instructional strategies teachers are using to implement the new standards. The gap in practice was how elementary teachers were incorporating or failing to incorporate inquiry-based curriculum, based on the NGSS, without identifying the instructional strategies they were using to implement the new standards.

Evidence of the Problem from the Professional Literature

Science educational reform created by policymakers has influenced local educational systems shifts to teaching practices in the classroom. Bybee (2014) examined the shifts required in teacher development to meet the requirements of the education reform and found that a requirement for the successful implementation of NGSS includes science content knowledge, practice, and pedagogical implications. Teachers are ultimately responsible for the translation of science education reform curriculum and standards into a teachable format for the classroom (Wallace & Priestley, 2017). Chichekian et al. (2016) identified a shift in pedagogy as one of the main concerns to the successfulness of change from a traditional, teacher-centered learning environment to a student-centered learning environment. Low teacher efficacy limits a teacher's willingness to implement inquiry-based instruction (Silm et al., 2017). The movement of science education reform challenges teachers to implement inquiry-based instruction within the classroom.

Incorporating inquiry-based instruction into practice requires teachers to shift their pedagogy. Appropriate professional development is critical to the successful implementation of science education reform (Bell & Sexton, 2018). Zhang et al. (2015) identified the need for professional development, specifically in the areas of increasing content knowledge, practicing of inquiry-based skills, and modeling of inquiry to implement inquiry-based instruction. Models of inquiry-based instruction in the elementary setting is rare (Avraamidou, 2017). Avraamidou (2017) suggested the need for research on the day-to-day implementation of inquiry-based instruction in the elementary classroom; therefore, I conducted this study to address this need.

Rationale

The study site school district has had decreasing test scores on state science achievement tests in 2014, 2015, and 2016 (Maryland State Department of Education, 2016). On the fifth-grade 2015 Maryland Science State Assessment, student achievement was 56.8%; however, in 2016, achievement fell to 49.2%, which was after the implementation of NGSS in East School District. To address declining state assessment scores, school improvement plans at the local level included the adoption of inquiry-based instruction, based on NGSS, into the curriculum. According to the district science supervisor, teachers in this school district felt pressured to integrate inquiry-based instruction, based on the NGSS, into the current curriculum. The district science supervisor went on to say that teachers received 2 days of professional development during the summers before implementing inquiry-based instruction (i.e., 2016 and 2017) in the curriculum.

Science education reform based on NGSS requires teachers to change their instruction in the classrooms to student-centered learning environments. The concern-based adoption model (CBAM), which was built on Fuller's theory of teacher development, is a framework and methodology to identify the process of implementation of an innovation (Hord et al., 2006). The CBAM consists of three tools to monitor the change process: (a) the innovation configuration, which is used to monitor the implementation of change; (b) the stages of concern, which specifically focuses on the concerns teachers experience during a change effort; and (c) level of use, which is an instrument that notably portrays the way teachers and others work with an innovation (Hord et al., 2006). The CBAM was useful in identifying teachers' practices and their concerns related to the implementation of the inquiry-based strategies in their classroom.

Current education reform requires NGSS to be implemented into classes. The local problem in East School District could highlight this challenge. Smith and Nadelson (2017) identified the gap in elementary teachers' knowledge and practices in implementing NGSS practices. The purpose of this project study was to explore fourth- and fifth-grade science teachers' inquiry-based instructional strategies, why the strategies were chosen, and teachers' concerns about the implementation of the strategies.

Definition of Terms

Concerns: The feelings, thoughts, and reactions individuals have about a new program of innovation that touches their lives (Hord et al., 2006, p 30).

Innovation configurations map: A chart that describes the components of an innovation. It shows the range of the best practices to the least desirable practice or no practice. This type of rubric reads from a 4, 3, 2, to 1 with 4 being *the best practice* and 1 being *no practice*. Each innovation configurations map is created specifically for each research project (Hord et al., 2006).

Inquiry-based learning: This type of learning starts with a question, problem, or challenge that the teachers pose and facilitates. The students work to discover and construct understanding by asking further questions (Nariman & Chrispeels, 2016).

Levels of use: An instrument used to focus on an individual's behavior and how they use an innovation (Hord et al., 2006).

Problem-based learning: A student-centered approach where learners are given a problem and work towards finding a solution that they can justify (Barrows, 2002).

Project-based learning: This type of learning requires students to design and complete projects during which they are confronted with a wide range of problems that force them to think, act, and process like a scientist to find solutions (Mahasneh & Alwan, 2018).

Stages of concern: An instrument that focuses on an individual's attitudes and feelings (Hord et al., 2006).

Significance of the Study

The purpose of this project study was to explore fourth- and fifth-grade science teachers' inquiry-based instructional strategies, why the strategies were chosen, and teachers' concerns about the implementation of the strategies. The findings of this study provide the research literature with an example of inquiry-based strategies implemented within an elementary classroom. Avraamidou (2017) examined the day-to-day practices of the implementation of inquiry-based instructional practices within a fifth-grade classroom and suggested the need for more examples of actual classroom practice.

This study has the potential to promote positive social change by providing administrators with insight into the instructional needs of elementary teachers. Professional development designed to address specific needs of teachers has been shown to be effective (Knowles et al., 2005) in a greater implementation of an initiative that can ultimately increase student achievement (Marshall et al., 2017). As science reform calls for changes in the way science is taught, teachers will continue to need appropriate professional development to meet the challenges. This study will help teachers and administrators meet the goal of increasing student knowledge by identifying targeted professional development for teachers.

Research Questions

I designed the following research questions to guide this study:

RQ1: What inquiry-based instructional strategies are teachers using to implement NGSS into the curriculum?

RQ2: From the perspective of the teachers, why were these instructional strategies chosen?

RQ3: What are teachers' concerns about the implementation of the instructional strategies?

Review of the Literature

A literature review provides the scholarly framework within which a problem is defined and given significance. In this study, I focused on the implementation of inquiry-based instruction into elementary science classrooms. The major themes of the literature review include the NGSS, student-centered instruction, and change. I conducted an exhaustive search for resources through multiple databases until no further relevant studies were found to ground the study.

I obtained the assistance of a Walden University librarian to help direct this review of the literature. The review of the literature was conducted using multiple databases: Google Scholar, Education Source, and ERIC. The following search terms were used: *Next Generation Science Standards, implementation, curriculum, inquiry, NGSS, concern based-adoption model, CBAM, teacher self-efficacy, self-efficacy, inquiry-based learning, teacher learning, inquiry-based instruction, professional development,* and *inquiry-based science instruction.*

Through the review of literature process, the themes of science reform and teacher change emerged as the central idea in the broader problem. The content of science education within K–12 schools has gone from learning facts to constructing meaning, influenced by Darwin to Dewey (Cowles, 2020). With the implementation of science reform has come the need for the teacher to change from leading a teacher-centered to a student-centered classroom. There was an abundance of information on these themes, but with the incorporation of the NGSS, the focus on the topic became narrower to reach saturation.

Conceptual Framework

In this subsection, I explain the structure used to support and inform this study (see Yin, 2002). The CBAM (Hord et al., 2006) and the learning theory of self-efficacy (Bandura, 1977) were used as the major elements of the conceptual framework for this study. CBAM was developed to examine the concerns that individual teachers have as they implement an innovation (Hord et al., 2006). In this study, I examined the implementation of inquiry-based instruction (i.e., the innovation). There were three categories of teacher's concerns about the innovation: impact on self, concerns about management, and concerns about how the innovation will affect the student.

Teachers move through different categories of concerns as they implement an innovation. The impact on self is the first of three categories in the CBAM where teachers start the implementation of an innovation (Hord et al., 2006). In the category, in this classroom, a teacher may ask how an innovation will affect their time or routine. As teachers continue to implement the innovation, some teachers will move to the category of concerns about management (Hord et al., 2006). In the category, the teacher attempts to follow the prescribed method of implementation of the innovation in the classroom.

The third category of concern related to implementation is focused on students (Hord et al., 2006). When teachers reach this category, they begin to focus on changing the innovation to best suit the needs of their students.

Hord et al. (2006) explained that the CBAM is based on the following 12 assumptions about change:

- Change is an ongoing process, not a single event.
- The development and implementation of one innovation is significantly different from that of another innovation.
- An organization does not change until the individuals within the organization change.
- Innovations come in different levels of intensity and different forms.
- Interventions are actions and events that are important to the success of change.
- Although top-down and bottom-up perspectives of change can work, horizontal perspectives of change are best.
- Administrative leadership is essential to the long-term success of change.
- National, state, and district mandates can work for schools when implementing change.
- Schools are the primary units of change.
- Facilitating change is a team effort.
- Appropriate interventions reduce the challenges of change.
- Contexts of schools influence their processes of change.

These 12 assumptions of change are the foundation of the CBAM and should be considered when using the tools of CBAM to measure the adoption of change. The following three CBAM tools guided the change process in this study: stages of concern, level of use, and innovation configuration.

Stages of concern is the first instrument of the theoretical framework of the CBAM and encompasses the feelings the teachers might have during the curricular change (Anderson, 1997). According to Hord et al. (2006), change involves seven developmental stages of concern: (a) Stage 0: unconcerned, (b) Stage 1: informational, (c) Stage 2: personal, (d) Stage 3: management, (e) Stage 4: consequence, (f) Stage 5: collaboration, and (g) Stage 6: refocusing. After identifying the developmental stage of concern of an individual, appropriate assistance can be developed to facilitate change. The following are examples from research on the implementation of stages of concern.

Stages of concern data can be obtained through interviews or by administering the Stages of Concern Questionnaire. Sarfo et al. (2017) used the Stages of Concern Questionnaire to identify the concerns of teachers as they implemented a math curriculum. Konstantinou (2016) used the Stages of Concern Questionnaire to determine the decrease of concerns over time as teachers implemented a new music innovation. Other researchers have obtained Stages of Concern data through interviewing (Lambert et al., 2014). The use of the CBAM stage of concern instrument allows teachers to voice concerns, questions, and strategies that affect the implementation of change into the classroom.

Level of use is a construct developed to monitor the innovation, and there are eight levels of use that are identified through the behaviors of the teacher: (a) Level 0: nonuse, (b) Level 1: orientation, (c) Level 2: preparation, (d) Level 3: mechanical use, (e) Level 4a: routine, (f) Level 4b: refinement, (g) Level 5: integration, and (h) Level 6: renewal. An informal interview instrument has been developed to assess the behaviors of individuals based on the level of use instrument within a classroom. The stages of concern and the level of use instruments can be used to look at the feelings and actions of teachers as they implement an innovation within the classroom.

Researchers have used the stages of concern and level of use instruments to describe the change process of an individual teacher in a school. Wang (2013) used these instruments to describe the implementation of a curriculum. While the stages of concern and level of use instruments are used to describe the individual change process, the third instrument, the innovation configuration, is used to describe what the innovation looks like by each implementer.

Innovation configuration is the patterns of innovation implemented that result in the overall activities and programs used in an individual classroom (Hord et al., 2006). An innovation configuration map was developed to characterize how an innovation is being used (Hord et al., 2006). An innovation configuration map can be used to tell which specific strategies are being employed in a classroom. Through the identification of effective strategies, an innovation configuration map can be used to pinpoint targeted professional development to increase student achievement.

This study adds to the literature on the strategies that elementary teachers use in their classrooms to implement inquiry-based instruction. CBAM made up part of the conceptual framework used to address the implementation of an innovation in an educational setting (see Anderson, 1997; Hord et al., 2006). CBAM has been used to access the implementation of other innovations (Gudyanga & Jita, 2018; Konstantinou, 2016; Lambert et al., 2014; Tunks & Weller, 2009). In the current study, I used CBAM to examine the incorporation of inquiry-based instruction strategies into the curriculum.

In this study, RQ1 focused on the inquiry-based instructional strategies teachers are using to implement NGSS into the curriculum. I employed the level of use instrument to look at the behaviors teachers use to implement an innovation (see Hord et al., 2006). Through the use of interviews and classroom observations, I identified and assessed the inquiry-based instructional strategies from levels of *no use* (Level 0) to *renew* (Level 6). The goal of determining an individual's level of use was to help the individual move toward full implementation of an innovation.

RQ2 in this study focused on why the teachers chose the instructional strategies they used. I used the stages of concern instrument to understand the teacher's attitude and feelings of implementation of an innovation (see Hord et al., 2006). The teachers' implementation ranged from *unconcerned* (Stage 0) to *refocusing* (Stage 6). Educational leaders were able to determine the next steps to increase teacher implementation from these developmental stages of concern.

RQ3 in this study focused on teachers' concerns related to the implementation of the strategies. I used the stages of concern instrument to understand the teachers' concerns with the implementation of an innovation (see Hord et al., 2006). I also used the CBAM framework in the data analysis process to understand the concerns of the teachers. Together, the use of these instruments provided insight into teachers' implementation of inquiry-based instruction.

In addition to CBAM, I used Bandura's (1977) concept of self-efficacy as part of the conceptual framework. According to Bandura, self-efficacy is defined as how much effort and the duration the effort is expended necessary to accomplish a task. Teachers' pedagogical self-efficacy is their believed capacity to effectively educate students (Bandura, 1977). During the incorporation of new standards that require inquiry-based lessons, teachers' self-efficacy is critical to the success of the implementation.

Self-efficacy is derived from four sources: mastery experiences, verbal persuasion, vicarious experience, and physiological and emotional arousal (Bandura, 1977). Mastery experiences occur through successful experience and the development of coping strategies. Verbal persuasion refers to a belief that a person can cope. In a school setting, this could be praise or encouragement from the administration or a mentor. Vicarious experiences are indirect information about abilities to accomplish personal activities, often this occurs through modeling. Physiological states are when dysfunctional fear is reduced. When teachers have higher self-efficacy they are able deal with the stressors in a classroom (Bandura, 1977). With appropriate skills and incentives, efficacy expectations are a major determinant in a person's choice of activity (Bandura, 1977). The use of self-efficacy, the ability of elementary teachers believing that they can teach science, was appropriate in the investigation of elementary teachers' perceptions of their ability to implement NGSS into the current curriculum.

Bandura's (1977) theory of self-efficacy provided a framework through which to look at teachers' implementation of inquiry-based instruction in the classroom. In this study, I examined the implementation of inquiry-based instruction that necessitates a teacher developing a student-based classroom. Seneviratne et al. (2019) asserted that the "higher the self-efficacious more likely to plan for and conduct inquiry-based teaching" (p. 1605). Through classroom observations, the review of lesson plans, and teacher interviews, I identified sources of teacher self-efficacy in the current study. This data allowed for a deeper understanding and validation of the stated assertion.

The latest science literacy reform, NGSS was produced in 2013 as a result of a Carnegie Corporation research report (National Research Council, 2013). The report focused on the need to prepare future innovators for work in the science, technology, engineering, and mathematics (STEM) field. The NGSS provides inquiry-based standards in the student-centered classroom. There are eight scientific and engineering practices (SEPs) (National Research Council, 2013) expected for science classroom teachers to implement:

SEP 1: Asking questions and defining problems: Description and explanation of how the natural and design world works.

SEP 2: Developing using models: Tools to represent ideas and explanations.

SEP 3: Planning and carrying out investigations: Systematic collection of data.

SEP 4: Analyzing and interpreting data: Identification of patterns and trends as well as sources of error and degree of certainty.

SEP 5: Using mathematics and computational thinking: Tool for representation physical variable and their relationship.

SEP 6: Constructing explanations and designing solutions: Answering problems.

SEP 7: Engaging in argument from evidence: Process which by explanations and solutions are reached.

SEP 8: Obtaining, evaluating, communicating information: Communicate results.

These outcomes are being incorporated in the classroom by science teachers, but science teachers are struggling to fully implement them in the classroom (Capps & Crawford, 2013; Nollmeyer et al., 2019). There are both external and external factors to this lack of full implementation. What follows are the challenges and barriers found in the current literature of how classroom teachers are implementing inquiry-based instruction, including the SEPs, into their classrooms.

Implementation of NGSS

Science education reform and the incorporation of NGSS require the implementation of a new curriculum. Smith and Nadelson (2017) found that teachers often have limited familiarity with NGSS and the SEPs. Drocelle (2020) reported that upper elementary teachers' understanding of what inquiry-based instruction was limited. Most of the participating teachers could not identify inquiry or explain what inquiry means (Drocelle, 2020). These results were similar to those of Smith and Nadelson (2017) who collected observation and interview data from three elementary teachers to determine the level to which teachers perceived they engaged in teaching science aligned to the eight SEPs. Their results showed only partial implementation of the outcomes.

The implementation of science reform will not force the total abandonment of previous practices. Smith and Nadelson (2017) research findings indicated that elementary teachers instinctively implement some of the elements of NGSS. In chemistry classrooms teachers implemented many scientific and engineering practices (Boesdorfer & Staude, 2016) with 97% of teacher's self-reporting using mathematics and computational analysis corresponding to SEP 5 and 96% using analyzing data corresponding to SEP 4 before the implementation of NGSS. Over half of the teachers implemented some science and engineering practices (Boesdorfer & Staude, 2016). These results are supported by Smith and Nadelson in which they identified all elementary teachers in their study implementing at least one science and engineering practice.

The implementation of NGSS SEPs by teachers has been shown to be challenging due to a number of factors: time, curriculum, lack of administration support, pressure to focus on other disciplines and lack of content knowledge (Nollmeyer et al., 2019). Smith and Nadelson (2017) found teachers not implementing certain practices because of their beliefs that some SEP were too difficult for their students. Boesdorfer and Staude (2016) results indicated that 52% of teachers were unwilling to include engineering in class due to the concern from teachers that the students were not able to comprehend such topics.

Science Education Reform

Science education reform supports a shift from traditional teacher centered to student centered instruction. Traditional science education occurs through lectures, question and answer sessions, giving notes to students (Kaymakamoglu, 2018). In contrast inquiry-based is student centered. The teaching shift to inquiry-based engages learners in investigating and explaining the science phenomenon in order to improve student learning (Krajcik & Delen, 2017). A child's wonder in the world creates opportunities to provide experiences for students to learn and grow.

Science learning begins before entering formal education with children's natural curiosity about how the world works. The National Science Teachers Association (2018) suggested that formal elementary education should build on children's natural curiosity. Inquiry-based instruction is student centered and can use a children's natural curiosity. Lifelong science education is based on children's initial curiosity.

Elementary teachers often need more training and/or confidence to bridge the gap of natural curiosity to formal learning of young students. When teachers lack confidence or content knowledge, they are unlikely to implement a subject like science (Appleton, 2008; Nollmeyer et al., 2019). This is supported in a case study by Fitzgerald et al. (2019) which identified confidence and competence of teachers as barriers which inhibited inquiry-based teaching. Elementary science teachers will need more confidence to overcome barriers to implementation of inquiry-based instruction.

Another barrier to implementing inquiry-based instruction is time to plan and gather the materials needed to implement these strategies. Elementary science instruction nationally has received less focus than other subjects so teachers often spend less time and energy planning for them. Third-grade students spent over 30 % of their classroom time engaged in English/ language arts/ reading compared to 17.6 % engaged in math/arithmetic instruction but only 8.8% of their time engaged in science instruction (Hoyer & Sparks, 2017). Third-grade students averaged less than 3 hours per week engaged in science (Hoyer & Sparks, 2017). These factors compound the issue of implementation in the classroom of inquiry-based instruction. In a case study conducted by Nollmeyer et al. (2019) classroom teachers identified that classroom science time varied from 40 minutes a week to 30 minutes a day. Another barrier to implementation of inquiry-based learning besides for planning and instructional time is content knowledge of the teacher. Many teachers feel unprepared with science content to fully implement science topics in the classroom (Lee & Glass, 2019).

Teacher Learning

Elementary classroom teachers require support to develop the scientific expertise needed to implement inquiry-based science education. Most teacher preparation programs do not require a uniform approach to science certification (Rose et al., 2017). A challenge for many elementary teachers who often are only required to have two laboratory science courses in their formal training yet will be expected to address topics in life, physical science, Earth and space science (Lee & Glass, 2019; National Research Council, 2010). This concern was also identified in research conducted by Nollmeyer et al. (2019) in which elementary teachers were interviewed to identify the barriers to teaching inquiry-based science. In the above study teachers identified content knowledge was a barrier to implementing inquiry-based science. Some teachers specifically identified poor advising from their undergraduate programs in which they only took two science classes

(Nollmeyer et al., 2019) so they may feel unprepared to implement inquiry-based science methods.

Elementary teachers' continued learning is dependent on professional development. Research findings revealed that several factors influence teachers' implementation of professional development and teacher learning: length of time of the training (Granger et al., 2019; Marshall et al., 2017), reflection from the teacher on the training (Mathew et al., 2017), active learning from the teachers (Darling-Hammond et al., 2017; Granger et al., 2019), and collaboration with others (Darling-Hammond et al., 2017; Yue, 2019). Research by Mitchell et al. (2018) identify long-term professional development as critical to teacher implementation of the training content. Longer professional development allows the participants an opportunity to test, investigate and improve skills that will be used in the classroom (Granger et al., 2019). Professional development that has the teachers actively participate in the content helps in the understanding of the material (Darling-Hammond et al., 2017). Active participation in a professional development setting allows teacher to work through problems and concepts similar to their students. The process of teacher gaining experience from the student point of view enhances their ability to implement inquiry-based lessons (Granger et al., 2019). Teacher learning is best supported by professional development which have the characteristics stated above. Teacher change will require other components that support teachers' confidence with the material to support their own self-efficacy.

Teacher Change

Science reform requires teachers to change their classroom practices to conform to the reform expectations. Miller et al. (2017) identified a link between teacher self-efficacy and implementation of science reform. The science education reform requires a change in classroom practice from a teacher-centered instruction to a student-centered inquiry-based instruction (Saka & Keklikci, 2019). In their study, Favre and Knight (2016) correlated teachers with high self-efficacy feel pedagogical discontentment and a lack of interest in changing what they are currently doing in the classroom. These teachers with high self-efficacy believe in their current practices and may not be able to critically reflect on their practices and be able to identify the benefits on science education reform (Favre & Knight, 2016).

Mentoring programs can help teachers implement new classroom practices. Mentoring is about relationships that allow a teacher to reflect on other teacher's practices and in turn reflect on their own instruction (Newberry, et al., 2018). Through this paradigm, mentoring can lead to meaningful reflection and progress in the change of teacher practices. The initial recognition in teachers' beliefs is the first step in teacher change.

Once teachers' self-beliefs are addressed there are other personal factors that can lead to teachers support and resistance to making changes to inquiry-based instruction. Teachers saw barriers to implementation such as the need for individual professional development, lack of time, and classroom management in a student-centered classroom (Ramero-Ariza et al., 2020). In student-centered inquiry-based elementary classroom teachers found students lacked the foundational skills to implement inquiry-based learning (Xiao-Fan et al., 2020). The students lacked academic depth in communication in written and verbal responses. Teachers also struggled letting students lead the learning process as the change took place from teacher centered to student centered classrooms (Xiao-Fan et al., 2020). One of the concerns is the students' ability and classroom management of a student center instruction. As the teacher became more confident and comfortable in student centered instruction, the teacher's perspective changed allowing the students to be more autonomous in the learning process.

As teachers change from traditional teacher-centered instruction to student-centered instruction, instructional time and planning time must be considered (Nariman & Chrispeels, 2016). In a study by Murphy and Haller (2015), teachers felt concern with time constraints in the school day that did not allow many concentrated hours for the implementation of new content. Hoyer and Sparks (2017), examining the instructional time of third graders, before the implementation of NGSS, found students spent 2.9 hours per week engaged in science instruction. Wright and Cotwals (2017) found that kindergarten student's science learning increased with the implementation of NGSS, but it was in part due to the increased time of 45 minutes allotted to science. Additional instructional time will be required to implement inquiry-based pedagogy.

Systematic factors can also lead to teacher resistance to change. Teachers are often concerned about their ability to adapt their curriculum to new standards (Hungwe & Shonnard, 2018; Murphy & Haller, 2015). New standards must be broken down into understandable units in which NGSS requires the classroom to become more student-focused than teacher-focused (Sulaiman et al., 2017). Teachers will need support with their changing roles of becoming a classroom facilitator (Sulaiman et al., 2017). These systematic factors require organizational support to help enact teacher change.

Organizational Support

Administration support is critical for the successful implementation of an innovation by classroom teachers. In a study by Pringle et al. (2020) school and district level leadership which provided an environment a collaborative learning environment had a positive impact on teacher implementation of reform curriculum. Administrators who are strong instructional leaders can direct professional development at the school level to meet teacher's needs (Pringle et al., 2020) specifically in the area of content knowledge and pedagogical content knowledge. School-based administration can support implementation through providing more time for science instruction. Administrators can also provide teachers with verbal persuasion as a means to increase self-efficacy (Bandura, 1977) and improve implementation in the classroom.

There are two major types of barriers identified in the literature that affect the implementation of inquiry-based instruction: external and internal. Organizational support can help with the external factors that teachers perceive prevents inquiry-based instruction (SSempala & Masingila, 2019). Smith and Nadelson (2017) found that teachers' perceived school culture and resources as essential to their adoption of SEPs. A culture for implementation is important for the success of an innovation.

School Culture

Beyond administration support, school culture plays a major role in the implementation of inquiry-based learning. School culture refers to the way teachers and other staff work together and the set of beliefs and values they share. In a study conducted by Ssempala and Masingila (2019) one of the main factors that influenced teachers' practice of inquiry-based instruction was school culture. Likewise Mitchell et al. (2018) identified the importance of professional development that builds school culture was important in implementation of new curriculum. Peer support can affect the implementation of innovation.

Professional learning communities (PLC) are dependent on successful school culture. Antinluoma et al. (2018) identified characteristics of school culture that are supportive of PLC which included collegiality between teachers. These results support research by Nagle and Pecore (2017) which highlighted the importance of peer collaboration when implementing educational reform. In the above research a veteran science teacher with limited pedagogy to implement NGSS was able through collaboration with peers to overcome barriers.

Implications

One outcome of the implementation of this study is that the current elementary science curriculum reform in the classroom is characterized as a change from a teacher focus to a student focused environment. Student-centered science lessons, such as problem based learning emphasized the students reconstructing their understanding and interacting with real-world problems, collect data and ask questions (Merritt et al., 2017).

Using CBAM, this study identified the concerns of elementary teachers' instructional practices and their encompassing NGSS. This study informed the administration in the East School District of the current practices in the elementary classroom implementing NGSS.

Summary

The adoption of the NGSS is the latest step in the reform of science reform. Science reform can start at the political, or district level but real change takes place at the teacher level which implements the changes in the classroom. This study explored the instructional strategies of fourth- and fifth-grade science teachers that implemented a new inquiry-based curriculum, based on NGSS, in the East School District. The following chapter provides an overview of the research design and rationale used to investigate these instructional strategies.

Section 2: The Methodology

Research Design and Approach

The purpose of this project study was to explore fourth- and fifth-grade science teachers' inquiry-based instructional strategies, why the strategies were chosen, and teachers' concerns about the implementation of the strategies. I used the dimensions of the CBAM to describe the process of the change from traditional teaching to an inquiry-based instructional approach. In this section, I describe the qualitative research design, the approach, the participants, and the data collection data analysis processes.

The research design and approach of this study derived logically from the research problem and research questions. The problem at the local level was a new inquiry-based curriculum, based on the NGSS, is being mandated without identifying the instructional strategies teachers are using to implement the new standards. The research questions that guided this study were as follows:

RQ1: What inquiry-based instructional strategies are teachers using to implement NGSS into the curriculum?

RQ2: From the perspective of the teachers, why were these instructional strategies chosen?

RQ3: What are teachers' concerns about the implementation of the instructional strategies?

The methodological approach that I used to address the problem and research questions was a qualitative, exploratory case study. This was an appropriate approach for the research problem because case study researchers investigate a current phenomenon bounded by time or space (Creswell, 2012) and interactions are independent of the researcher's presence (Yin, 2002). According to Yin (2002), an exploratory case study is appropriate when investigating an intervention without a single clear outcome. I chose an exploratory case study over other common qualitative designs, such as phenomenology, ethnography, a narrative approach, grounded theory, or a basic quantitative study.

Other research approaches were not as well aligned to explore the research questions. Quantitative approaches, which tend to have a deductive approach and focus on testing theory, would not have been appropriate to answer the research questions in this study at an in-depth level. Likewise, grounded theory would not have been appropriate because this study was not an endeavor to create theories. A phenomenological approach was considered, but not chosen, because my interest was the entire case apart from any single phenomenon. An ethnographic approach was not appropriate because it would not have provided rich data of the teachers' perceptions of their concerns about the implementation of inquiry-based instruction. Lastly, a narrative approach mainly highlights the description of the phenomenon, while a case study approach focuses on the generalizable aspect of the unit of study.

An exploratory case study was justified as the research design of this inquiry because this design is used to investigate a distinct phenomenon that is characterized by a shortage of detail and defined by a specific research environment that limits the choice of methodologies (see Creswell, 2012). Harrison et al. (2017) identified a case study as being appropriate if the investigator exercises no control over the phenomenon. Blackburn (2017) stated that an exploratory case study was appropriate to explore a phenomenon that addresses the "what," "how," and "why" questions. In this case study, the phenomenon of elementary teachers implementing inquiry-based instruction was defined as a rural school district in which I exercised no control over the phenomenon. The research questions in this study addressed what and why questions related to teachers' implementation of inquiry-based instruction.

Participants

The criteria used for the selection of participants were appropriate for qualitative research. In this study, I explored fourth- and fifth-grade science teachers' implementation of inquiry-based instruction using an exploratory case study design comprising interviews and observations. Purposeful sampling is the strategy qualitative researchers most often use to select participants (Merriam, 2009). In this study I used purposeful sampling to select participants. For the current project study, the school district was considered a case.

The participants were selected based on three criteria. The first selection criterion was the grade level the teacher currently teaches. I contacted upper elementary science teachers who taught fourth and fifth grade. Fifth grade teachers were chosen for the project study because this was the grade in which students take the state assessment. The fourth-grade teachers were also chosen for the project study because in East School District, fourth- and fifth-grade teachers work together during professional development. The fourth-grade teachers prepared the upcoming fifth-grade students for the state assessment. The second criterion was teachers who attended the optional professional development that instructed teachers on the implementation of inquiry-based instruction.

Professional development on Project Lead the Way, which was given during the summer, served as training on how to implement inquiry-based lessons and was used as a model for inquiry-based lessons that the teachers developed. The third criterion was that the teacher teaches at least one science class during the school day.

I desired a sample size of 10 participants for this study. In the determination of the appropriate sample size of participants, Merriam (2009) suggested that it was dependent on research questions, data collection, data analysis, and availability of resources. If the sample was too small, it would not be able to support claims, but if too large, it would prevent deep case-oriented analysis and saturation of data (Sandelowski, 1995). A sample size of nine to 10 participants was appropriate compared to the population in the case. East School District has a total of 16 teachers who are either in self-contained fourth- or fifth-grade classrooms or are assigned as a science/math teacher for fourth- or fifth-grade students. After several exhaustive attempts to recruit 10 teachers, only nine teachers agreed to participate in the study, which was still a reasonable number for a qualitative study of this type (see Yin, 2014). The seven teachers that did not participate in the study stated they did not have time or did not reply to request.

I asked participants to complete a consent form upon agreeing to participate in the study. The consent form included the following information: the background and purpose of the study; the requirements for participation; and an explanation of the voluntary nature of the study, the risks associated with the study, and the right to withdraw at any time from the research study. During the consent meeting, I assigned a pseudonym letter-number code to protect the participant's identity. To ensure that information was kept secure, data were kept either in a file in a locked desk or on a password-protected computer. The data were only seen by me as the sole researcher. After consent forms were signed, I developed a schedule for participant interviews and observations. Table 1 displays the data collected from the participants in this study.

Table 1

Data Collected from Participants

Participant	Interview	Observation	Lesson plans	Years of experience
Participant 1	Yes	Yes	Yes	15
Participant 2	Yes	Yes	Yes	3
Participant 3	Yes	Yes	Yes	4
Participant 4	Yes	Yes	Yes	5
Participant 5	Yes	Yes	Yes	2
Participant 6	Yes	Yes	Yes	5
Participant 7	Yes	No	No	14
Participant 8	Yes	No	No	1
Participant 9	Yes	No	No	first year

Nine teachers volunteered to participate in this study. As shown in Table 1, all nine participants participated in the interview, but only six agreed to be observed. Lesson plans were collected from the teachers that agreed to classroom observations. The participants ranged in teaching experience, from a first year (i.e., 0 years of experience) teacher to a teacher with 15 years of experience.

Data Collection

In this research study, I employed a qualitative, exploratory case study design. Qualitative research is used to understand a phenomenon through multiple sources of data (Yin, 2002). The main sources of data in this study were interviews with fourth- and fifth-grade teacher. Interviews are often the primary mode of data collection in a case study, but other sources of data should be collected to support the findings (Yin, 2002). I used multiple sources of data to provide corroborating evidence of the teachers' experiences for this study.

I intended to collect the data in the following order: lesson plans, participant interviews (see Appendix C) and classroom observations (see Appendix D). Participant interviews were conducted at the participant's school, up to 2 weeks before the classroom observation. I conducted one-on-one interviews with nine participating teachers. I used the interview protocol (see Appendix C) that was developed to address the research questions of this study. Each interview was digitally recorded and was intended to last 45–60 minutes. The interviews occurred starting mid-January 2020 and were completed by mid-September 2020. The recorded interviews were stored on a password-protected computer.

Lesson plans were another source of data used to gather information to answer the research questions. Documentation mining provides another type of data to support the validation of a phenomenon (Yin, 2014). Prior to the interviews being held, I requested science lesson plans to be emailed to my personal email address from each participant. None of the participants sent lessons plans to me prior to the interviews. Lesson plans were to be used during the participant interviews to prompt the discussion; however, they were not shared with me until classroom observations. Six teachers provided lessons plans at the start of the observation protocol. Lesson plans of science lessons that were observed were collected from teachers to support evidence of planned strategies used to implement inquiry-based instruction. Lesson plans were intended to aid in the discussion of which strategies the teacher chose to incorporate, why the strategies were chosen, and the other research questions. The collected lesson plans were stored in a secured location.

Classroom observations were scheduled with the school principal and classroom teacher within 2 weeks of the interview. Six of the nine participant agreed to be observed. Each was observed once during a 60-minute science class using an observation protocol I created (see Appendix D). I entered the classroom prior to the start of science instruction and identified a location to observe from outside the normal flow of instruction. The observation lasted until the end of science instruction for the day, normally a 60-minute class period. The observations occurred mid-January 2020 and were completed by mid-March 2020. The protocol used displayed the SEPs, the actions of the teacher, and student activities (see Appendix D). Field notes taken during the science lessons were collected using recommendations from Phillippi and Lauderdale (2018). Phillippi and Lauderdale suggested the following when collecting observations: a count of attendees, including demographics; a physical map of setting; a portrayal of where participants are positioned over time; and a description of activities being observed (using exact quotes when possible). The completed observation protocols for each participant then remained in a secured file cabinet at my residence until further analysis took place.

The following procedures were completed prior to meeting with participants and collecting data. I first secured approval from Walden University's Institutional Review Board #02-12-20-0556017, then obtained permission from the East School District superintendent, followed by the school administration. East School District policy states that research within the school system must be approved in writing from the superintendent. After receiving superintendent approval, I obtained a list of teachers' email addresses from each school principal that fit the criteria of this study. I emailed each teacher to provide a brief overview of the purpose of the study, a consent form, and a request that they volunteer for the research.

Role of the Researcher

The role of the researcher must be clearly defined due to their close involvement with the research and the participants. I am the instructional supervisor of special programs within the East School District with music, physical education, and art under my supervision. In my role, I do not supervise any fourth- or fifth-grade science teachers. Given my role as an employee in the East School District, I had a unique opportunity to gather data. A researcher must identify their bias on a topic to understand the possible influence on data collection and interpretation (Merriam, 2002). To keep my bias from influencing the data collection and interpretation, I recorded reflective notes into my research diary after each interview. I also kept a research journal by logging the data collection activities.

Data Analysis Results

I used a qualitative approach to collect, transcribe, and analyze the data to address the problem and research questions of this case study. The data analysis plan for this study followed the recommendations of Miles et al. (2014). I analyzed data from nine semi-structured interviews, six classroom observations and six lesson plans to gain understanding of perception of fourth- and fifth-grade science teachers. The data analysis was informed by the conceptual framework using CBAM (Hall & Hord, 2011) and Bandura's (1977) theory of self-efficacy.

Once the data were collected and reviewed, I transcribed the interview and typed the classroom observation and the classroom lessons plans into a word document. While the initial research plan included collecting lessons plans during the interview, none of the participants shared lessons plans at the time of the interview. East School District requires lessons plans for each lesson. All teachers that were observed shared lessons plans during the classroom observation. Each interview was recorded, transcribed and reviewed several times for accuracy. I reviewed the notes recorded during the classroom observation. The classroom observation data were typed into a word document. Data analysis of each of the six classroom observations were compared and contrasted to the interview responses. Lesson plans were collected, reviewed, then compared and contrasted with the other data collected. Qualitative data analysis is a process that allows collected data to be organized in a manner to bring meaning to the data (Creswell, 2012).

To ensure quality of data each participant was offered an opportunity to receive an email copy of the transcript for their review as a method of transcript review. The intent was for the teacher to return the transcript via email with any questions or concerns about the accuracy of the teacher's perceptions and experiences. I used one on one interviews, classroom observations and lessons plans to triangulate and gain a rich full understanding of the phenomena. I kept field notes to reflect on my observations during the interview as a process to control for my own biases.

East School District incorporates two project lead the way modules (PLTW) during the fourth- and fifth-grade. PLTW are inquiry-based modules which align to NGSS, and common core standards for ELA and mathematics. NGSS are three dimensional focusing on cross-cutting patterns, core content and eight SEPs. The cross-cutting patterns are major themes that cross grade levels and content such as energy. Core content focus on the major content areas of physical science, life science, earth and space sciences and engineering, technology, applications of science. The eight SEPs are the major practices which students engage in to understand scientific concepts. Not all SEPs are covered during each 10 hour module. The PLTW unit which is used in fifth-grade only covers SEP 5 and SEP 6. In East School District PLTW is used as exemplary model for teachers to create their own lesson.

In inquiry-based learning the students are encouraged to ask questions, explore and share ideas as they work to discover and construct understanding. In this study to capture the strategies teacher used to implement inquiry-based instruction I used in vivo coding and SEP as priori codes to analyze the voice of the fourth- and fifth-grade teachers in East School District. The SEP are the specific standards which students are used in the classroom. The teachers in East School District used many different strategies to implement science instruction.

Interview Data

First cycle

To obtain textual data, I transcribed the recordings from each interview into a document within 72 hours of the interviews. During the first phase of coding, I used in vivo coding which allowed the prioritizing and honoring of the participant's voice (Miles et al., 2014) to address the concerns of teachers implementing inquiry-based instruction. I used open coding to examine the data for emergent words and phrases. I italicized the keywords and phrases from each transcribed interview. I created a table in a word document to record the participants ID, the raw data, and the key words and phrases. This table allowed me to highlight the code and reference back to the specific participant quote.

Second cycle

During the second phase, I used axial coding to code the italicized words and phrases from the first phase of coding. Axial coding is a process of going from coding chucks of data to starting to see how those codes come together. A total of 27 axial codes emerged from reviewing the open codes generated in the first cycle codes. Those axial codes were used to support converting the initial codes into categories, more suitable for deeper consideration.

I next combined the key terms and phases into similar categories to create subthemes. These categories were further combined in logical groups to emerge as themes relying on the research questions for guidance. The creation of the themes was 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; Miles et al., 2015).

Observation Data

First cycle

I used open coding of the field notes recorded on the observation template. During the open coding of the field notes, I read over the note several times to become familiar with the data. I then highlighted the key terms and phrases. I used NGSS SEPs) as priori codes to start the analyses process of the observational data. SEP are the skills that students should engage in during a science class to help them understand the concepts of science. There are eight SEP: (a) SEP 1. Asking questions and defining problems, (b) SEP 2. Developing using models, (c) SEP 3. Planning and carrying out investigations, (d) SEP 4. Analyzing and interpreting data, (e) SEP 5. Using mathematics and computational thinking, (f) SEP 6. Constructing explanations and designing solutions, (g) SEP 7. Engaging in argument from evidence, (h) SEP 8. Obtaining, evaluating, and communicating information.

Second cycle.

Similar to the analysis of interview data, in second cycle coding of observational data, I read over the open coding and italicized the key words and phrases. Similar words or phrases were highlighted. In addition to the open coding, I incorporated the a priori codes identified from the SEP and identified during the classroom observation. Axial coding is a process of going from coding chucks of data to starting to see how those codes come together. Open coding and a priori codes collected during classroom observations were placed into axial codes used to support converting the initial codes into categories more suitable for deeper consideration. Observational data were used to support the themes that emerged from the interview data.

Lesson Plan Data

Six of the nine participants provided lessons plans from their science lessons. The process of lesson plan data analysis included organizing and preparing the data, reducing the data into themes through the process of coding and condensing of codes to finally representing the data in figures and graphs (Miles et al., 2014). I read each of the lesson plans several times to fully immerse myself into the data. Each lesson plan was typed into a Word document and labeled.

First cycle

First, a priori coding were used to identify NGSS science and engineering practices. Next, open coding was used to identify key words and phrases in the lesson plan. Keywords and phrases were italicized. I created a table in a word document to record the participants ID and the keywords and phrases.

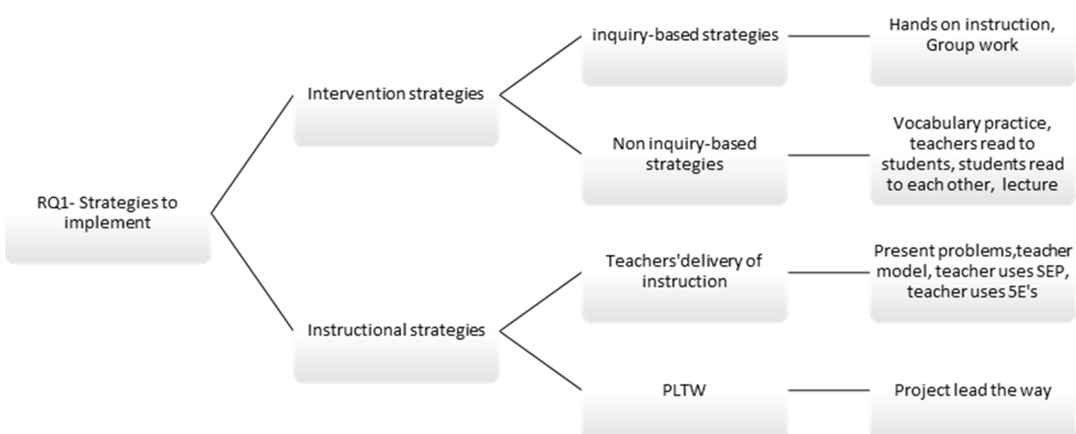
Second cycle

In second cycle coding, I read over the open coding and italicized the key words and phrases. Similar words or phrases were highlighted. Additionally, I incorporated the a priori codes collected during the classroom observation. Open coding and a priori codes collected from the lesson plan data were placed into axial codes used to support converting the initial codes into categories more suitable for deeper consideration. Lesson plan data were used to support the themes that emerged from the interview data.

The subthemes and themes were found in the data collected from the nine interviews, the six observations, and the six lessons plans. I combined the data from the three data sources. I used the patterns in the data to determine the axial codes, subthemes, and themes. The research questions guided the organization of the data. The themes, subthemes and axial codes for research questions are presented in Figure 1.

Figure 1

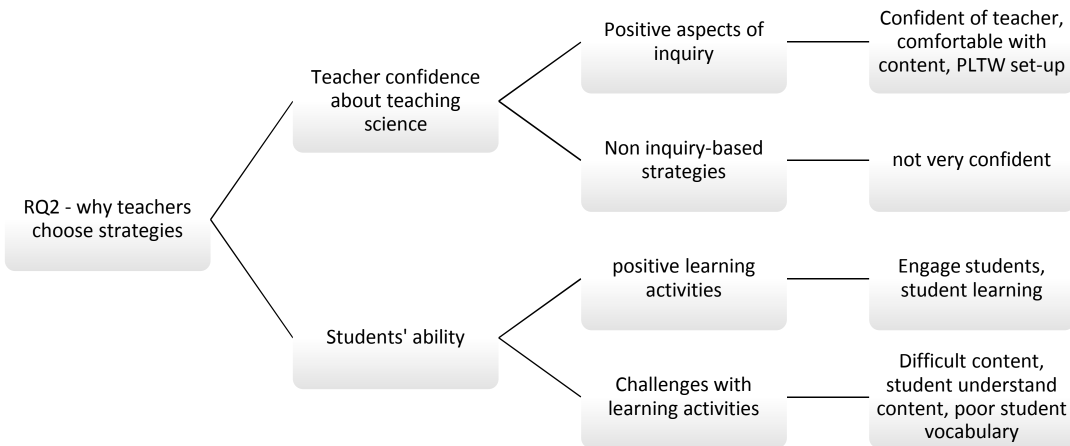
Themes, Subthemes, and Codes for RQ1 Related to Teacher Strategies to Implement Inquiry-based Instruction



In Figure 1 the themes, subthemes, and axial codes for RQ1 are presented. RQ1 examines the inquiry-based instructional strategies teachers are using to implement NGSS into the curriculum. Two major themes and four subthemes emerged from the data that aligned with RQ1. The themes identified were: intervention strategies and instructional strategies. Four subthemes emerged: inquiry-based strategies, non-inquiry-based strategies, teachers' delivery of instruction and PLTW. In Figure 2 the themes, subthemes, and axial codes for RQ2 are presented.

Figure 2

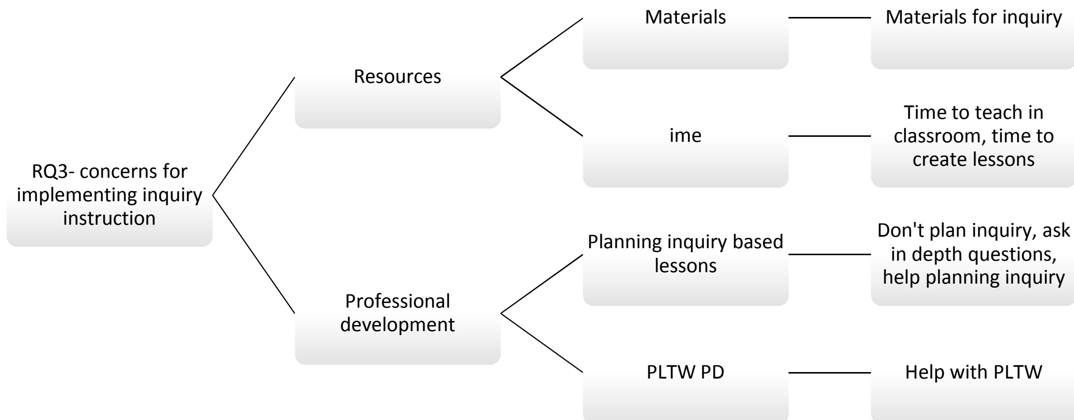
Themes, Subthemes, and Codes for RQ2 Related to Why Teachers Choose Strategies to Implement Inquiry-based Instruction



In Figure 2 the themes, subthemes, and axial codes for RQ2 are presented. RQ2 addresses why the teaching strategies were chosen. Two major themes and four subthemes emerged from the data that aligned with RQ2. The themes identified were: teacher confidence and student ability. Four subthemes emerged: positive aspects of inquiry, negative aspects of inquiry, positive learning, and challenges with learning. In Figure 3 the themes, subthemes, and axial codes for RQ3 are presented.

Figure 3

Themes, Subthemes, and Codes for RQ3 Related to Teachers Concerns with Implementation of Inquiry-based Instruction



In Figure 3 the themes, subthemes, and axial codes for RQ3 are presented. RQ 3 was designed to understand the concerns teachers have about implementation of inquiry-based instruction. Two major themes and four subthemes emerged from the data that aligned with RQ3. The themes identified were: resources and professional development. Four subthemes emerged: materials, time, planning inquiry-based lessons, and PLTW professional development.

Findings

The findings are based on data collected through observations, lesson plans and participant interviews. Nine interviews and six classroom observations were completed. Six lessons plans were collected at the time of the observation. The results of the data collection are as follows.

Strategies to Implement

Nine interviews were conducted to answer the question of what teachers perceived are the inquiry-based instructional strategies they use to implement the NGSS in the curriculum. Three interview questions were asked to answer RQ 1 (one, two, and five). There were two themes found from the results to answer RQ1. Those themes are intervention strategies and instructional strategies. There were four subthemes for RQ1. Those subthemes were inquiry-based strategies, non-inquiry-based strategies, teachers' delivery of instruction, and project lead the way.

Intervention strategies

Current science education reform requires classrooms to move from teacher centered to a student-centered classroom. One of the main themes for RQ 1 was that of intervention strategies. These intervention strategies included both inquiry-based and non-inquiry-based strategies. All of the nine participants mentioned that having students work in groups was a major part of inquiry-based learning. The teachers also realized that value of non-inquiry-based strategies. Participant 3 stated "that if the topic was new, a lecture was an appropriate way to help the students."

Inquiry-based strategies.

The implementation of inquiry-based strategies was one of the subthemes for RQ1. All participants were asked about the teaching strategies they used to implement inquiry-based learning in the classroom. Five of the nine participants mentioned they are using questioning and presenting problems to engage students in science. Participant 5 stated, "Then that when I pose the questions. Well, what do you think that this person in the story could do?" Through posing questions the teacher promotes the student to engage in the lesson and has the students come up with solutions.

> Participant 3 stated: "[the students] have a story that they read and the story will present a problem that they need to work on as a group to solve. And then they give criteria they need to follow but let them openly explore activities ideas to solve that problem."

Non-inquiry based strategies

Implementation of non-inquiry based strategies was a subtheme mentioned by participants to answer RQ1. Three of the nine participants mentioned that they had to work on reading skills during science class. Participants 6 stated: "Abilities of my students really play a major role in how I teach my class. I have two young people that need help reading and there are a few others." Sometimes participants use other non-inquiry-based strategies such as teacher lead instruction. Six of nine participants used lecture as part of their science instruction. Participants 5 stated: "Sometimes you do the lecture type method in science."

Instructional strategies

One of the main themes for RQ1 was that of instructional strategies to implement inquiry-based learning in the classroom. These instructional strategies included the subthemes of teacher's delivery of instruction and PLTW. All nine participants used a variety of methods of teacher's delivery of instruction and identified the use of PLTW. The following section describes these subthemes.

Teacher's delivery of instruction

The delivery of instruction was a subtheme mentioned by the participants. Teacher's delivery of instruction included presentation of the problem, teachers modeling of activities, the use of SEP and the use of development of lessons based on the 5E framework. The instruction emphasis was on making the students active learners. All nine participants mentioned making the students active learners in the lessons. The student-centered activities included conducting experiments, working in teams, exploring, investigating and solving problems. In these activities students think and explore like a scientist Bybee (2014). Participant 3 stated: "We do a lot of experiments to try get as hands-on as much as possible." Five of the nine participants mentioned they want their students to see information in context of real-world activities. Participant 1 stated: "So we tested four mystery powders … flour, brown sugar, sand, and baking soda. [The student] had to just looking at the physical characteristics … figure out what they were … things that they use before in the kitchen."

PLTW

All nine participants referred to PLTW as a means which they used to implement inquiry-based instruction. PLTW are science units which East school district has purchased and are designed to engage students using inquiry-based instruction. Participant 4 stated: "Project Lead the Way lessons are inquiry-based instruction. They start with a question which the students have to work in teams to gather information and solve." All of the nine participants mentioned that they felt that PLTW lessons are engaging for students.

> Participant 5 stated: "I've noticed the kids, they show more growth [when I used PLTW] … because it's not just on me as a teacher … I give them a proposed problem, and the wheels start turning in their heads … it gives them more of the opportunity to take the lead role without me."

Of note, participants highlighted PLTW used presentation of a question and having students work in groups to solve the problem.

Each of the PLTW units include some of the SEP. SEPs are one of the three dimensions of the NGSS. SEP are the actions which students do to make sense of a phenomena. The eight SEP reflect the major practices that scientists and engineers use to investigate, design and build systems in the world. During interviews the participants identified at least one SEP used during science classes. These practices are what teachers want and the East School District expect the students to be engaged in during science classes. The following table (Section 2, Table 2) outlines the SEPs that participants identified during their interview as being used during science instruction.

Table 2

Science and Engineering Practices Described During Interviews

Science and Engineering Practices	Number of participants identified in interview
SEP 1: Asking questions and defining Problems	5
SEP 2: Developing using models	5
SEP 3: Planning and carrying out investigations	9
SEP 4: Analyzing and interpreting data	5
SEP 5: Using mathematics and computational thinking	1
SEP 6: Constructing explanations and designing solutions	0

SEP 7: Engaging in argument from evidence	1
SEP 8: Obtaining, evaluating, communicating information	0

Table 2 lists the number of participants that shared using each SEP during interviews. During the interviews five participants described implemented SEP 1 (Asking Questions and Defining Problems; P1, P3, P4, P5, P7), five participants mentioned that they implemented SEP 2 (developing and using models; P2, P4, P5, P7, P9), all nine participants implemented SEP 3 (Planning and caring out investigations; P1, P2, P3, P4, P5, P6, P7, P8, P9), five participants implemented SEP 4 (Analyzing and interpreting data; P1, P2, P3, P4, P5), one participant implemented SEP 5 (Using mathematics and computational thinking; P5), and one participant implemented SEP 7 (Engaging in argument from evidence;P4). None of the participants stated using SEP 6 (Constructing explanations and designing solutions) or SEP 8 (Obtaining, evaluating, communicating information).

The inquiry-based instructional strategies teachers mentioned they use showed two main themes: intervention strategies and instructional strategies. The teachers mentioned in interviews using PLTW within their classes and using PLTW as a model for designing their non-PLTW lessons. In these non-PLTW lessons teachers stated using questioning and presenting problems to engage students. Teachers indicated that they wanted students to be actively engaged in activities such as conducting experiments, working in teams and investigating problems. Sub themes used by participants were identified: inquiry-based strategies, non-inquiry based, teachers' delivery of instruction, and project lead the way instruction.

Observations

The observation data addressed RQ1. During the observation protocol most of the teachers did not implement inquiry-based instruction. Only two of the six participants implemented SEP. Table 3 below shows the science and engineering practices that were observed during the observation protocol.

Table 3

Science and Engineering Practices Observed in Classroom

Science and Engineering Practices	SEP implemented during observation
SEP 1: Asking questions and defining problems	None
SEP 2: Developing using models	P1
SEP 3: Planning and carrying out investigations	P2
SEP 4: Analyzing and interpreting data	P2
SEP 5: Using mathematics and computational thinking	None
SEP 6: Constructing explanations and designing solutions	P2
SEP 7: Engaging in argument from evidence	None
SEP 8: Obtaining, evaluating, communicating information	P2

During the observation protocol, participants were observed during science classes which they identified as inquiry-based lessons. Table 3 above shows the eight SEP's and the participants that were observed implementing in the classroom. Only 2 of the 6 participants observed, implemented SEPs during the classroom visit. Of the SEPs observed, only 5 of the 8 were not seen implemented at all during the classroom visits.

In addition to the SEP identified during the observation protocol the following data were collected through field notes. Two of the six classrooms which were observed had students' desk in clusters of four or five desk. Four of the six classrooms had student desk in rows. In 1 of the 6 classrooms students moved from station to station while in 5 of the 6 classrooms students stayed in their seats throughout the lesson. In all six classrooms the teacher-participant moved around the classroom through the lesson.

Non-inquiry-based strategies were used during the observation protocol. One of the six participants modeled for the students. Participant 3 demonstrated potential energy and kinetic energy as the students sat in rows. Two of the six participants had teacher centered classrooms and lectured during the science lesson. Three of the six participants had students read information and fill in worksheets to understand the science concepts.

The following inquiry-based strategies were used during the observation protocol: students developed models of scientific concepts, and students work cooperatively to answer questions and design answers. Two of the six participants used group work during the observation protocol. Participant 2 classroom had students work together to determine what type of energy was at each station. Two of the six participants had students develop models to explain a concept. Participant 1 had students create a model of a food web to explain how organisms interact.

In summary, with the exception of two participant P1 and P2, none of the participants used any SEPs during the lesson. Half of the classrooms were set-up in rows which did not allow for easy group interaction. In classes that did not use SEP the lesson were teacher focused, the teacher did most of the talking compared to the lessons which included SEP which were more student working together, student centered classroom. According to the concern-based adoption model, level of use, teachers mainly feel into

Level II. Preparation: preparing for use, but has not implemented inquiry-based instruction.

There was a difference between the science and engineering practices teacher mentioned during the participants' interviews and the classroom observations. Capps and Crawford (2013) also identified the desire to implement inquiry-based instruction and the lack of classroom implement of inquiry-based practices. Section 2, Table 4 shows a comparison of the description of science and engineering practices mentioned by participants during interviews and the SEP observed in the classroom.

Table 4

Sample Table Title Comparison of Description of Implementation of SEPs in Interviews and Observation of SEPs

Science and Engineering Practices	Number of teachers that mention implementing SEP in interview	Number of teachers that implementing SEP in classroom observation
SEP 1: Asking questions and defining problems	4	0
SEP 2: Developing using models	3	1
SEP 3: Planning and carrying out investigations	6	1
SEP 4: Analyzing and interpreting data	5	1
SEP 5: Using mathematics and computational thinking	1	0
SEP 6: Constructing explanations and designing solutions	0	1
SEP 7: Engaging in argument from evidence	1	0
SEP 8: Obtaining, evaluating,	0	1

communicating information	

Note. Table consists of six teachers that agreed to interview and observation.

Six of the nine participants agreed to be interviewed and observed. In the Section 2, Table 4 was a comparison between the number of participants that mentioned each SEP during the interview and then number of participants that implemented the SEP during the observation. Four of the participants described implemented SEP 1 (Asking Questions and Defining Problems), none of the participants implemented SEP 1 during the observation. Three of the participants mentioned that they implemented SEP 2 (developing and using models), one of the participants implemented SEP 2 during the observation. Six of the participants mention implementation of SEP 3 (Planning and caring out investigations), one of the participants implemented SEP 3 during the observation. Five of the participants mention implementation of SEP 4 (Analyzing and interpreting data), one of the participants implemented SEP 4 during the observation. One participant mentioned implemented SEP 5 (Using mathematics and computational thinking), none of the participants implemented SEP 5 during the observation. None of the participants mention implementation of SEP 6 (Constructing, explanations, and designing solutions) during the interview, one participant was observed implementing SEP 6 during the classroom observation. One participant mentioned implementation of SEP 7 (Engaging in argument from evidence) during the interview. None of the participants implemented SEP 7 during the observation. None mentioned implementation of SEP 8 (Obtaining, evaluating, and communicating information) during the interview. One of the participants implemented SEP 8 during the observation.

Why strategies were chosen

To address RQ2, two interview questions were asked (6 and 7) to nine participating teachers. There were two themes found from the results to answer RQ2. Those themes were: teachers' confidence about teaching science, and students' ability. There were four subthemes for RQ2. Those subthemes are positive aspects of inquiry, factor that limit inquiry, positive learning activities and challenges with learning activities.

Teachers' confidence about teaching science

A main theme why the instructional strategies were implemented by participants was their perceived confidence in their ability to teach science. Five of nine participants self-identified themselves as confident or comfortable in being able to teach inquiry-based science lessons. Participant 4 stated: "It's taken me a long time to feel comfortable in science. But this year, I finally feel comfortable in science. And this is my third year teaching fifth grade science. So I finally hit a comfortableness with it." Of the participants that feel confident and comfortable three of the four share that experience with teaching the content is the reason they feel more confident with teaching science. Participant 2 stated: "I feel like, as the years go on, I get more confident. I feel confident because right now, like, I've been teaching the longest of all my partner teachers, in science, so I feel confident."

Three of the nine participants shared that they were not comfortable with inquiry-based instruction identified that they struggled with the content. Participant 5 stated: "I struggle like when a student asked today about was an ant a consumer or producer because other things ate it, I [said], ‘we’ll look it up’.” Another participant stated that they were becoming more comfortable. Participant 8 stated: “This is my first year so I’m trying to get it.”

Positive aspects of inquiry

Teachers viewed teaching science through hands on instruction as positive aspect of inquiry. Seven of nine participants mentioned using inquiry-based instruction as being helpful for student learning. Participant 2 stated: “To me science is experimenting and figuring out how to solve problems.” Participants 7 stated: “The best way for students to learn is by doing, getting their hands dirty.”

Factors that limit inquiry

Teacher content knowledge seems to be one of the factors that limit participants implement of inquiry-based instruction. Three of the nine teachers mentioned being concerned about the content. Participant 8 stated: “I was a social studies major just two years ago and now I’m teaching science. Science is not my strongest subject.” Another teacher committed on their lack of understanding fundamental science concepts. Participant 6 stated: “I struggle like when a student asked about kinetic energy, I got confused for a moment.”

Students’ ability

The perceived ability of the student’s plays a role in the strategies which the participants choose to implement in the classroom. Six of the nine participants stated the academic ability of the students played a role in the decision to implement inquiry-based instruction in the classroom. Sometimes it was the non-science skills that in the view of the participant that prevented inquiry-based instruction. Participant 6 stated: “The abilities of my students really plays a major role in how I teach my class. In the class that just ended I have two young people that need help reading and there are a few others.” Other times it was the science content:

> Participant 3 stated: Well it depends on [the students] familiarity with the topic, if it's something new, I usually will be up there teaching them, if it's something that we worked on for a while, I usually will either have them working independently or as a group work. But if it's something fresh and new, you know, I don't want to just throw them in the deep end and see what happens.

Positive learning activities

Positive learning activates which promoted student engagement played a role in teacher’s choice of instructional strategies. Four of the nine participants mentioned that students wanted activities that they played an active role. Participant 2 stated: “Building equals more fun.” Participant 1 stated; “students enjoy … the hands on instruction being able to see the learning or doing the learning themselves.” Another factor in teacher’s choice of instructional strategies was the impact of inquiry-based instruction on student understanding. Participant 2 stated; “I feel like the students do really well with building and trying to solve problems. So when I have them change heat to other forms of energy through experiments they really get it.” Three of the six teacher believed that inquiry-based instruction helped student understand the concepts at a deeper level.

Challenges with learning activities

Another subtheme that emerged was challenges with learning activities. Three of nine teachers mentioned that learning activities such as inquiry-based activities presents challenges to students that lack a foundation in the concept. Inquiry-based activities are designed to allow student to explore to solve problems. Participant 3 stated: “Well it depends on their familiarity with the topic, if it's something new, I usually will be up there teaching them.”

In summary from the perspective of the teachers two main themes guided the implementation of instructional strategies: teacher confidence toward science, and student’s ability. Based on CBAM, stages of concern, 3 of 9 teachers were at Stage 3 management level of implementing an innovation. Another two teachers were at Stage 2 personal level of implementing an innovation. These teachers identified problems which effected themselves as the cause for not being fully implementing the innovation or implementing the innovation at a minimum level or only parts of it.

Concerns for implementing inquiry instruction

To address RQ 3, two interview questions were asked (three and four) to the nine participants. There were two themes found from the results to answer RQ 3. Those themes are resources and professional development. There were four subthemes: materials, time, planning inquiry-based lessons and PLTW professional development.

Resources

One of the main themes that the teachers mentioned was the concerns of resources. Teachers mentioned the following concerns which were group under concerns about resources:

- materials in PLTW kits
- materials for teacher created inquiry-based lessons
- classroom time to implement inquiry-based lessons during the class period
- challenges with the pacing guides
- time to create inquiry-based lessons.

Five of nine teacher mentioned either lack of classroom time to implement the lessons or concerns about the time it takes to create inquiry-based lessons. Three of the nine teachers mentioned the concern about resources to implement science lessons.

Time

One of the subthemes that the teachers mentioned was the concerns of time. Five of the nine participants mentioned that lack of time was a concern in the implementation of inquiry-based instruction. Four of the nine participants mentioned their concern about the lack of classroom time required for students to conduct non-PLTW labs and experiment with materials. Participant 4 stated: “I would say the time it takes to do a lab because … if we don't finish a lab in a day, then I'm cutting out my math in the afternoon.” Another participant identified that science takes more classroom time. Science lessons often continued for days as students needed time to create or build components, test hypothesis, redesign and test again. Participant 3 stated: “Sciences is unique, were each day is not just a new lesson. Most of the time, it takes a week or 2 to get through something like that. So it's usually continuation."

In addition participants mentioned being concern about the lack of time to develop which they have to develop an inquiry-based lessons. Three of the nine participants mentioned being concern about the length of time it takes to develop inquiry-based lessons. Participant 4 stated: "It's just the time it would take to do the lab and finding it. I would say that is a struggle." This same concern, the concern about time to develop and find non-PLTW inquiry lessons was shared by another participant. Participant 2 stated that inquiry-based lessons increases the time spent preparing for the class.

> Participant 2 stated: So for like the cookie/ fossil lab you would have to bake a bone into a cookie … I've done gummy bears with fossils, gummy bears in bread and let that sit and explore ... I've done different experiments, see which ones my kids like better, but try different things.

Materials

One of the subthemes under resources was the materials that are needed to implement inquiry-based in the classroom. Six of the nine participants mentioned materials to either implement PLTW or implement teacher created inquiry-based lessons. Participant 3 stated: "PLTW is easy because it is kind of step by step. It has everything you need. And the kits give you all the materials." Other participants identified concerns about the need for materials to implement. Participant 5 stated: "Sometime materials determines what we do."

Professional development

A need for more professional development was mentioned as an emerging theme by most of the participants. Seven of nine teachers mentioned being concerned about need for more professional development for PLTW training or how to implement inquiry-based lessons. When asked about confidence in integrating inquiry-based activities, participant 5 stated: “I think if I had more of instruction myself on how to use the materials, and I think I would be better off because it feels like now I'm teaching myself.” Participant 6 stated: “I don't typically plan that way [use inquiry-based instruction], even though I know it's a great way to teach.”

Planning inquiry-based lessons

One of the subthemes was the need for professional development on how to plan inquiry-based lessons. Only 2 of the 9 use the 5E method of planning science lessons. Participant 3 stated: “I typically will plan science … [using] 5E's.” The 5E method is one of the recommended methods to create inquiry-based lessons.

PLTW professional development

One of the subthemes was that participants needed more professional development on PLTW. Seven of the nine teachers mentioned that they wanted more professional development on PLTW. When asked about professional development Participant 2 stated: “I've been to PLTW professional development, but that's was only a little.” All participants in this study received professional development on PLTW prior to the start of the school year.

In summary, RQ 3 revealed that the teachers have concerns about implementing inquiry-based learning. The findings in this section are based around the themes resources and professional development. The subthemes of materials, time, planning inquiry-based instruction, and PLTW professional development emerged. Specifically not all of the participants (3 of 9) felt as confident in the implementing of inquiry-base instruction developed outside of the PLTW units. This was evident in the expressed concerns of participants wanting more professional development, and the concerns of students not being able to meet the rigor of inquiry-based instruction. Using the concern-based adoption model teachers, stages of concern, teachers level of concern ranged from the personal: anxieties and concern about skill set to implement inquiry-based instruction to consequence: concerns about the impact of inquiry-based instruction lessons on students.

Document review

The initial plan was to collect lesson plans prior to the interview of the participants. None of the teachers provided lessons plans prior to or during the interview. All teachers did provide lessons plans during the classroom observations. It is the procedure of East School District that teachers have lesson plans available daily when classes are taught. The lesson plans reflected the activities that took place during the observation protocol. Two of the six lesson plans described student working in groups. Two of the six lessons plan had students build something to help understand a concept. Three of the six lessons plans had students taking notes on science concepts. Four of the six lesson plans collected had no evidence of planning for inquiry-based instruction.

Salient Data Discrepant Cases

The salient, or most noticeable, patterns in the data were that all teachers understood that PLTW is the desired model to implement inquiry-based instruction. There was a discrepancy between what the teachers stated were good inquiry-based practices and what was observed during classroom observations. During interviews all teachers reported that the use of SEP as being part of a science lesson that could help students achieve, specifically SEP 3 planning and caring out an investigation. In practice during the observation protocol only one teacher was observed implementing this SEP 3. Another teacher used the developing using model practice in the classroom (SEP 2). Some possible reasons for this could be student ability level, student interest, and the time it takes to implement inquiry-based instruction as shared in teacher interviews. This discrepant could be related to the lack of professional development for the teachers to match their desire to implement inquiry-based instruction and their knowledge of inquire-based instruction as disclosed by three teachers.

Evidence of Quality

I used triangulation to ensure accuracy and credibility of the data. Credibility refers to the accuracy and trustworthiness of the data collation and data analysis. Trustworthiness establishes the results of the study as being true, based on the methodology used and supports the credibility of the study (Creswell, 2012). Credibility measures used in this study include peer debriefing and the use of multiple tools for the gathering of data.

The multiple sources of evidence were gathered in this study consisting of observations, interviews and documentation mining. Using multiple sources of evidence as part of one process in the analysis of the data lends to the triangulation of evidence (Yin, 2014). Triangulation strengthen the construct validity of developing convergent evidence (Yin, 2014). Discrepant cases were identified and analyzed for possible reasons for conflicts for rival explanations. Sample field notes and research logs are located in the appendices.

Summary of Outcomes

The outcomes connected to the analysis of all three data sources rendered information in support of the study's problem and RQs. The RQs stemmed from the problem at the local level is a new inquiry-based curriculum, based on the NGSS, is being mandated without identifying the instructional strategies teachers are using to implement the new standards. RQ 1: What inquiry-based instructional strategies are teachers using to implement NGSS into the curriculum? The interview responses, the documentation and the observation protocol addressed this RQ. Data from the interviews revealed that the participants, using the concern-based adoption model, stages of concern, fell beyond the personal stage of concern. Many teachers perceived that they were incorporating inquire-based strategies in their classrooms. The interview data did not correspond to the data collected through the observation protocol. From the review of literature there was a gap between teacher intended practices during interviews and teacher enacted practices observed in the classroom (Smith & Nadelson, 2017, Ssempala & Masingila, 2019; Tairab & Al-Naqbi, 2018). RQ 2: From the perspective of the teachers, why were these instructional strategies chosen? The interview responses revealed that five of the nine teacher confident and teaching self-esteem was high for the implementation of inquiry-based instruction. This is supported in the literature through the identification of high self-esteem of teachers for implementation of inquiry-based instruction (Kang et al., 2018). Beyond the impact of teacher confidence student interest and ability affected the instructional strategies chosen in the classroom. RQ 3: What are teachers' concerns about the implementation of the instructional strategies? Interview data reveled that teachers were concern with the time needed to find and development non-PLTW inquiry-based instruction. They were also concerned about the class time needed to implement inquiry-based instruction. Teachers also voiced their concerns for the need of more professional development to implement inquiry-based instruction. Table 5 displays a summary of the themes found in the study. The data from the participants through analysis highlighted six major themes.

Table 5

Major Themes

Themes numbers	Themes
Theme 1	Intervention strategies
Theme 2	Instructional strategies
Theme 3	Teacher confidence about teaching science
Theme 4	Students' ability
Theme 5	Resources
Theme 6	Professional development

The Section 2 Table 5 identifies the major themes of this study. In answering the RQ1 in this study the themes focused on intervention strategies and instructional strategies. RQ 2 which examined why teachers choose specific strategies the main themes were teacher confidence about teaching science and students' ability. RQ3 which focus on the concerns teachers have concerns in the implementation of inquiry-based instruction focus on the theme of resources and professional development. These themes were used to develop the project in the following section.

The findings of this project study correlate to the earlier studies that found that teachers attitude toward inquiry-based learning is positive yet the enactment of inquiry-based learning is low (Drocelle, 2020; Ramero-Ariza et al., 2020; Ramnarain & Hlatswayo 2018). There is a general agreement that supports the effects of inquiry-based learning on students learning of science concepts (Capps & Crawford, 2013; Davenport Huyer et al., 2020; Ramnarian & Hlatswayo, 2018). This study also found teacher's perception of inquiry-based instruction as positive. Associated with the implementation of inquiry-based learning is the need for teachers to go through a change process. CBAM is tool which allows school systems to understand the concerns when implementing a new innovation (Hord, 1997). This study used the CBAM to identify the stage of concern of the teachers to develop an appropriate professional development.

Conclusion

The project was developed as an outcome of the results from interviews, observations, and document mining. The data among the three sources showed a pattern between responses, which highlighted a desire for access to training. Some of the concerns shared were the need for professional development. Considering these results, the project was the designed to include a 3-day training session on implementation of inquire-based instruction.

Section 3: The Project

The purpose of this project was to provide a baseline understanding of the SEPs, a collaborative opportunity for teachers, and the skills to create inquiry-based lesson. The goals of this project are to assist teachers in their transition from a teacher-center to a student-centered classroom. After completing the professional development program, the teachers will be able to understand the SEPs and create and/or modify lessons plans to include inquiry-based instruction. This project will consist of a 3-day professional development.

I developed a 3-day professional development program in response to the need to assist teachers in the implementation of inquiry-based instruction into their lessons. On the first day, the participants will perform activities to help them define and identify examples of the eight SEPs. The day will conclude with the participants completing an inquiry-based activity and a reflection of the day's activities. Day 2 will consist of activities to help teachers practice the skills of formulating questions and testing hypotheses as well as the use of a template to develop inquiry-based lessons. Day 3 will consist of creating inquiry-based lessons in groups to use within the school year. At the end of the day, participants will share lessons to receive feedback from other members in the professional development workshop. The professional development will also include a pre/posttest and daily reflection time to help assess the project as well as help participants' self-assess. This section includes a description of the project my goals and rationale for the project, and a review of literature as well as a discussion of the project implementation, evaluation plan, and implications.

Rationale

The research findings clearly indicated that teachers' intentions to implement inquiry-based instruction and their actual observed practices within the classroom were not aligned. This phenomenon of the disconnect between teachers' perceived actions and implementation in the classroom has been identified in other research (Kaymakamoglu, 2018). Kaymakamoglu (2018) found that teachers identified their plan to implement inquiry-based instruction in the classroom during interviews but then during classroom observations that the teachers did not implement the inquiry-based instruction at the level implied during interviews. In a similar study, Ramnarain and Hlatswayo (2018) surveyed 10 teachers and found a generally positive attitude toward inquiry-based instruction and that teachers recognized the benefits of inquiry-based instruction on student learning. However, the teachers were less inclined to enact inquiry-based learning in the lessons. Both in the literature and in the current study, there was a gap found between teachers' perceived actions and beliefs and their implementation of lessons in the classroom. In this study, I identified the teachers' need for professional development that would help them understand how to and believe in the implementation of inquiry-based instruction.

A key takeaway from the data analysis in the current study was that teachers felt they need more professional development in the implementation of inquiry-based instruction. These findings correlate to previous work completed by Avraamidou (2017) and Nagle and Pecore (2017). Avraamidou examined a beginning elementary teacher's beliefs and practices in the implementation of inquiry-based instruction and identified the need for professional development. This finding was supported by Nagle and Pecore's research that focused on a veteran teacher transition to NGSS and also identifying the need for professional development. The need for professional development is seen specifically in a participant in this study who stated that they were currently teaching themselves the inquiry-based instruction and felt the need for more assistance.

Review of the Literature

Teachers should participate in a professional development program that focuses on inquiry-based instructional strategies as informed by the findings of the data analysis. This professional development will give the teachers knowledge of SEPs, the skills to develop, and implement inquiry-based instruction lessons. Based on the evidence from the collected data and literature review, I identified professional development as the appropriate project genre for this study. This review of literature was conducted using multiple databases, including both Google Scholar and the following databases accessible through Walden University's online library: ProQuest, Education Source, and ERIC. In this review of literature, I focused on the relevance and importance of professional development. The following search terms were used: *professional development, goal setting, 5E instructional model, mentoring, professional learning community, community of practice, adult learning theory, teacher confidence, classroom observation,* and *evaluation.*

Through interview and classroom observation data, I identified a gap between teacher intentions to and practices when implementing inquiry-based instruction. The literature supports this finding. Ramnarain and Hlatswayo (2018) found that 10th-grade physical science teachers had a positive attitude toward inquiry-based instruction but that they were less likely to implement it. In another study of 10 secondary science teachers, there was a gap in the teachers' perceived practices and actual classroom practices (Kaymakamoglu, 2018). Unlike the literature, I identified this phenomena in the elementary science classroom in the current study.

Through a review of the extant literature, I found a gap between teachers' self-efficacy toward implementation of inquiry-based instruction and observation of their classroom practices. A teacher's confidence in their teaching ability has an effect on their practices in the classroom. Tao (2019) reported that kindergarten teachers' attitude toward STEM education was high, yet their confidence in implementation of STEM activities in the classroom was low. Results from the current study support the finding of Tao in that observations show that teacher self-efficacy toward implementation of inquiry-based instruction and teacher practice in the classroom are not connected.

There was a disconnect between what was seen in classroom observations and teachers' self-efficacy toward the implementation of inquiry-based instruction (Drocelle, 2020). Drocelle (2020) stated that teachers indicated a high self-efficacy for the implementation of inquiry-based instruction, yet during the classroom observation of what teachers believed to be an inquiry-based science lesson, none of the components of inquiry-based science instruction were actually implemented by the teachers. Science teachers are aware of inquiry-based teaching methods and believe that inquiry-based teaching methods are useful for student understanding but did not implement them in the classroom (Akuma & Callaghan, 2019).

Professional development is essential to increasing the implementation of new reform practices in the elementary science classroom. Through a review of literature Darling-Hammond et al. (2017) summarized that there are seven common features of successful professional development: content focused, adult learning theory, collaboration, modeling, coaching support, reflection, and sustained duration. Use of most of these components in the delivery of professional development has resulted in successful programs (Darling-Hammond et al., 2017).

Current science curriculum reform requires teachers to change classroom practices. Successful implementation of inquiry-based science instruction at the classroom teacher level requires content knowledge (Haag & Megowan, 2015), pedagogical content knowledge, (Dobber et al., 2017) and teacher self-efficacy. Through a review of the literature, I put together an outline of how professional development can affect each of the components previously mentioned. What follows are suggestions from the literature for the implementation of inquiry-based instruction into science classes.

Elementary teachers often teach all subjects. Professional development that is designed to increase teachers' content knowledge has increased student knowledge (Seraphin et al., 2017). A possible reason for this could be the lack of course work and experiences that elementary teachers have had in the past with science instruction. Increasing science content knowledge has been shown to increase teachers' use of science in the classroom (Lotter et al., 2017). Other researchers have suggested that professional development aimed at enhancing the content knowledge of experienced teachers may not result in significant gains in teachers' content knowledge (Gardner et al., 2019). Beyond content knowledge, inquiry-based instruction requires a change in pedagogical content knowledge.

Pedagogical content knowledge is the ability to make information accessible to others and is a skill in inquiry-based teaching that is different from the skills used in traditional teaching (Khalaf & Zin, 2018) Traditional teaching is defined as teacher-directed instruction, while inquiry-based teaching is referred to as student-directed instruction (Khalaf & Zin, 2018). Professional development that empowers teachers to become directors of instruction and facilitators of investigations permits them to shift their pedagogical practice and build their pedagogical content knowledge (Lotter et al., 2017; Shernoff et al., 2017). Building pedagogical content knowledge is important because it builds teacher self-efficacy.

Self-efficacy is critical to teachers' implementation of innovations. Professional development that allows teachers to practice skills and gain experience can increase their self-efficacy in implementing new practices such as inquiry-based science instruction (Mitchell et al., 2018). Gardner et al. (2019) researched the impact of yearlong professional development and found professional development increased teacher self-efficacy in teaching STEM content. Through continual practice teacher self-efficacy increases; Bandura (1977) stated that mastery experience is the main source of self-efficacy. Mahasneh and Alwan (2018) found an increase in self-efficacy when they conducted a quasi-experiment to determine the effect of project-based learning on student-teacher self-efficacy. Another means of increasing teacher self-efficacy is through verbal encouragement. Gibson and Brooks (2012) reported that teachers receiving support from school leadership is viewed as valuable (Liu & Hallinger, 2018). In training that uses modeling to demonstrate how to implement an innovation, self-efficacy can increase through vicarious experiences. In the current study, professional development was presented the summers before teachers began implementing inquiry-based instruction. Professional development also promotes teacher collaboration (Shernoff et al., 2017) and is viewed as helpful and may lead to an increase in self-efficacy. Gardner et al. found that professional development that focused on STEM integration increased teacher self-efficacy to implement inquiry-based lessons.

Adult learning theory, which is based on art and science of helping adults learn, was formalized by Knowles et al. (2005). There are six elements necessary for optimal learning to take place: a need to learn, an individual feeling responsible for their own learning, the role of experience in an individual’s own learning, a readiness of application of information from a person’s life situation, motivation to learn, and problem-centered learning with real-life problems (Knowles et al., 2005). Using these elements of adult learning theory as a framework has proven effective in guiding professional development and has yielded positive results (Schattman et al., 2019; Senyshyn & Smith, 2019).

There are many types of professional developments that are based on collaboration, reflection, and coaching. Some examples in the literature include communities of practice and PLCs. PLCs are teachers and administrators in a school that seek to share learning in an effort to increase effectiveness to benefit students (Hord, 1997). Communities of practice are groups of people who share a concern or passion for something they do and who meet regularly to reflect and support achievement in the area

(Farnsworth et al., 2016). Miranda and Damico (2015) looked at professional development that paired a scientist with a teacher, allowing the teacher to receive hands-on scientific field experience followed by an engagement in a community of practice. The community of practice focused on a shift from teacher-centered model to student-centered instructional model. This approach helped in the teachers modifying their instructional approach (Miranda & Damico, 2015).

Both of the models: community of practice and PLC, share some commonalities with mentoring. Mentoring programs are multidimensional programs which included guiding, supporting, and influencing a new or beginning teacher. Mentoring programs work in situations of mutual trust and beliefs making a one-on-one connection between mentor and mentee (Gholam, 2018). Korthagen (2017) identified the importance of connection with the person of the teacher as critical factor in an effective professional development. Mentoring professional development programs have been shown to increase pedagogical knowledge (Prasetyo, 2019) and self-efficacy (Miller et al., (2019). In research conducted by Forbes et al. (2017) professional development which was mentor supported through building a community of science practice led to gains in teacher content knowledge as well as pedagogical knowledge. The overarching concept between all of these approaches are the shared approach to evaluating, sharing and solving common objectives.

Another key component identified by Darling-Hammond et al. (2017) was that professional development should be content focused. Research by Ssempala and Masingila (2019) which examined the professional development and the implementation of inquiry-based strategies into the classroom identified an increase of understanding of inquiry-based instruction and the ability to engage students in the science and engineering practices. An inquiry-based professional development that integrated pedagogical content knowledge and content knowledge helped teachers increase student achievement compared to a control group (Asheri et al., 2016). Professional development which focuses on inquiry-based instruction has been shown to increase teacher understanding and confidence to teach inquiry-based instruction (Maeng et al., 2020). Asheri et al. (2016) used workshops which consisted of using the 5E instructional model when engaging teachers in an inquiry-based workshop.

The 5E instructional model is designed to be a student focused model. The 5E model consist of five phase: engagement, exploration, explanation, elaboration, and evaluation. Engagement: a task which accesses a learner's prior knowledge and helps them become engaged with new concepts. Exploration: an experience which current concept, processes and skills are identified. This activity help students generate new learning based on prior knowledge. Explanation: the teacher has an opportunity to directly introduce a process, skill, or concept. The student can explain their understanding. Elaboration: teacher challenges and extends students conceptual understanding and skill. Evaluation: provides the teachers an opportunity to evaluate students' progress toward achieving objectives. Ong et al. (2020) used the professional development on the use of the 5E instructional model to enhanced content knowledge and pedagogical knowledge.

Goal setting is an appropriate evaluation for this professional development based on the literature review. Goals setting which provided individuals with specific, difficult but attainable goals resulted in performances which were better than those with no goals at all (Locke, 1996). Research by Locke and Latham, (2019) leaders in goal-setting theory, has a general model of goal-setting theory. In this model values effect a desire and intentions to perform actions that are in-line with them. If the intentions are well defined as goals the actions will produce specific desired outcomes. Goals can also lead to higher motivation through the accomplishment (Locke, & Latham, 2019).

Project Description

Needed Resources

The objectives of the professional development program were to improve teacher implementation of inquiry-based instruction. In research conducted by Roth et al. (2019) as teacher knowledge increased there was an increase in student achievement. With student achievement being a core goal of the East School District this program has the potential to be well accepted. To successfully implement the inquiry-based instruction professional development program there will be several resources that will be needed. Administrative support will be needed to recruit teachers and motivate the participants in the professional development program. Administrative team will also need to allow previously build-in professional development days to be ear-marked for the inquiry-based instructional professional development program. The teacher-participants need to be actively engaged in the professional development instruction. Space will be needed to hold the professional development. Lab materials will be needed to conduct the inquiry-based activities during the professional development.

Existing support

The school system currently has a number of programs already in existence that can support and promote this professional development program. One of the main supports is the new teacher mentor program. This program assigns a mentor for each non-tenured teacher to assist them in the implementation of critical instructional programs based on the needs of the school system. This program could help maintain the thrust of the inquiry-based instructional professional development program through helping with the creation of lessons, observing classes and motivating teachers. Another support is the build-in professional days which the teachers are contracted to complete. Each year the administrative team determines the focus of the professional development days.

Potential barriers and solutions

Potential barriers of the proposed project include potentially unwilling participants, unwilling administration team and the potential timing of the professional development. There may be teachers that feel that professional development program may not meet their needs. To address this concern the professional development program will have teachers work in peer groups to address community factors that may limit teacher full participation in professional development (Noonan, 2019). Administration teams have many priorities pulling on their energy and time and without keeping this program as a priority their participation may wane. To keep administration engaged updates will be shared biweekly from the mentoring program. The inclusion of a mentoring program will continue to provide support thought the school year.

Program Implementation and Timetable

The proposed timetable for the implementation of the professional development program will be 3 days prior to the start of the school year. The program will start each day at 8:00 a.m. and last until 4:00 p.m. Each day will begin with an introduction, followed by modeled activities, collaborative actives, and reflective journaling. During the school year a mentoring program to support the teachers will consist of biweekly check-in with teacher-participants.

Roles and Responsibilities of Researcher and Others

The researcher

I will be responsible for the presentation of the professional development program proposal to the schools system to garner support for the project. Included in this proposal would be recommendations on implementation, proposed timetable for implementation, goals, and evaluation of the professional development program. I will acquire a space and materials for the program and acquire the mentors that will provide the professional development instruction to the teachers. I will conduct formative and summative evaluation of the professional development project with recommendations for future implementations and improvements.

The school's administration team

The school's administration teams will have multiple roles in the training. First they will need to encourage teachers to attend the professional development. Second they will need to provide approval for the time, location, and budget. Third they will be encouraged to attend each session so they understand the inquiry-based instruction program, monitor teacher implementation and motivate teacher participants to activity engage in the professional development.

Project Evaluation Plan

The overall goals for this inquiry-based instruction professional development program are to assist teachers in their transition from a teacher-center classroom to a student-centered inquiry-based classroom. After completing the professional development program, the teachers should be able to understand the scientific and engineering practices of inquiry-based instruction, create / modify lessons plans to include inquiry-based instruction and to implement inquiry-based instruction into their classroom lessons. A goals-based evaluation will determine the successes, failures, needs, and future of the program. The goals for this program are to increase teacher understanding of science and engineering practices to implement inquiry-based instruction, create lessons based on inquiry-based practices, and to increase the number of inquiry-based lessons in the classroom. At the start and completion of the program teachers will be asked to complete a survey on the effectiveness of the program and its content.

Project Implications

This professional development program is designed to address the challenges and gaps in practice identified in the study. The teacher-participants in their interviews emphasized professional development as a need to implement inquiry-based instruction.

Four of the six lesson plans collected had no evidence of planning for inquiry-based instruction. This 3-day professional development training will address these concerns.

This project will foster positive social change for the teacher-participants who engage in this training, and their students. Local data provides evidence of a lack of performance by upper elementary school students in science. When this group is compared to their peers in the state there is a gap between East School District students and other school districts. This project will provide teachers with the knowledge and skills to create, plan and implement inquiry-based lessons. Teachers will benefit from having the knowledge of effective instructional practices. Students in the district will benefit from having teachers who are more equipped to provide inquiry-based instruction.

This project has the potential to have a positive impact on local stakeholders which includes teachers and students in East School District. The project was designed based on the challenges identified through the data collected in this study. Professional development was intended to improve teacher skills and knowledge to implement inquiry-based instruction through teacher development of inquiry-based lessons and understanding of SEPs. Another benefit of this project to the local stakeholders is the development of an inclusive school culture from school administration, mentor teachers, and classroom educators. Together these actions will address the local problem of poor student success on statewide assessments in science, as gains in teacher knowledge, results in student achievement. Therefore, implementation of this professional development program is important because of these benefit to the local teachers and students.

This project was designed to meet the needs in East School District based on the concerns identified in this study. The inquiry-based instruction professional development program provided (see Appendix A) can be used by other districts as they undertake the task of providing professional development to their school districts. As science reforms shift to an inquiry-based instructional model the skills needed to accompany this new learning, such as: questioning, argument reasoning and developing conclusions from evidence can be used outside of the science classroom. Therefore, this project may foster a positive social change far beyond East School District classrooms.

Stakeholders such as teachers and administrators outside of East School Districts may benefit from this study because of the increased understanding of teachers' perceptions of the needs to implement inquiry-based instruction. By communicating views of elementary science teachers within East School District other may gain a clear understanding of the concerns and challenges that face teachers implement inquire-based instruction in the elementary school setting. The professional development training can be used as a resource to begin or enhance implementation of inquiry-based instruction. Ultimately, through increasing teacher knowledge student achievement can be affect.

Section 4: Reflections and Conclusions

The creation and implementation of an elementary science professional development program in East School District provides a means to support elementary teachers in their efforts to implement inquiry-based instruction into their classroom. In this section, I evaluate the strength and limitations of the professional development project and recommend ways in which the project's limitations may be remediated. I reflect on what I learned as a result of developing this project study in the areas of scholarship, project development and evaluation, and leadership. The project's potential for social change is also discussed. Finally, I describe the project's implications and propose possible directions for future research.

Project Strengths and Limitations

This project provides fourth- and fifth-grade teachers and mentors with skills, methods, and strategies to implement inquiry-based instruction into their classroom. These instructional strategies were identified based on the data collected from interviews, observations, and lessons plans gathered during this study. The results indicated that teachers needed training to develop non-PLTW, inquiry-based lessons; implement inquiry-based learning strategies; and understand the SEPs.

A strength of the professional development project is that it provides content knowledge. The inquiry-based strategies and lessons plans developed during the 3-day professional development program will be based on current science standards that will be taught during the fourth- and fifth-grade courses. Participants in the study identified content knowledge as being one of the concerns for limiting their implementation of inquiry-based instruction.

The project will increase teachers' implementation of inquiry-based lessons through developing their understanding of SEPs and how to create 5E lessons plans. The SEPs are the skills and practices that students will perform in the classroom. These practices are similar to those that scientists and engineers use to understand, investigate, and address phenomena in the world. Participants will use the 5E model to create inquiry-based lessons. The 5E instructional model (i.e., engagement, exploration, explanation, elaboration, and evaluation) is a template that can be used to guide inquiry-based instruction. Lastly, a mentorship program will provide support as the teachers implement inquiry-based instruction and will provide them with opportunities for feedback and reflection during the school year.

Another potential strength of the professional development program is the use of a mentor program throughout the school year. Through the process of having the mentor teachers attend and becoming enmeshed in the project subject, they will potentially become a part of the yearlong program. This will be accomplished through an intentional evaluation survey sent out to teachers and mentors at midyear and at end of the school year. This program will benefit elementary teacher and students by offering teachers a science support system of other elementary teachers with a strength in science content. A mentoring program will provide teachers with an opportunity to reflect on implemented lessons and have an ongoing support. Reflection on professional development and ongoing support are two of the components that are necessary for quality professional development (Darling-Hammond et al., 2017).

The project faces some limitations in addressing teacher implementation of inquiry-based instruction in the classroom. One of the limitations to the program is time. The professional development will be held during the summer, and the teachers may not be willing to devote their time to the project. In addition, the mentoring program will require teacher-mentees to dedicate some of their time during the school year to meet with and reflect upon implemented strategies with the teacher-mentor. Another limitation of this program is teacher buy-in. Whereas, the nine study participants have identified their concerns and demonstrated their willingness to obtain support, the remainder seven teachers that make up the fourth- and fifth-grade faculty may show resistance based on their priorities and perceived relevancy of the program.

Recommendations for Alternative Approaches

The 3-day professional development training was the most appropriate project to address the findings of this study; however, an alternative approach to addressing the problem of this project study would be through online modules or a virtual class. Online modules would be an effective way to provide teachers with the information about the SEPs and the templates to design inquiry-based lesson. However, online modules would lack the opportunity to build community between teachers. Without support and the accountability that face-to-face programs bring, it would be possible for the implementation of inquiry-based lessons to be inconsistent at best. A virtual class maybe another option to deliver the information in this project. However, virtual classes often address fewer learning styles and would not allow teachers to practice the skills that their students will implement during the classroom lessons. The 3-day professional development project will provide information on the implementation of inquiry-based instruction and allow teachers to create support systems to help implement the lessons.

Scholarship, Project Development and Evaluation, and Leadership and Change

Scholarship

Over the course of my scholar journey, I have developed in several different areas that served as the guiding force behind the evolution of this project study. Throughout this process, the development of the skill to research current content in my practice has led to major steps in my growth. Conducting the research helped redefine the original problem and objectives of this project study. Later in the process, the skills of interviewing and observing led to the detection of the misunderstanding the East School District administration had of the needs within a classroom and the perspectives of the teachers implementing instruction. Again, through research to identify effective measures to address the gap in expectations and implementation in the classroom, I was able to use current research to create a professional development project with best practices. I will use my new knowledge to inform and inspire positive changes in the teaching practices of others.

Project Development and Evaluation

The project genre selected was based on the results of the project study and a review of current literature. The resulting professional development program will provide East School District with a new way to improve teaching and learning. Because my research revealed a gap between teachers' desire to implement inquiry-based instruction and their ability to do so in the classroom, I looked in the literature for an effective way to increase teachers' implementation of inquiry-based instruction in the classroom. The professional development project was chosen and designed based on the information found, including the characteristics of an effective professional development program, which were taken into consideration when designing the resulting professional development activity. The goal for the professional development activity was to increase teacher implementation of inquiry-based instruction. The evaluation method I chose for the professional development program was a goal evaluation.

Leadership and Change

Successful education reform requires school leadership to guide the change, and effective leadership comes from listening to the needs of others. Throughout the process of this capstone project, I found that being a good listener was critical for understanding the perceived needs of teachers. Through the interview process, I found teachers desired to be heard and supported. This project study and professional development program will serve to support teachers. This experience has provided me with the confidence and the tools to contribute to positive school change by improving the quality of instruction in East School District.

Reflection on Importance of the Work

The results of the study performed as a part of this project study are in agreement with the research found in the current literature. Teachers' perceptions of their classroom practices do not always match enacted practices. To help bridge this concern, I developed the professional development project to present an opportunity for the local school system to understand the current actions and perceptions of elementary science classroom teachers as well as provide them with a tool to move forward with science reform in the district. Lastly, the findings of this study present an understanding of the classroom experience for those enacting inquiry-based instruction outside of the local school system.

Implications, Applications, and Directions for Future Research

The results of this project study are in alignment with the research found in current literature. The teachers' perceived implementation does not always meet the actual implementation of inquiry-based instruction in the classroom. This study is important because it presents a qualitative view of elementary teachers' implementation of inquiry-based instruction in the classroom. The incorporation of inquiry-based instruction is a goal of the local school system. The professional development program project provides a suggested way to achieve this goal through increasing teacher knowledge and supporting teacher practices. At the conclusion of the professional development program, there will be an assessment to determine if the goals were achieved. If the goals were achieved, further research will be needed to establish the impact of inquiry-based instruction on student achievement in East School District.

Conclusion

Science reform in elementary science classrooms is a problem locally, in many parts of the United States, and in other parts of the world. Locally, elementary science teachers are not fully implementing inquiry-based instruction in the classroom. The results of this study support the research previously conducted by others and present a possible solution. Providing the professional development program in East School District may increase teacher implementation of inquiry-based instruction, which may increase the number of student-centered classrooms and, thereby, increase student achievement.

References

Akuma, F., & Callaghan, R. (2019). Teaching practices linked to implementation of inquiry-based practical work in certain science classrooms. *Journal of Research in Science Teaching, 56*(1), 64-90. https://doi.org/10.1002/tea.21469

Anderson, S. (1997). Understanding teacher change: Revisiting the concerns based adoption model. *Curriculum Inquiry, 27*, 331-367. https://doi.org/10.1111/0362-6784.00057

Antinluoma, M., Ilomäki, L., Lahti-Nuuttila, P., & Toom, A. (2018). Schools as professional learning communities. *Journal of Education and Learning, 7*(5), 76–91.

Appleton, K. (2008). Developing science pedagogical content knowledge through mentoring elementary teachers. *Journal of Science Teacher Education, 19*(6), 523-545. https://doi.org/10.1007/s10972-008-9109-4

Asheri, S., Gillies, R., & Wright, T. (2016). The effectiveness of a guided inquiry-based, teachers' professional development programme on Saudi students' understanding of density. *Science Education International, 27*(1), 16-39.

Avraamidou, L. (2017). A well-started beginning elementary teacher's beliefs and practices in relation to reform recommendations about inquiry-based science. *Cultural Studies of Science Education*, *12*(2), 331–353. https://doi.org/10.1007/s11422-015-9700-x

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215. https://doi.org/10.1037/0033-

295x.84.2.191

Barrows, H. (2002). Is it truly possible to have such a thing as dPBL? *Distance Education, 23*(1), 119-122. https://doi.org/10.1080/01587910220124026

Bell, S., & Sexton, S. (2018). Science education professional development for primary/elementary teachers: A tale of two systems. *Science Education International*, *29*(2), 117–123. https://doi.org/10.33828/sei.v29.i2.7

Blackburn, G. (2017). A university's strategic adoption process of an PBL-aligned eLearning environment: An exploratory case study. *ETR&D-Educational Technology Research and Development*, *65*(1), 147–176. https://doi.org/10.1007/s11423-016-9472-3

Boesdorfer, S., & Staude, K. (2016). Teachers' practices in high school chemistry just prior to the adoption of the next generation science standards. *School Science and Mathematics*, *116*(8), 442–458.

Bybee, R. (2014). NGSS and the next generation of science teachers. *Journal of Science Teacher Education*, *25*(2), 211–221. https://doi.org/10.1007/s10972-014-9381-4

Capps, D., & Crawford, B. (2013). Inquiry-based instruction and teaching about nature of science: Are they happening? *Journal of Science Teacher Education 24*(3), 497-526. https://doi.org/10.1007/s10972-012-9314-z

Chichekian, T., Shore, B., & Tabatabai, D. (2016). *First-year teachers' uphill struggle to implement inquiry instruction.* SAGE Open. https://doi.org/10.1177/2158244016649011

Creswell, J. (2012). *Educational research: Planning, conducting and evaluating* *quantitative and qualitative research*. Pearson.

Darling-Hammond, L., Hyler, M., & Gardner, M. (2017). *Effective teacher professional development.* Learning Policy Institute.

Davenport Huyer, L., Callaghan, N., Dicks, S., Scherer, E., Shukalyuk, A., Jou, M., & Kilkenny, D. (2020). Enhancing senior high school student engagement and academic performance using an inclusive and scalable inquiry-based program. *NPJ Science of Learning, 5*(1), 17 https://doi.org/10.1101/822783

Dobber, M., Zwart, R., Tanis, M., & van Oers, B. (2017). Literature review: The role of the teacher in inquiry-based education. *Educational Research Review*, *22*, 194–214. https://doi.org/10.1016/j.edurev.2017.09.002

Drocelle, N. (2020). Primary school teacher's understanding and self-efficacy towards implementation of inquiry-based instruction in primary science curriculum: Case of Kigali city Rwanda. *Unnes Science Education Journal, 9*(2).

Farnsworth, V., Kleanthous, I., & Wenger-Trayner, E. (2016). Communities of practice as a social theory of learning: A conversation with Etienne Wenger. *British Journal of Educational Studies, 64*(2), 139-160. https://doi.org/10.1080/00071005.2015.1133799

Favre, D. E., & Knight, S. L. (2016). Teacher efficacy calibration in education reform: When highly efficacious teachers don't spell "implement." *International Journal of Educational Reform*, *25*(4), 361. https://doi.org/10.1177/105678791602500402

Fitzgerald, M., Danaia, L., & McKinnon, D. H. (2019). Barriers inhibiting inquiry-based science teaching and potential solutions: Perceptions of positively inclined early adopters. *Research in Science Education*, *49*(2), 543–566. https://doi.org/10.1007/s11165-017-9623-5

Forbes, A., Kadir, M., & Yeung, A. (2017). Advancing primary teachers' awareness of the nature of science through communities of science practice. *Journal of Education Research, 11*(4), 417-436.

Gardner, K., Glassmeyer, D., & Worthy, R. (2019). Impacts of STEM professional development on teachers' knowledge, self-efficacy, and practice. *Frontiers in Education*. 4 https://doi.org/10.3389/feduc.2019.00026

Gholam, A. (2018). A mentoring experience: From the perspective of a novice teacher. *International Journal of Progressive Education*, *14*(2), 1–12. https://doi.org/10.29329/ijpe.2018.139.1

Gibson, S., & Brooks, C. (2012). Teachers' perspectives on the effectiveness of a locally planned professional development program for implementing new curriculum. *Teacher Development*, *16*(1), 1–23. https://doi.org/10.1080/13664530.2012.667953

Granger, E. M., Bevis, T. H., Southerland, S. A., Saka, Y., & Ke, F. (2019). Examining features of how professional development and enactment of educative curricula influences elementary science teacher learning. *Journal of Research in Science Teaching*, *56*(3), 348–370. https://doi.org/10.1002/tea.21480

Gudyanga, R., & Jita, L. (2018). Mapping physical sciences teachers' concerns regarding the new curriculum in South Africa. *Issues in Educational Research*, *28*(2), 405–421.

Gutierez, S. (2015). Collaborative professional learning through lesson study: Identifying the challenges of inquiry-based teaching. *Issues in Educational Research, 25*(2), 118-134.

Haag, S., & Megowan, C. (2015). Next generation science standards: A national mixed-methods study on teacher readiness. *School Science and Mathematics*, *115*(8), 416. https://doi.org/10.1111/ssm.12145

Hall, G. E., & Hord, S. M. (2011). *Implementing change: Patterns, principles, and potholes* (3rd ed.). Pearson.

Harrison, H., Birks, M., Franklin, R., & Mills, J. (2017). Case study research: Foundations and methodological orientations. *Forum: Qualitative Social Research, 1*.

Hord, S. (1997). *Professional learning communities: Communities of continuous inquiry and improvement*. Southwest Educational Development Laboratory.

Hord, S., Rutherford, W., Huling-Austin, L., & Hall, G. (2006). *Taking charge of change*. Southwest Educational Development Laboratory

Hoyer, K., & Sparks, D. (2017, February). *Instructional time for third and eighth graders in public and private schools: School year 2011- 12.* https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2017076

Hungwe, K., & Shonnard, D. (2018). Supporting curriculum reform in science education. *International Journal of Science, Mathematics & Technology Learning*, *25*(1/2), 23–35.

Kang, E. J. S., Donovan, C., & McCarthy, M. J. (2018). Exploring elementary teachers' pedagogical content knowledge and confidence in implementing the NGSS science and engineering practices. *Journal of Science Teacher Education*, *29*(1), 9–29. https://doi.org/10.1080/1046560x.2017.1415616

Kaymakamoglu, S. E. (2018). Teachers' beliefs, perceived practice and actual classroom practice in relation to traditional (teacher-centered) and constructivist (learner-centered) teaching (Note 1). *Journal of Education and Learning*, *7*(1), 29–37. https://doi.org/10.5539/jel.v7n1p29

Khalaf, B., & Zin, Z. (2018). Traditional and inquiry-based learning pedagogy: A systematic critical review. *International Journal of Instruction, 11*(4), 545-564. https://doi.org/10.12973/iji.2018.11434a

Knowles, M., Holton, E., & Swanson, E. (2005). *The adult learner: The definitive classic on adult education and human resource development* (6th ed.). Elsevier

Konstantinou, C. (2016). Introducing technology in Cypriot primary classroom music lessons: "I learnt using things in music I didn't know existed." *Journal of Music, Technology & Education*, *9*(2), 175–190. https://doi.org/10.1386/jmte.9.2.175_1

Korthagen, F. (2017). Inconvenient truths about teacher learning: Toward professional development 3.0. *Teachers and Teaching Theory and Practice, 23*(4), 387-405. https://doi.org/10.1080/13540602.2016.1211523

Krajcik, J., & Delen, I. (2017). How to support learners in developing usable and lasting knowledge of STEM. *International Journal of Education in Mathematics, Science and Technology*, *5*(1), 21–28. https://doi.org/10.18404/ijemst.16863

Lambert, M., Velez, J., & Elliott, K. (2014). What are the teachers' experiences when implementing the curriculum for agricultural science education? *Journal of Agricultural Education*, *55*(4), 100–115. https://doi.org/10.5032/jae.2014.04100

Lee, T. D., & Glass, B. (2019). Developing the next generation of elementary science teachers. *Journal of College Science Teaching*, *49*(2), 18–23. https://doi.org/10.2505/4/jcst19_049_02_18

Liu, S., & Hallinger, P. (2018). Principal instructional leadership, teacher self-efficacy, and teacher professional learning in China: Testing a mediated-effects model. *Educational Administration Quarterly*, *54*(4), 501–528. https://doi.org/10.1177/0013161x18769048

Locke, E. (1996). Motivation through conscious goal setting. *Applied and Preventive Psychology, 5*(1), 117-124. https://doi.org/10.1016/s0962-1849(96)80005-9

Locke, E., & Latham, G. (2019). The development of goal setting theory: A half century retrospective. *Motivation Science, 5*(2), 93-105. https://doi.org/10.1037/mot0000145

Lotter, C., Smiley, W., Thompson, S., & Dickenson, T. (2017). The impact of a professional development model on middle school science teachers' efficacy and implementation of inquiry. *International Journal of Science Education*, *38*(18), 2712–2741. https://doi.org/10.1080/09500693.2016.1259535

Maeng, J., Whitworth, B., Bell, R., & Sterling, D. (2020). The effect of professional development on elementary science teachers' understanding, confidence, and classroom implementation of reform-based science instruction. *Science Teacher Education, 104*(1), 326-353. https://doi.org/10.1002/sce.21562

Mahasneh, A., & Alwan, A. (2018). The effect of project-based learning on student teacher self-efficacy and achievement. *International Journal of Instruction*, *11*(3), 511–524. https://doi.org/10.12973/iji.2018.11335a

Marshall, J. C., Smart, J. B., & Alston, D. M. (2017). Inquiry-based instruction: A possible solution to improving student learning of both science concepts and scientific practices. *International Journal of Science and Math Education, 15*, 777-796. https://doi.org/10.1007/s10763-016-9718-x

Maryland State Department of Education. (2016). Maryland State Department of Education http://mdk12.msde.maryland.gov/index.html

Mathew, P., Mathew, P., & Peechttu, P. (2017). Reflective practices: A means to teacher development. *Asia Pacific Journal of Contemporary Education and Communication Technology, 3*(1), 126-131.

Merriam, S. (2002). *Qualitative research in practice: Examples for discussion and analysis* (Kindle version). Jossey-Bass.

Merriam, S. (2009). *Qualitative research: A guide to design and implementation.* Jossey-Bass.

Merritt, J., Lee, M., Rillero, P., & Kinach, B. (2017). Problem-based learning in k-8 mathematics and science education: A literature review. *Interdisciplinary Journal of Problem-Based Learning, 11*(2), https://doi.org/10.7771/1541-5015.1674

Miles, M., Huberman, A., & Saldana, J. (2014). *Qualitative data analysis: A methods sourcebook* (3rd ed.). Sage Publications.

Miller, A., Ramirez, E., & Murdock, T. (2017). The influence of teachers' self-efficacy on perceptions: Perceived teacher competence and respect and student effort and achievement. *Teaching and Teacher Education, 64,* 260-269. https://doi.org/10.1016/j.tate.2017.02.008

Miller, M., Hanley, D., & Brobst, J. (2019). The impacts of a research-based model to mentoring elementary preservice teachers in science. *Journal of Science Teacher Education, 30*(4), 357-378. https://doi.org/10.1080/1046560x.2019.1573127

Miranda, R., & Damico, J. (2015). Changes in teachers' beliefs and classroom practices concerning inquiry-based instruction following a year-long RET-PCL program. *Science Educator, 24*(1), 23-35.

Mitchell, J. T., Roy, G., Fritch, S., & Wood, B. (2018). GIS professional development for teachers: Lessons learned from high-needs schools. *Cartography and Geographic Information Science*, *45*(4), 292–304. https://doi.org/10.1080/15230406.2017.1421482

Murphy, A., & Haller, E. (2015). Teachers' perceptions of the implementation of the literacy common core state standards for English language learners and students with disabilities. *Journal of Research in Childhood Education*, *29*(4), 510–527. https://doi.org/10.1080/02568543.2015.1073200

Nagle, C., & Pecore, J. (2017). A veteran science teacher's transitions to NGSS. *Electronic Journal of Science Education, 23*(4), 1-15.

Nariman, N., & Chrispeels, J. (2016). PBL in the era of reform standards: Challenges and benefits perceived by teachers in one elementary school. *Interdisciplinary Journal of Problem-Based Learning*, *10*(1) https://doi.org/10.7771/1541-5015.1521

National Research Council. (2010). *Preparing teachers: Building evidence for sound policy. Division of behavioral and social sciences and education, committee of the study of teacher preparation programs in the United States, center for education.* National Academies Press.

National Research Council (2013). *Next generation science standards: For states, by states.* The National Academies Press. https://doi.org/10.17226/18290

National Science Teachers Association (2018). *NSTA position statement elementary science education*. https://www.nsta.org/about/positions/elementary.aspx

Newberry, M., Sanchez, L., & Clark, S. (2018). Interactional dimensions of teacher change: A case study of the evolution of professional and personal relationships. *Teacher Education Quarterly 45*(4) 29-50.

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

Nollmeyer, G. E., Morrison, J., & Baldwin, K. A. (2019). Barriers to authentic science inquiry in the elementary classroom. *Educational Research: Theory and Practice, 30*(1), 1-6

Noonan, J. (2019). An affinity for learning: Teacher identity and powerful professional development. *Journal of Teacher Education, 5*, 526. https://doi.org/10.1177/0022487118788838

Ong, E., Luo, X., Yuan, J., & Yingprayoon, J. (2020). The effectiveness of a professional development program on the use of STEM-based 5E inquiry learning model for science teachers in China. *Science Education International, 31*(2), 179-184.

https://doi.org/10.33828/sei.v31.i2.7

Phillippi, J., & Lauderdale, J. (2018). A guide to field notes for qualitative research: Context and conversation. *Qualitative Health Research*, *28*(3), 381–388. https://doi.org/10.1177/1049732317697102

Prasetyo, Z. (2019). The implementation of mentoring based learning to improve pedagogical knowledge of prospective teachers. *International Journal of Instruction, 12*(3), 529-540.

Pringle, R. M., Mesa, J., & Hayes, L. (2020). Meeting the demands of science reforms: A comprehensive professional development for practicing middle school teachers. *Research in Science Education*, *50*(2), 709–737. https://doi.org/10.1007/s11165-018-9708-9

Pruitt, S. (2014). The next generation science standards: The features and challenges. *Journal of Science Teacher Education, 25*, 145-156. https://doi.org/10.1007/s10972-014-9385-0

Ramero-Ariza, M., Quesada, A., Abril, A., Sorensen, P., Oliver, M. (2020). Highly recommended and poorly used: English and Spanish science teachers' views on inquiry-based learning (IBL) and its enactment. *Eurasia Journal of Mathematics, Science and Technology Education, 16*(1). https://doi.org/10.29333/ejmste/109658

Ramnarain, U., & Hlatswayo, M. (2018). Teacher beliefs and attitudes about inquiry-based learning in rural school district in South Africa. *South African Journal of Education, 38*(1), 1-10. https://doi.org/10.15700/saje.v38n1a1431

Rose, M. A., Carter, V., Brown, J., & Shumway, S. (2017). Status of elementary teacher development: Preparing elementary teachers to deliver technology and engineering experiences. *Journal of Technology Education*, *28*(2), 2–18. https://doi.org/10.21061/jte.v28i2.a.1

Roth, K. J., Wilson, C. D., Taylor, J. A., Stuhlsatz, M. A. M., & Hvidsten, C. (2019). Comparing the effects of analysis-of-practice and content-based professional development on teacher and student outcomes in science. *American Educational Research Journal*, *56*(4), 1217–1253. https://doi.org/10.3102/0002831218814759

Saka, Y., & Keklikci, N. (2019). Exploring the interaction between science teachers' self-efficacy beliefs and pedagogical discontentment: An attempt to understand why science education reform fails. *International Journal of Psychology and Educational Studies, 6*(2), 1-14. https://doi.org/10.17220/ijpes.2019.02.001

Sandelowski, M. (1995). Sample size in qualitative research. *Research in Nursing and Health, 18*(2), 179-183.

Sarfo, F. K., Amankwah, F., Baafi-Frimpong, S., & Asomani, J. (2017). Concerns of teachers about the implementation of information and communication technology curriculum in basic education in Ghana. *Contemporary Educational Technology*, *8*(2), 103–118. https://doi.org/10.30935/cedtech/6190

Schattman, R., Kaplan, M., Aitken, H., & Helminski, J. (2019). Climate change curricula for adult audiences in agriculture and forestry: A review. *Journal of Adult and Continuing Education, 25*(1), 131-151. https://doi.org/10.1177/1477971419840670

Seneviratne, K., Hamid, J., Khatibi, A., Azam, F., & Sudasinghe, S. (2019). Multi-faceted professional development designs for science teachers' self-efficacy for inquiry-based teaching: A critical review. *Universal Journal of Educational Research, 7*(7), 1595-1611. https://doi.org/10.13189/ujer.2019.070714

Senyshyn, R., & Smith, P. (2019). Global awareness dialogue project exploring potential for faculty transformation through a professional development series. *Journal of Transformative Education, 17*(4), 318-336. https://doi.org/10.1177/1541344619833342

Seraphin, K., Harrison, G., Philippoff, J., Brandon, P., Nguyen, T., Lawton, B., & Vallin, L. (2017). Teaching aquatic science as inquiry through professional development: Teacher characteristics and student outcomes. *Journal of Research in Science Teaching*, *54*(9), 1219–1245. https://doi.org/10.1002/tea.21403

Shernoff, D., Sinha, S., Bressler, D., & Schultz, D. (2017). Teacher perceptions of their curricular and pedagogical shifts: Outcomes of a project-based model of teacher professional development in the next generation science standards. *Frontiers in Psychology*, *8*, 1-16. https://doi.org/10.3389/fpsyg.2017.00989

Silm, G., Tiitsaar, K., Pedaste, M., Zacharia, Z., & Papaevripidou, M. (2017). Teachers' readiness to use inquiry-based learning: An investigation of teachers' sense of efficacy and attitudes toward inquiry-based learning. *Science Education International, 28*(4), 315.

Smith, J., & Nadelson, L. (2017). Finding alignment: The perceptions and integration of the next generation science standards practices by elementary teachers. *School*

Science & Mathematics, *117*(5), 194–203. https://doi.org/10.1111/ssm.12222

Ssempala, F., & Masingila, J. (2019). Effect of professional development on chemistry teachers' understanding and practice of inquiry-based instruction in Kampala, Uganda. *International Journal of Scientific Research and Education, 7*(2), 8085-8105.

Sulaiman, S., Sulaiman, T., & Rahim, S. S. A. (2017). Teachers' perceptions of the standard-based English language curriculum in Malaysian primary schools. *International Journal of Instruction*, *10*(3), 195–208. https://doi.org/10.5901/mjss.2015.v6n2p494

Tao, Y. (2019). Kindergarten teachers' attitudes toward and confidence for integrated STEM education. *Journal for STEM Education Research, 2,* 154-171. https://doi.org/10.1007/s41979-019-00017-8

Tairab, H., & Al-Naqbi, A. (2018). Provision of inquiry instruction and actual level of practice as perceived by science teachers and their students. *Eurasia Journal of Mathematics Science and Technology Education*, *14*(1), 397–412. https://doi.org/10.12973/ejmste/80320

Tunks, J., & Weller, K. (2009). Changing practice, changing minds, from arithmetical to algebraic thinking: An application of the concerns-based adoption model (CBAM). *Educational Studies in Mathematics, 72*(2), 161–183. https://doi.org/10.1007/s10649-009-9189-x

Wallace, C., & Priestley, M. (2017). Secondary science teachers as curriculum makers: Mapping and designing Scotland's new curriculum for excellence. *Journal of*

Research in Science Teaching, *54*(3), 324–349. https://doi.org/10.1002/tea.21346

Wang, W. (2013). Teachers' stages of concern and levels of use of a curriculum innovation in China: A case study. *International Journal of English Language Teaching, 1*(1), 22-31. https://doi.org/10.5430/ijelt.v1n1p22

Wright, T., & Cotwals, A. (2017). Supporting kindergartners' science talk in the context of an integrated science and disciplinary literacy curriculum. *The Elementary School Journal, 117*(3), 513-537. https://doi.org/10.1086/690273

Xiao-Fan, L., Dandan, T., Weipeng S., Zhong-Mei L., Yaner T., Chin-Chung T., (2020) Exploring the relationship between perceived technology-assisted teacher support and technology-embedded scientific inquiry: the mediation effect of hardiness. *International Journal of Science Education*, *42*(8), 1225-1252.

Yin, R. (2002). *Case study research: Design and methods.* SAGE Publications

Yin, R. (2014). *Case study research: Design and methods* (5th ed.) SAGE.

Yue, X. (2019). Exploring effective methods of teacher professional development in university for 21st century education. *International Journal of Innovation Education and Research, 7*(5), 248-257. https://doi.org/10.31686/ijier.vol7.iss5.1506

Zhang, M., Parker, J., Koehler, M., & Eberhardt, J. (2015). Understanding inservice science teachers' needs for professional development. *Journal of Science Teacher Education*, *26*(5), 471–496. https://doi.org/10.1007/s10972-015-9433-4

Appendix A: The Project

Professional Development /Training

Based on the findings from the study, the design of the following project seeks to support teachers when implementing inquiry-based instruction. The primary objective includes identifying what inquiry-based instruction looks like in the classroom and how to adapt lessons to implement inquiry-based instruction into the classroom.

Purpose	• To provide baseline understanding of the SEPs • Provide collaborative opportunities • Provide skills to modify lessons plans to increase inquiry-based activities • Provide skills to create inquiry-based lessons
Goals	Goals for this inquiry-based instruction professional development program is to assist teachers in their transition from a teacher-center classroom to a student-centered inquiry-based classroom. After completing the professional development program, the teachers should be able to understand the scientific and engineering practices of inquiry-based instruction, create and / or modify lessons plans to include inquiry-based instruction and to implement inquiry-based instruction into their classroom lessons
Learning Outcomes	• Increase proficiency in teaching inquiry-based lessons

	• Practical application in peer-developed lessons plans for use in the classroom • Awareness of teaching thought self-assessment/reflection
Target Audience	• Fourth and fifth grade science teachers • School administrators • Science mentors
Timeline	During the summer for 3 days prior to the start of school. Mentoring reflections will be held throughout the school year.

Proposed Activities

The professional development/training consists of activities designed to address the barriers to fully implement inquiry-based instruction. Each set of activities is described by day. The set of activities for the first day of training includes administration of a pretest. Following this participants will be introduced to what the science and engineering practices are how they relate to their work and what inquiry-based instruction looks like in the classroom. Administrator(s) present will be asked to participate in the activities. Groups will end the day reflecting on activities that were shared and on challenges to previous concepts.

In the morning of day two of the training, the instructor will present activities that will help develop teachers' abilities to identify the process skills and to redesign science activities in ways that will promote students' continuing development of these skills. In the afternoon of day two of the training the teacher will complete an activity to help them modify or create a student-centered classroom. Further on during the day the instructor will present an activity which help the teacher recognize that small changes to activities they already are doing to make them inquiry-based.

On the final day of the training, teachers will have an opportunity to co plan with mentors to develop inquiry-based lessons which that can implement in the classroom. Teachers will be able to present lesson plans through a modeled lesson to their peers who will provide feedback. Teachers will use this reflection activity to modify and enhance their lesson and to increase their confidence. Teachers will end the day completing a post-test of the professional development and a reflective discussion of their three day journey.

Module Format/Hour-by-hour Layout

Session	Activities	Timeline	Resource materials
Day 1	Welcome/introduction	8:00 – 8:30	PowerPoint
	Goals for professional development	8:30 – 9:00	
	Pretest / Break	9:00 – 10:00	Pre-test
	Brainstorm and sort	10:00 – 11:00	Activity 1 Day 1
	Lunch	11:00 – 12:00	
	SEP Circus	12:00 – 1:00	Activity 2 Day 1
	Science Engineering Comparison	1:00 – 2:00	Activity 3 Day 1
	Inquiry based activity	2:00 – 3:00	Activity 4 Day 1
	Reflection	3:00 -3:30	

Day 2	**Welcome / icebreaker** **Ice Balloons** **Lunch** **Process Circus** **Reflection**	**8:00 – 8:30** **8:30 – 11:30** **11:30 – 12:30** **12:30 – 3:00** **3:00 – 3:30**	**PowerPoint** **Activity 1 Day 2** **Activity 2 Day 2**
Day 3	**Welcome / icebreaker** **Inquiry-based lesson development** **Lunch** **Model lessons** **Post-test** **Reflection**	**8:00 – 8:30** **8:30 – 11:30** **11:30 – 12:30** **12:30 – 2:30** **2:30 – 3:00** **3:00 – 3:30**	**PowerPoint** **Activity 1 Day 3** **Activity 2 Day 3** **Post-test**

Detail Outline of Day 1

Timeline	Activates
8:00 – 8:30	**Welcome/introduction** • **Introduction of participants** • **Review professional learning expectations** *(be engaged in today's work. Stay off of personal technology as much as possible.)* • **Introduction of presenters** *(researcher, mentors)*

8:30 – 9:00	**Goals for professional development** • Assist teachers in their transition from a teacher-center classroom to a student-centered inquiry-based classroom. • Understand the scientific and engineering practices of inquiry-based instruction, • Create and / or modify lessons plans to include inquiry-based instruction • Implement inquiry-based instruction into their classroom lessons
9:00 – 10:00	**Pretest / Break** • Pretest
10:00 – 11:00	**Brainstorm and sort** • Have participants become familiar with the titles of the eight SEPs • Build definitions of the eight SEPs • Discover that the SEPs are not new or foreign ideas • https://www.calacademy.org/educators/practices-brainstorm-and-sort
11:00 – 12:00	**Lunch** • Lunch on their own

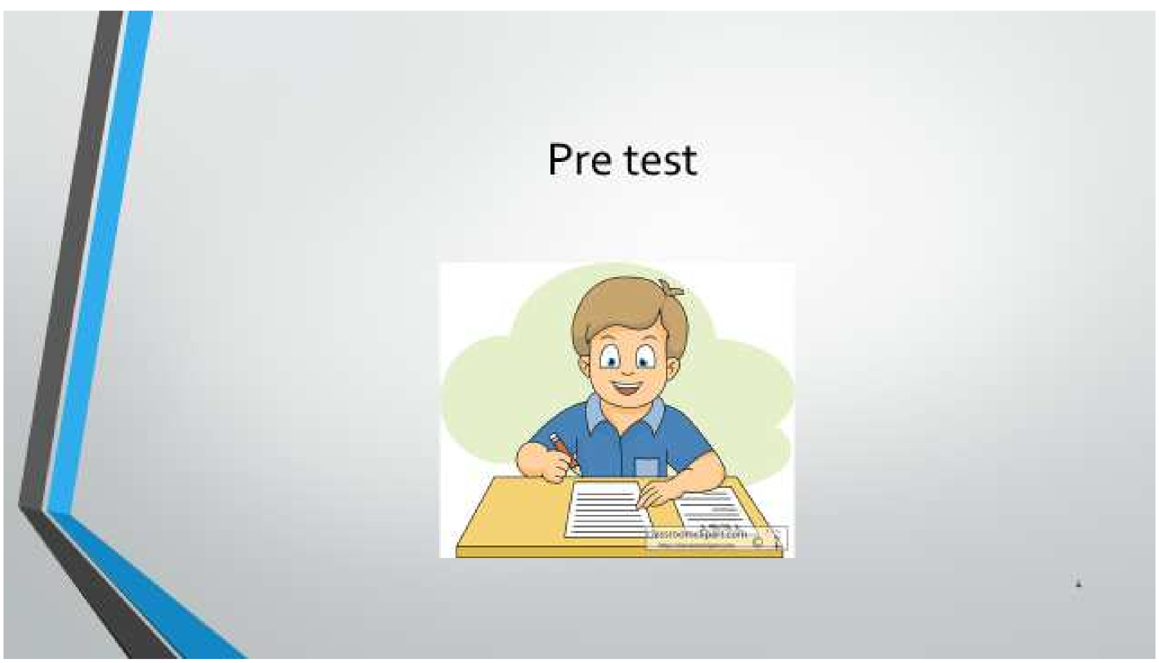
12:00 – 1:00	**SEP Circus** • Have participants become more familiar with SEPs • See simple examples of the classroom activities connected to the practices • https://www.calacademy.org/educators/science-and-engineering-practices-circus
1:00 – 2:00	**Science Engineering Comparison** • Compare and contrast the SEPs • Discover how science and engineering are similar and different. • Analyze some of the NGSS language defining the SEPs • https://www.calacademy.org/educators/comparing-science-and-engineering
2:00 – 3:00	**Inquiry based activity** • Teachers will experience an inquiry-based activity (Mystery Tubes activity) • https://undsci.berkeley.edu/lessons/mystery_tubes.html
3:00 – 3:30	**Reflection** • What did we get from the session • Three word summary

Day 1 slides

1. Share housekeeping for professional development (bathrooms, Timesheet, start - end times)

1. Introduce participants, introduce presenters

1. Explain how this professional development will help teachers implement inquiry-based lessons they create and that much of their current lessons can be easily modified.



1. Have participants take pre test and then take a break to set up next activity

Materials needed:

a. large easel paper/chart paper
    i. 1 blank poster per group
    ii. 8 posters with headings of the 8 SEPs
    iii. 1 poster with the heading "Missing"
b. post-its (1-2 stacks for each group of 3-5 people)

Web page

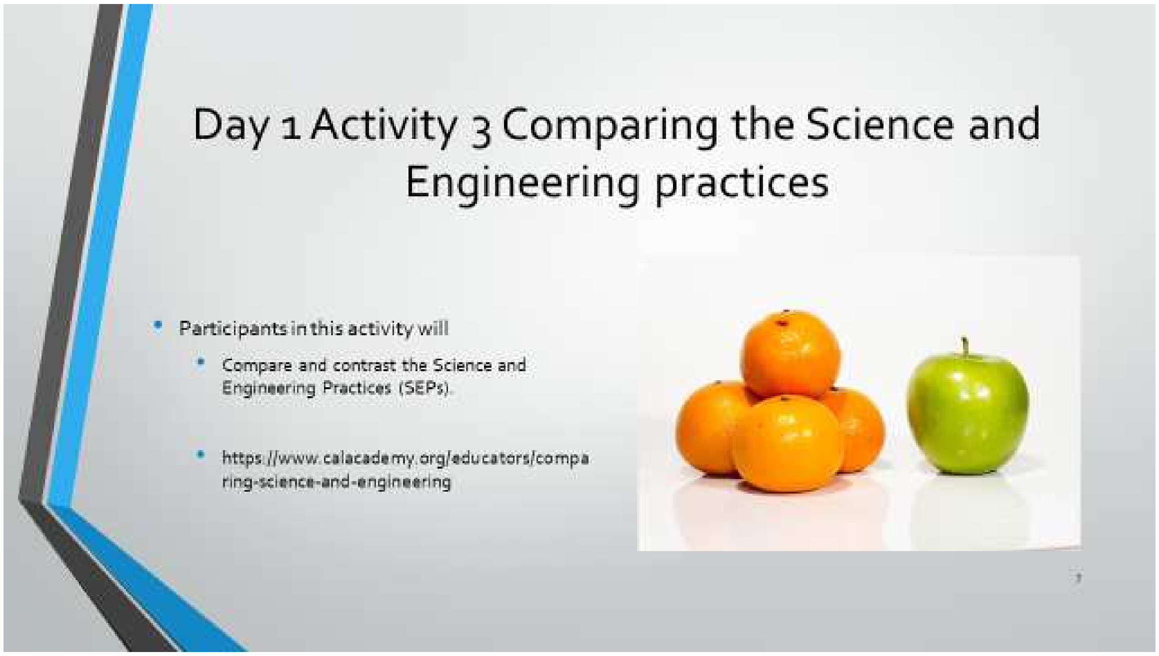
https://www.calacademy.org/educators/practices-brainstorm-and-sort

Materials: Station materials:

- station 1: samples of two different soils; water; small plates or petri dishes; eye droppers; beakers or other containers for the soil and water
- station 2: fresh flowers; tray; tools for dissecting flowers (such as scissors, picks, knives or scalpels)
- station 3: water; salt; ice; beakers or other containers for the water and ice
- station 4: hard boiled eggs; small plate or napkin; knife
- station 5: warm water; sugar; yeast; beaker or cup; spoon
- station 6: calculator
- station 7: plastic bottle; eyedropper; water.

Website:

https://www.calacademy.org/educators/science-and-engineering-practices-circus



Materials:

- **Science and Engineering Practice comparisons handouts 1-8** (1 Practice per group, 1 handout per participant)
- **Science and Engineering comparisons notes tool** (1 per participant)
- Large easel paper/chart paper (1 sheet per group, 8 total)
- Scratch paper
- Markers

Website:

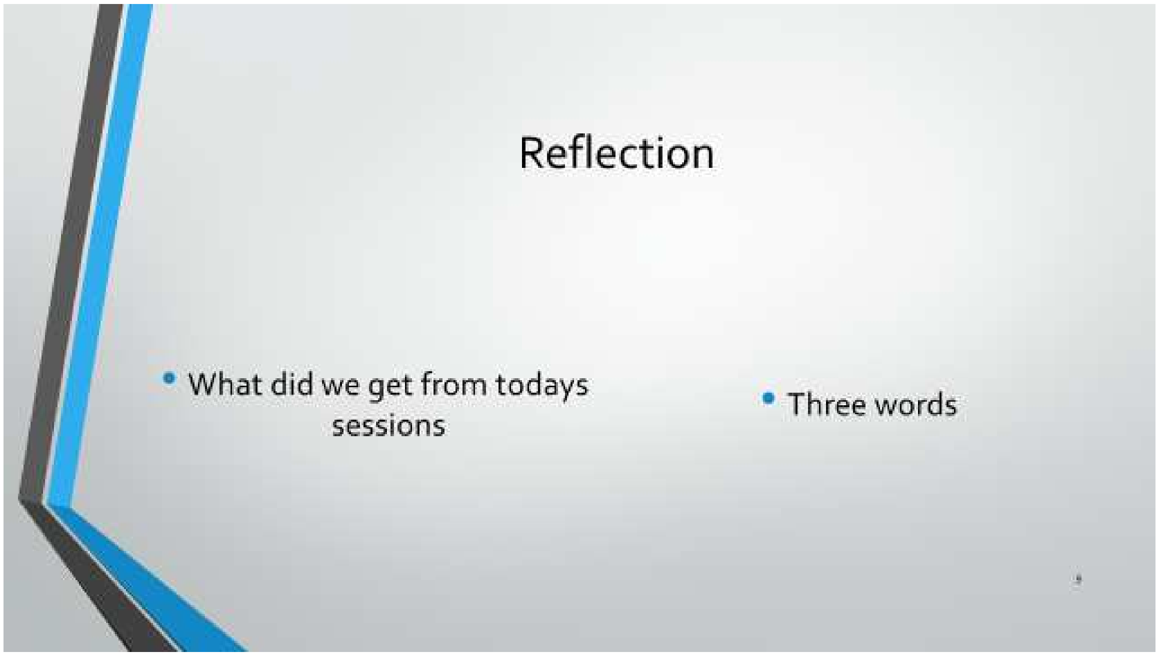
https://www.calacademy.org/educators/comparing-science-and-engineering

Materials:

- One Mystery Tube per two students — diagram and supply list below
- Scratch paper for drawing diagrams
- Packets/zip lock bags for building models (see step 5 below). These should contain a variety of items that they might use to build a model: scissors, paper punch, buttons, string, beads, rings, paper clips and also an empty toilet paper roll handed out separately

Website:

https://undsci.berkeley.edu/lessons/mystery_tubes.html



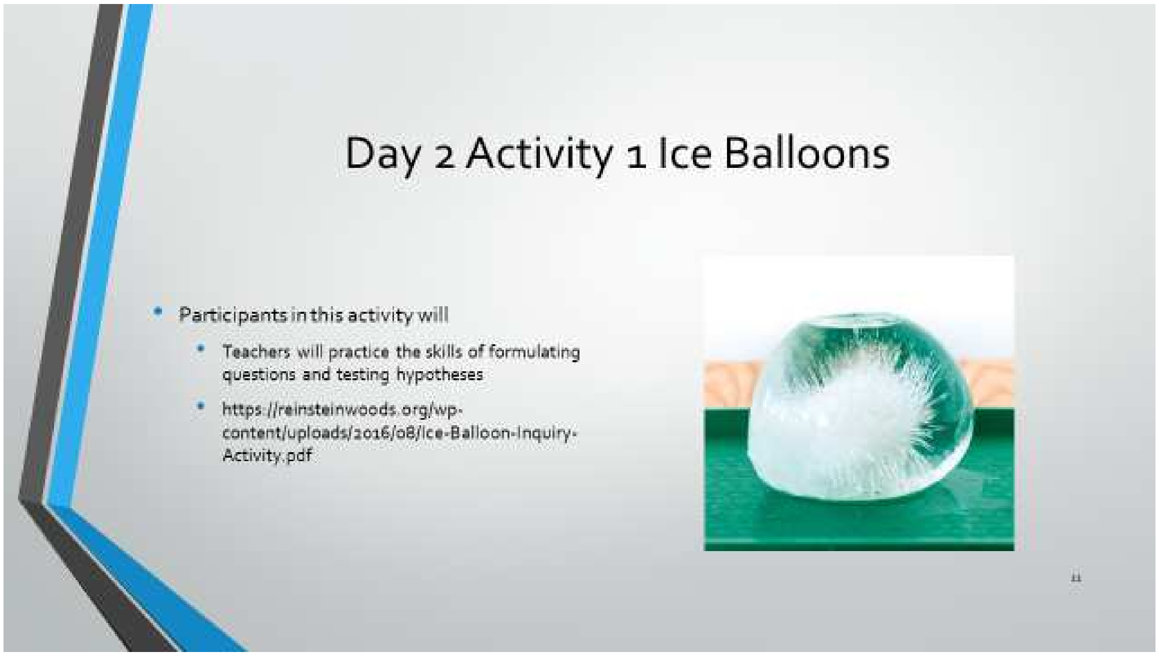
Use these tools to start classroom discussion and reflection on day's activities

Detail outline of Day 2

Timeline	Activates
8:00 – 8:30	**Welcome / icebreaker**
8:30 – 11:30	**Ice Balloons** • Teachers will practice the skills of formulating questions and testing hypotheses. • https://reinsteinwoods.org/wp-content/uploads/2016/08/Ice-Balloon-Inquiry-Activity.pdf
11:30 – 12:30	**Lunch**

12:30 – 3:30	**Process Circus** • Participants will practice inquiry-based activities: observing, questioning, hypothesizing, predicting, planning and investigating, interpreting, and communicating scientific information • https://www.exploratorium.edu/sites/default/files/pdfs/ifi/Process_Skills.pdf
3:00 – 3:30	**Reflection** • What did we get from the session • Three word summary

Have the participants guess your superhero name activity.



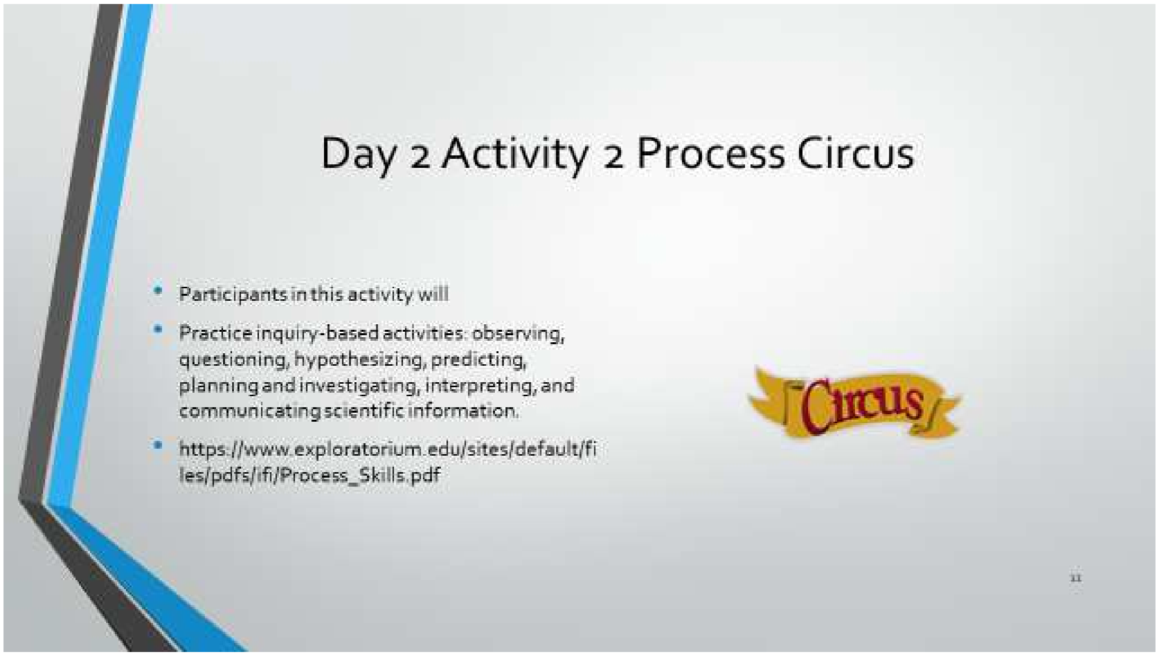
Website

https://reinsteinwoods.org/wp-content/uploads/2016/08/Ice-Balloon-Inquiry-Activity.pdf

Materials

- 9-inch (20-cm) spherical balloons (12-inch will also work)
- Water faucet (or some other way to fill balloons)
- Access to a freezer
- Plastic tub big enough and deep enough to float an ice balloon: 12 x 12 x 9 inches (30 x 30 x 22 cm) or larger
- Scissors
- Cafeteria-style plastic tray (to catch the meltwater)
- Salt
- Food coloring

After activity have participants go to lunch and prep for Activity 2 Day 2



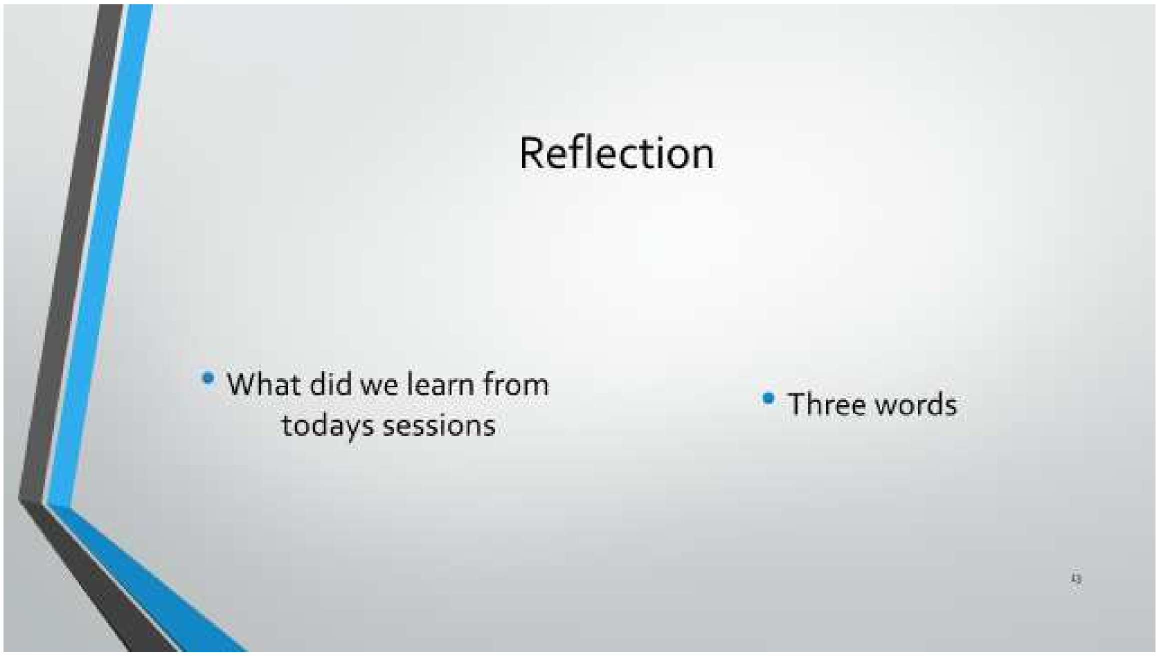
Webpage

https://www.exploratorium.edu/sites/default/files/pdfs/ifi/Process_Skills.pdf

Materials:

- 1 votive candle on a four-inch-square piece of foil
- 1 book of matches
- 1 cup of water (for fire safety)
- 9 sheets of blank paper
- 2 pencils
- 2 paired two-inch pieces of Velcro
- 1 hand lens (magnifying glass)
- 9 sheets of blank paper
- 2 pencils
- 2 mirrors approximately four inches square (preferably Plexiglas) joined
- 1 protractor
- 1 penny
- 1 clean, empty, shiny food can—stripped of label—without lid (15 oz. to 28 oz.) NOTE: Be sure inside edges of can are smooth.
- 1 container of ice cubes (enough to fill the can, above)
- 8 paper towels
- 1 clear plastic cup (8–9 ounces) filled with water

- 8 strips of filter paper, approx. 1/2” x 3” (may be cut from coffee filters)



Use these tools to start classroom discussion and reflection on day’s activities

Detail outline of Day 3

Timeline	Activity
8:00 – 8:30	**Welcome / icebreaker**
8:30 – 11:30	**Inquiry-based lesson development** Teachers will working in groups to create inquiry-based lessons or modify current lessons to make them inquiry-based lessons
11:30 – 12:30	**Lunch**
12:30 – 2:30	**Model lessons** Teachers will present their created inquiry-based lessons to the class.
2:30 – 3:00	**Post-test**
3:00 – 3:30	**Reflection** What did we get from the session Three word summary

Teachers will bring in their lessons plans and modify them or create new lessons plans that are inquiry-based.

Have prticpants go to lunch after lessons are completed

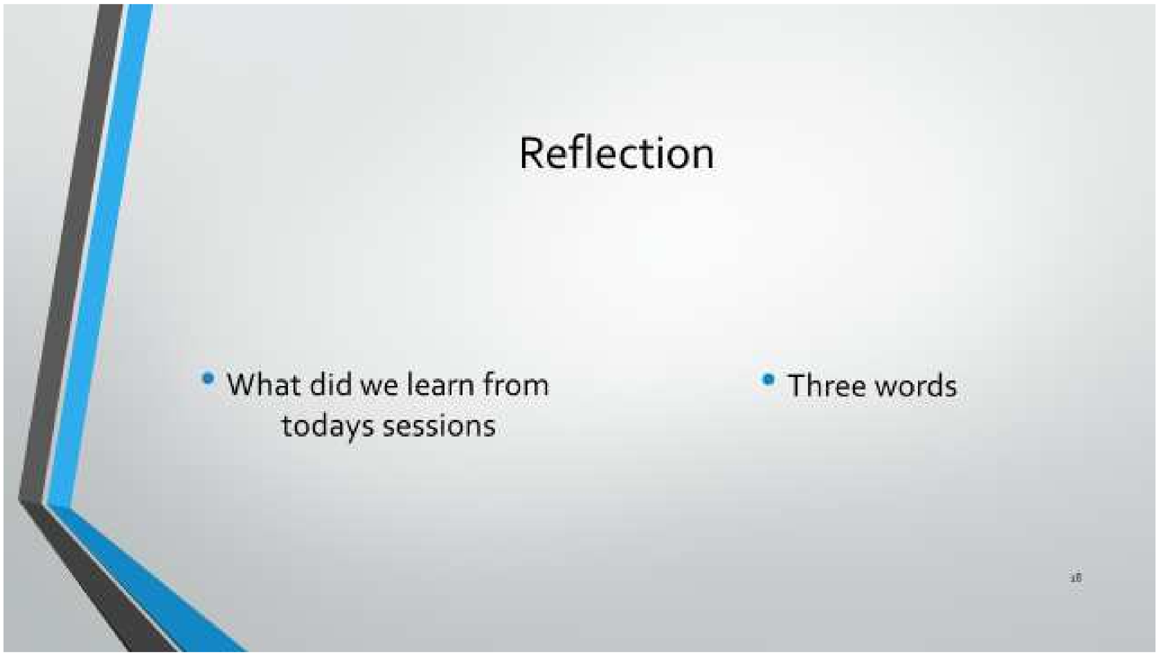
Activity 2 Day 3 Model lessons for Cohort

- Participants will model created lessons plans for the class.
- Participants will give feedback to help work through challenges of lessons

16

Post-test

17


Reflection
What did we learn from todays sessions
Three words

Appendix B: Interview Protocol

Interview protocol

Introduction and review of the consent form.
Clarification that the interview will be recorded.
Background information
Please tell me about your teaching background for teaching science?
Years of experience?
Professional development to teach inquiry?
Formal classes for teaching inquiry?
How often do you teach science?
For how long (describe the model time/days)

1. Tell me about your experiences with teaching inquiry. (RQ1)
2. Give some examples of how you typically implement inquiry-based instruction in your classroom? (RQ1)
3. Describe your confidence in teaching science. (RQ3)
4. Describe your confidence in integrating inquiry-based activities. (RQ3)
5. What typical pedagogical (instructional strategies) do you use in your classroom? (RQ1)
6. Describe the type of instructional strategies you choose? (RQ2)
7. What factors influence your selections of the instructional strategies used in your classroom? (RQ2)
8. We have addressed the questions I had, is there anything else you would like to add to our conversation?

Thank you for your time and insight. If you have any questions or comments, later on, you have the contact information on the consent form for follow up.

Appendix C: Observation Protocol

Teacher: ____________________ Course: ___________________

Class: _____________________ Date: _____________________

	Observed	**Not Observed**	**Not Applicable**
Science and Engineering Practice 1: Asking Questions and defining problems			
Science and Engineering Practice 2: Developing using models			
Science and Engineering Practice 3: Planning and Caring out investigations			
Science and Engineering Practice 4: Analyzing and interpreting data			
Science and Engineering Practice 5: Using mathematics and computational thinking			
Science and Engineering Practice 6: Constructing explanations and designing solutions			
Science and Engineering Practice 7: Engaging in argument from evidence			
Science and Engineering Practice 8: Obtaining, evaluating, communicating information			

Observation Summary:

Appendix D: Coding Examples

RQ 1 strategies to implement

Open Coding Example	Axial Codes	Subthemes	Themes
Participant 1(interview*)* *I love teaching science*. I*nquiry-based part is the best and that's the part students enjoy the most*, the *hands on instruction* being able to, *see the learning or do the learning themselves.* I may then actually do an activity where *they can explore, experiment*. Participant 5 (interview) The *abilities of my students really plays a major role in how I teach my class*. In the class that just ended *I have two young people that need help reading* too and there are a *few others*. Deborah, across the room, and the boy sits next to her I usually will go down and duck over there *and read to them as well*. And then there's Scott over here but usually Kenyan will read like, *they help the others*. You know, helping me. And a lot of times *Jordan will turn around and read to the other two*	Hands on instruction Group work Vocabulary practice Teacher read to student Student read to each other Teacher lecture	Inquiry based strategies Non-inquiry based strategies	Action teachers want students to do
Lesson Plan 2 The lesson plan teacher sets up lab stations. Each lab station is set up so that students in groups are able	Present problems Teacher models Teacher use SEP Teacher use 5 E's to develop lesson	Teachers delivery of instruction	Teacher actions in class

to explore concepts of kinetic and potential energy. Students engage in SEP to explore concepts. Participant 2 (interview) *I feel like Project Lead the Way helps me teach* gets the kids thinking they're doing more of the work. They're *answering the questions in their own way* and in their *own perspectives* based on what they observed in their *experiment* or *what they built*. I feel like the more I teach PLTW gets me out of my comfort zone with inquiry.	PLTW	PLTW	

RQ 2 Why teachers choose strategies

Open Coding Example	Axial Codes	Subthemes	Themes
Participant 4 (interview) I'm confident in my ability because I feel like as a teacher, I really try my best to engage them in a topic, whether it is Project Lead the way or science. So I wouldn't say I feel more confident in one or the other but I might be more comfortable with Project Lead the way because I just follow it, versus my own and how I want them to understand a standard.	Confident of teacher Comfortable with content PLTW set-up	Positive aspects of inquiry	Teacher confidence about teaching science
Participant 6 (interview) I think it's hard for me to watch them struggle. And I want to help give a push.	Not very confident	Factors that limit inquiry	

So I think maybe that's why I struggle with it a little bit more. It's not that I don't believe in it. It's just, it's not my comfort, comfortability with it. So, I don't typically plan that way, even though I know it's a great way to teach			
Participant 1 (interview) students enjoy the most, the hands on instruction being able to, you know, see the learning or do the learning themselves Participant 4 (interview) They need more help with vocabulary	Engage students Student learning Difficult content Student understand content Poor student vocabulary	Positive learning Challenges with learning	Student ability

RQ 3 Concerns for implanting inquiry instruction

Open Coding Example	Axial Codes	Subthemes	Themes
Participant 3 (interview) Well I feel like Project Lead the way is easy because it is kind of step by step. It has like everything you need. And the kits give you all the materials. So basically I feel comfortable with teaching inquiry activities. Participant 4 (interview) I would say the time it takes to do a lab because we have to, you know, if we don't finish a lab in a day, then I'm cutting out my math in the afternoon. It's just the time it would take to do the lab and	Materials for inquiry Time to teach in classroom Time to create lessons	Materials Time	Resources

finding it. I would say that is a struggle, I did find a photosynthesis lab where I could bring in plants and then, take out the soil and take sunlight. And you know, I would love to do that. But then the time it would take to document and chart the growth of a plant, you know. How can I do that?			
Participant 1 (interview) I say that I'm confident but there's always room for improvement. One thing that I want to work on is coming up with those higher level questions. Participant 5 (interview) Probably the training, I think if I had more of instruction myself on how to use the materials, and I think I would be better off because it feels like now I'm teaching myself. Project Lead the way I've been teaching the kids that's how I feel now.	Don't plan inquiry Ask in depth questions Help planning inquiry Help with PLTW	Planning inquiry based lessons PLTW PD	Professional Development