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Transforming Standards-Based Teaching: Embracing the Teaching and Learning of Science as Inquiry in Elementary Classrooms

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Abstract

The purpose of this research is to utilize a case study approach to demonstrate how to transform a 'hands-on' science unit into an inquiry-based learning experience. Specifically, the researchers will examine the results of the data analysis and identify the most useful techniques/strategies for developing inquiry-based science experiences in the elementary classroom. Evidence to support the use of inquiry-based teaching and learning to fulfill state and national standards will also be addressed. Finally, the researchers will use specific data from the research to provide concrete examples and suggestions for planning and implementing inquiry-based science experiences.

Keywords: Inquiry-based science instruction, science education, teacher education, planning and instruction

1. Introduction and Rationale

Inquiry-based teaching and learning has been a topic within science education reform. In fact, The National Science Education Standards (NSES) view scientific inquiry "as an integral component for restructuring science education" (Smolleck & Yoder, 2008, p. 291).

"This reform placed as much, if not more, emphasis on learning the processes of science as on mastering the subject matter of science alone" (National Research Council, 2000, p. 16) However, the visibility of science as inquiry in elementary classrooms is almost non-existent.

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One explanation or this can be explained by the current precedence elementary classrooms give to reading, language arts, and mathematics, leaving science and social studies as neglected areas of study. Science is taught about one fifth of the amount of time as reading and language arts (Fulp, 2002). Specifically, "grade K–5 self-contained classes spent an average of 25 minutes each day in science instruction, compared to 114 minutes on reading/language arts, 53 minutes in mathematics, and 23 minutes in social studies" (2002, p. 11).One driving force behind the lack of science teaching in elementary schools is the emphasis on standardized testing. Until very recently, science was not part of standardized testing practice. However, now that science has begun to be included in standardized testing, one can hope that there will be a resurgence in the presence of science in the elementary classroom.Although, the type of science experiences we will see is yet to be determined.

Although there are many ways through which science can be taught, it is important to note the effectiveness of inquiry-based instruction rather than traditional methods for all science teaching and learning. Science education reform suggests inquiry as a way to teach and learn science due to the fact that it adheres to the natural curiosities of learners (National Research Council 1996; National Research Council 2000).

Allowing students to be inquisitive within their learning provides experiences that are memorable as well as educational. This notion substantiates the idea that inquiry is not a process versus content debate, but rather allows the students to do and learn science simultaneously. Learning in such a way has numerous demonstrated benefits for student learning. Specifically, "greater emphasis on inquiry-based teaching is associated with higher science achievement overall" (Von Secker, 2002, p. 159). In addition, "inquiry-based instructional practices are associated with academic excellence, regardless of social context" (p. 158).

Based on the idea of Bandura's Social Learning Theory (1977), if science reform is to be successful for our elementary children, preservice teachers must feel confident in their abilities to teach science as inquiry. As such, the purpose of this study was to 1.) examine if or to what extent educational experiences may influence a change in participant self-efficacy in regard to the teaching of science as inquiry, and 2.)utilize a case study approach to demonstrate how to transform'hands-on' science unit into inquiry-based learning experiences for elementary school children.

Although the roles of teachers and students shift and may seem difficult when inquiry-based instruction is being utilized, the benefits of teaching science as inquiry far outweigh the momentary challenges that teachers may face. With practice, the skills to teach science as inquiry are attainable and advantageous. Within the context of this study, the researchers deliberately examined the results of the data analysis to identify the most useful techniques and strategies tohelp teachers to develop inquiry-based science experiences in the elementary classroom.

2. Framework

2.1 Inquiry

Inquiry is gaining much more attention as a goal for classroom teaching and learning as supported by the National Science Education Standards as well as State Academic Standards, however, it is not a new phenomena in science education. In fact, its roots can arguably be traced back to Dewey and Joseph Schwab. Schwab (1962) in particular supported inquiry-based teaching and described it as a method that "…operates through miscarriage and tends toward frustration. It does not itself have a guide or a set method for which to follow. It is engaged in invention, hence failures are among its normal expectation" (p. 17). From this definition alone, it is not surprising that many teachers shy away from the teaching and learning of science as inquiry.

More recently the National Research Council described inquiry as "…a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results" (2000, p. 23). This definition too does not seem simplistic, however at its core at the Essential Features of classroom Inquiry which make the task of teaching science as inquiry more attainable.

Regardless of the definition one uses, the teaching and learning of science as inquiry is recognized by both state and National Science Education Standards, thereby requiring teachers to plan inquiry-based experiences for the students in their classrooms.

For the purposes of this research the authors will use the Five Essential Features of Classroom Inquiry as described by the National Research Council (2000) as the foundation of the research. These essential features include:

1. “Learner engages in scientifically oriented question
2. Learner gives priority to evidence in responding to questions
3. Learner formulates explanations from evidence
4. Learner connects explanations to scientific knowledge
5. Learner communicates and justifies explanations” (p. 29).

As described by the NRC, these features run along a continuum moving from very teacher directed experiences to student directed experiences. For example, for the feature, “Learner engages in scientifically oriented questions”, the variations range in nature from “Learner poses a question” (student centered) to “Learner engages in questions provided by teacher, materials, or other sources” (p. 29).

2.2 Importance of Inquiry

Teaching science as inquiry is not a new phenomena. In fact, it has vast proven empirical findings associated with increased academic achievement. For example, inquiry teaching and learning can lead to higher academic achievement for students (Anderson, 1997; Freedman, 1997; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999). Instead of simply participating in traditional teaching where there is only a one-way transfer of learning (from teacher to student), students learning through inquiry experience validation in their own abilities as learners. Hence, teaching science through inquiry is more effective because children have the opportunity to generate their own questions and gather evidence through investigations in an attempt to uncover the answers to their questions. Due to this process whereby students are taking ownership and responsibility for their own learning, the content, processes and skills gained have more meaning and, as a result, longevity in relation to learning.

Children are innately inquisitive about the world around them therefore, allowing children to investigate their own questions instills a lasting love of learning. Inquiry gives students the ability to find answers, which gives them a sense of empowerment in their learning.

Teaching science through inquiry “exploits natural curiosity in children, so they maintain their motivation for learning not only during their school years, but through life” (National Research Council, 2000, p. xiii). In particular, through inquiry, students not only master content, but they also develop critical skills that they will use throughout their entire educational experience and beyond. Thorough understanding of inquiry strengthens every day skills such as solving problems creatively, thinking critically, and working cooperatively (National Research Council, 1996). Furthermore, the skills that students learn through inquiry are not restricted to the study of science. Students will be able to apply these skills to other academic subjects as well as their every day lives. Problem solving, critical thinking, and working cooperatively, are all skills necessary for future success, which will help students thrive both in and out of the classroom setting.

2.3 Self-Efficacy

One reason teachers may avoid the teaching of science as inquiry in the elementary classroom may be related to the self-efficacy of teachers. According to Bandura’s Learning Theory (1977), in order to feel confident teaching science as inquiry, one must first have had positive experiences learning science as inquiry. Bandura explains self-efficacy as having two constructs: personal self-efficacy and outcome expectancy (1977). Personal self-efficacy is defined as "a judgment of one's ability to organize and execute given types of performances" (Bandura, 1997, p. 21). Conversely, outcome expectancy relates to an individual's "...judgment of the likely consequences suchperformances will produce" (p. 21). These two dimensions work togetherto strongly influence behavior. Furthermore, self-efficacy has been proven to be malleable (Henson, 2001), and impacts“the choices individuals make and the courses of action they pursue” (Pajares, 1996, p. 544). Hence, reports of higher efficacy can lead to …“greater effort, persistence, and resilience” during challenging events (1996, p. 544).

Incorporating inquiry into one’s classroomcan often be seen as a matter of manipulating the order of activities.

Instead of introducing content, terms, definitions, etc. before exploration, it is essential for students to first explore, build curiosity and formulate questions based on observations.

Explanations can then begin to take place and the content, terms and definitions etc. can be linked to the explorations. In this way the understanding of scientific concepts and skills becomes more effective when students already have experience with the material and thereby have something by whichto relate their new learning.

Teaching through this process of science as inquiry places attention on children utilizing their prior knowledge to inform their investigations. To further substantiate this notion, the National Research Council (2000) states that "inquiry is intimately connected to scientific questions—students must inquire using what they already know and the inquiry process must add to their knowledge" (p. 13). "Students should work in the laboratory before being introduced to the formal explanation of scientific concepts and principles. Evidence should build to explanations and the refinement of explanations" (p. 15). This allows for a more organic approach to the material without the influence of the teacher. It is important for the teacher to provide opportunities for students to investigate, make observations and collect data as independently as possible. Of course, the teacher should be ever-present to guide and support students along their path of learning, as needed.

One way for teachers to provide these opportunities is through the use of the essential features of classroom inquiry (previously described) as well as the 5E Learning Model (Bybee, et al., 1989) within the planning and implementation of lessons and units. The 5E Learning Model consists of 5 phases of instruction "*engagement, exploration, explanation, elaboration, evaluation"* (Bybee, et al., 2006, p. 2). Each of these phases "…play a significant role in the curriculum development process as well as the enactment of curricular materials in science classrooms" (2006, p. 2). The goal of the engagement phase of the 5E Learning Model is to elicit prior knowledge, motivate students and engage student curiosity in a particular question. Exploration involves investigating questions through hands-on/minds-on methods. Explanation then follows where students attempt to answer their questions based on the observations during the exploration. They look for themes or patterns in their data and attempt to provide explanations to their questions. This is also animportant time for the teacher to introduce new vocabulary and content by linking it to the students understandings and shared experiences during the investigations.

Elaboration then follows where students reinforce their learning by applying their evidence and understandings to novel situations.

And finally, evaluation involves the students assessing their own understanding in light of the findings of other members of their learning community. Specifically, students listen to each others' findings and consider the evidence provided to determine which explanations best address the learning at hand (2006).

As a result of the proven significance and consequences of self-efficacy (Bandura 1977 1997), as well as the magnitudestate and national standards place on the teaching of science as inquiry, this study asserts toexamine if or to what extent educational experiences may influence a change in participant self-efficacy in regard to the teaching of science as inquiry. Additionally, the researchers utilize a case study approach to demonstrate how to transform 'hands-on' science unit into inquiry-based learning experiences for elementary school children.As such, within the context of this study, data was gathered to determine the extent to which the participant's personal self-efficacy and outcome expectancy changed over time as a result of educational experiences and impacted the methods chosen for teaching science to young children.

3. Methodology

Using a mixed method, case study approach, data were collected from one senior early childhood education major (Chelsea) during her senior year at a centralPennsylvania university. The student had completed her student teaching placement during the Fall 2013 in a second grade classroom. During the spring 2014, she was then enrolled in the "Science as Inquiry" course. This particular student completed the required coursework out of sequence because she was abroad during the time the course is typically offered("Science as Inquiry" is typically taken during the fall semester of the sophomore year).

3.1 Instrumentation and Design

Quantitative data was collected using the Teaching Science as Inquiry (TSI) Instrument. The TSI Instrument was developed "based on contemporary ideas about inquiry, as well as grounded in the fundamental ideas of Bandura, particularly the notion of self-efficacy being a context-specific construct" (Smolleck, Zembal-Saul, Yoder, 2006, p. 141).

It was administered to the participant using a pre/post test design during both the student's student teaching experience and during the Science as Inquiry course.

Qualitative data was also collected using the analysis of lesson and unit plans as well as interviews with the participant (Chelsea). The methods of choice for analyzing these data sources were grounded theory and text analysis (Denzin & Lincoln, 2000). Overall, the goal of using qualitative data analysis was to examine if or to what extent educational experiences may influence a change in participant self-efficacy in regard to the teaching of science as inquiry and .

3.2 Results: Teaching Science as Inquiry (TSI) Instrument Data

Examination of the pre-test quantitative data during the senioryear while the students was completing her student teaching revealed a mean self-efficacy score of 3.47and a mean outcome expectancy score of 3.57. Data analysis during the Science as Inquiry course indicated a pre-test mean self-efficacy score of 4.35 and a post self-efficacy score of 4.97. Result for outcome expectancy from the pre-test indicated a mean self-efficacy score of 4.40and a mean outcome expectancy score from the post-test of 4.63. (theoretical score range for both the pretest and the post-test was 1 through 5). This data is significant in that it indicates that the participant's TSI scores increased from pre-test to post-test, thereby demonstrating an increase in preservice teachers self-efficacy over the course of her experiences with the teaching of science as inquiry.

3.3 Results: Text analysis and Interviews associated with the Light and Shadow Unit Completed During Student Teaching (before the Science as Inquiry course)

Chelsea began her unit on light and shadow with a "KWL" chart. "Before learning more about inquiry-based instruction, this was the best way I knew how to assess prior knowledge at the start of a unit" (C. Parker, personal communication, December 4, 2013). Chelsea then read a fiction story, *Bear Shadow* by Frank Asch, aloud to the class. She wanted to "…integrate reading into the unit whenever possible because reading aloud is both beneficial and enjoyable for 2nd grade students" (C. Parker, personal communication, December 4, 2013). The next read aloud, *Light and Dark* by Angela Royston was a nonfiction book with difficult vocabulary. This was Chelsea's attempt at "…introducing vocabulary terms relevant to the science material" (C. Parker, personal communication, December 4, 2013).

However, since the students had no prior experience with which to relate the vocabulary, "…the students struggled"(C. Parker, personal communication, December 4, 2013). "The students found it difficult to understand the definitions by just having them read aloud to them"(C. Parker, personal communication, December 4, 2013).

On the second day of the unit, Chelsea began the science lesson with a poem "…in order to expose the students to a wide variety of literaturegenres" (C. Parker, personal communication, December 4, 2013). She read, *My Shadow*, by Robert Louis Stevenson, "which the children enjoyed" (C. Parker, personal communication, December 4, 2013). Next, they read *Guess Whose Shadow* by Steven R. Swinburne, an interactive story that demonstrates how shadows can come in varying shapes and sizes. After the read aloud, Chelsea performed a short story to the class using handmade shadow puppets and a projector against a white wall. "The class appreciated the humor of the story and was excited to perform stories of their own"(C. Parker, personal communication, December 4, 2013). Students worked in groups of two or three to write a script for a short performance and create shadow puppets for the show. Chelsea was pleased with how well the students "…worked together and how creative their stories were"(C. Parker, personal communication, December 4, 2013)."The performances were humorous and well thought out and the students were very proud of their work"(C. Parker, personal communication, December 4, 2013).It is important to note that although Chelsea was proud of her unit, at this point it is more reflective of literacy instruction as opposed to science instruction.

The next day, the class revisited the "KWL" chart "so that they could add what they had learned thus far throughout the unit"(C. Parker, personal communication, February 11, 2014). Then Chelsea informed the class that they would be venturing outside to investigate shadows further. She prefaced the field trip with a class "brainstorm" in which they predicted what sort of shadows they would see outside and how they could manipulate their shadows by moving their bodies. "The children enjoyed the field trip outside, made observations, and collected data"(C. Parker, personal communication, February 11, 2014). However, the way Chelsea prefaced the outdoor activity stifled the potential for inquiry. If students had gone outside before brainstorming, they would have been able to come up with their own questions without the influence of the teacher.

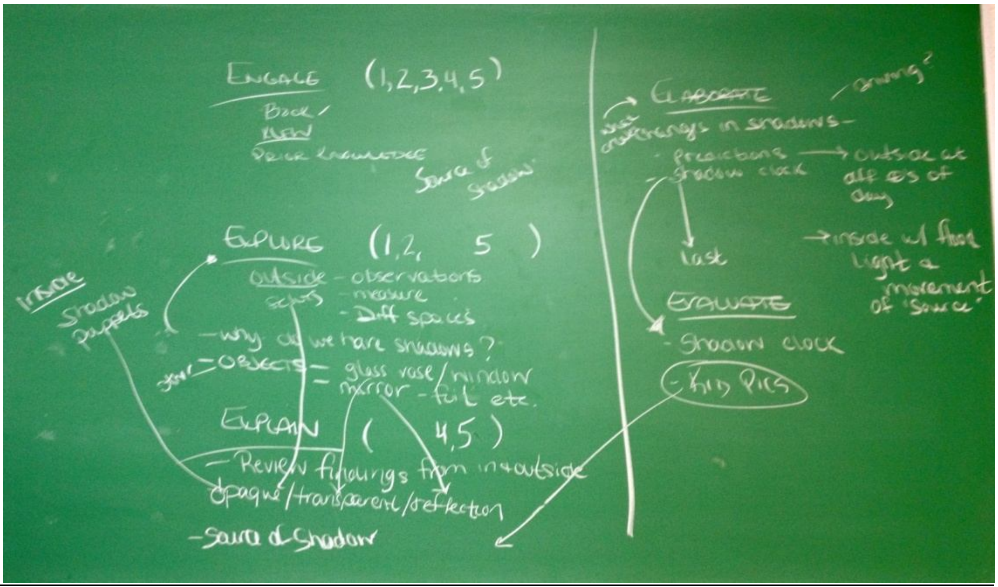
Chelsea could have asked probing questions while outside, instead of telling them what they should expect to see outside, i.e. allow the students to uncover their own ideas and learning associated with light and shadow.

The fourth day of the unit consisted of an activity with shadow clocks. Chelsea demonstrated how to use a shadow clock and explained how the students could use the shadow clock to better understand how shadows move throughout the day. Students used a template and explicit teacher instruction to create their own shadow clocks, which consisted of simply cutting and pasting pieces of paper together. Afterwards, Chelsea allowed time for experimentation with the clocks before answering a series of questions as a class using the shadow clocks. In retrospect, Chelsea believes this activity "could have been much more meaningful without the templates, which seemed like 'busy work' after learning more about the teaching and learning of science through inquiry"(C. Parker, personal communication, February 11, 2014).

On the last day of the unit, the class returned to the "KWL" chart one final time. Chelsea had students write down two things that they learned about light and shadow. Students then attached their writing to the "L" section of the chart, which represented what the class learned from the unit. Afterwards, the students created an illustration on "Kid Pix" (a computer-based illustrative tool created by Encore Software) using individual laptops. The guidelines for the illustration were that the illustrations had to contain a light source, an object of their choice, and the shadow that the object would create. This was the assessment for the unit, which Chelsea now believes "was not a valid or authentic assessment of all the students had learned about light and shadow" (C. Parker, personal communication, April 8, 2014).

"Although it was useful for assessing the students' knowledge of light sources and shadows, it was not the culminating activity that Chelsea had hoped for"(C. Parker, personal communication, April 8, 2014).

While taking the Science as Inquiry course and after having a great deal of exposure to inquiry-based teaching and learning. Chelsea revised her unit to make it more inquiry oriented. The following picture is a 'snap shot' of the process and beginning results of these efforts, which took place on March 21, 2014.



3.4 Results: Text analysis and Interviews associated with the Light and Shadow Unit Completed During Student Teaching (after the Science as Inquiry Course)

To revise her unit to represent inquiry-based teaching and learning, Chelsea used the 5E Learning Model(Bybee, et al., 1989)and the Essential Features of Classroom Inquiry (National Research Council, 2000). Beginning with the *Engagement* section, she replaced the “KWL” chart with a “KLEW” chart, which would allow students to make evidence-based explanations. Chelsea also wanted to “…incorporate the same books and poems into the revised unit because she previously found them to be very beneficial”(C. Parker, personal communication, March 21, 2014).However, to render the readings more effective, Chelsea “…moved them into more appropriate locations within the unit”(C. Parker, personal communication, April 8, 2014).

The lesson began with Chelsea reading *Bear Shadow* by Frank Asch, and *My Shadow* by Robert Louis Stevenson. Chelsea’s decision was influenced by her belief that “the fiction story and poem would be an effective way to introduce the class to light and shadow”(C. Parker, personal communication, April 8, 2014). Next, Chelsea guided the students through a discussion about the source of shadows, which further revealed prior knowledge and misconceptions.

For the *Exploration* portion of the unit, Chelsea took the class outside to experiment with shadows. “The students were encouraged to make observations and measurements using different instruments and objects from the classroom”(C. Parker, personal communication, April 8, 2014).Next, the class returned to the room to begin their performances using hand made shadow puppets. The performance of the students’ short stories allowed them to “investigate, through performance art and discussion, why shadows exist and why certain objects have shadows and others do not”(C. Parker, personal communication, April 8, 2014).(*Note how the instructor changed the order of these learning activities to represent a more student-centered approach to learning*).

The *Explanation* section involved an in-depth discussion about class findings from the field trip outside. BecauseChelsea discovered collaboration as an essential aspect of inquiry-based teaching and learning, “…students had the opportunity to share observations and data with one another”(C. Parker, personal communication, March 21, 2014). The nonfiction book, *Light and Dark* by Angela Royston, wasalso included here, which was appropriate because “students had first hand experiences with light and shadows at this point in the unit and thereby better understand the vocabulary presented in the text”(C. Parker, personal communication, April 8, 2014). The book has advanced vocabulary, but the students were able to relate the terms to their observations and data from the previous day. This led to a class discussion where students connected their findings and ideas to the key vocabulary, leading to sophisticated understanding of scientific concepts and ideas. This was also an appropriate time to revisit the “KLEW” chart “to add evidence and see what new questions may have been raised due to exploration and the development of new understandings”(C. Parker, personal communication, April 8, 2014). To conclude this portion of the unit, students used the laptops to make a “Kid Pix” illustration containing a light source, object of their choice, and the shadow that the object created.

“Moving this learning activity to the *Explain* section allowed the teacher to assess the students’ knowledge of light source and shadows earlier on”(C. Parker, personal communication, April 8, 2014), allowing Chelsea to address the existence of misconceptions in a timelier manner rather than later in the unit. The *Elaboration* portion began with the text *Guess Whose Shadow* by Steven R. Swinburne “…so that students could use their knowledge from the past few days to assist them with the interactive element of the book” (C. Parker, personal communication, April 8, 2014).

The class revisited the "KLEW" chart at this time and formulated any further questions that the class would like to explore. Chelsea found that "revisiting the "KLEW" chart multiple times throughout the unit was an effective way for students to synthesize their thoughts, acknowledge the progress they have made, incorporate evidence into their explanations, and explore new questions"(C. Parker, personal communication, April 8, 2014). The class took multiple field trips outside, in different types of weather, at different locations, and during different times of day in order to investigate varying factors that impact shadows. In addition to the outdoor field trips, Chelsea created an indoor shadow simulation using a floodlight against a white wall. Students were then able to manipulate the light source and immediately witness the impact that the change had on the shadow, "…which helped students better understand the relationship between light and shadow"(C. Parker, personal communication, March 21, 2014).

To conclude the unit, Chelsea guided the class in a discussion of the characteristics of shadows for the *Evaluation* section. Chelsea and the class discussed ideas associate with"what makes shadows longer, shorter, darker, and lighter"(C. Parker, personal communication, April 8, 2014). At this time, Chelsea introduced the culminating activity, which was to create shadow clocks. In order to produce a more authentic and meaningful assessment, students were*not* provided with a template. Instead, "there was collaboration between students where they brainstormed ideas for how to create a shadow clock on their own"(C. Parker, personal communication, April 8, 2014). Chelsea reminded the students of the floodlight simulation, "…which likely inspired student ideas for their projects"(C. Parker, personal communication, April 8, 2014). Students worked in groups of two or three to create their own shadow clocks. Once students were done, they used their creations to answer a series of questions about how shadows move throughout the day and how weather may impact the shadows being created.

4. Discussion

This research allowed the authors to critically examine the impact of self-efficacy was well as the ways in which a science unit on light and shadows could be adapted to include the teaching and learning of science as inquiry.

First, in regard to self-efficacy, it is clear from the data that positive experiences with teaching science as inquiry can lead to increased personal self-efficacy and outcome expectancy levels. As such with these increases in self-efficacy, one can expect that individuals will feel more efficacious in developing or revising units to reflect the teaching of science as inquiry.

As previously stated, the most useful means by which this transition can take place is by using the Essential Features of Classroom Inquiry (National Research Council, 2000) and the 5E Learning Model (Bybee, et al., 1989).“The blending of the Essential Features of Classroom Inquiry and the 5E Learning Model were the two most significantly useful ways…” (C. Parker, personal communication, April 8, 2014) by which the participant “inquirized” (Everett & Moyer, 2007, p. 54).“Each provided a framework from which to work, making it less challenging to recreate a unit”(C. Parker, personal communication, April 8, 2014) that had already been taught and conceptualized from the participant’s perspective. Although Chelsea’s original unit included many hands-on learning activities, she came to realize that “although the children were busy, they weren’t necessarily participating in inquiry-based learning” (C. Parker, personal communication, March 21, 2014). As Huber and Moore note, “hands-on does not guarantee inquiry” (2001, p. 9).

Because inquiry is a constructivist approach, it is important to not be afraid to make mistakes. The teacher and students must “value the search for understanding and acknowledge that mistakes are a necessary ingredient if learning is to occur” (National Research Council, 2000, p. 122). When children see that “the instructor is not afraid to be wrong, they are more likely to take risks and have more meaningful learning experiences”(C. Parker, personal communication, March 21, 2014). Teachers take on new roles when teaching science as inquiry. Instead of teachers being the only source of information, students take on more participatory roles in their learning. “As they develop their abilities to question, reason, and think critically about scientific phenomena, they take increasing control of their own learning…

Without this, school learning becomes a transitory experience with little application to future thought and action” (National Research Council, 2000, p. 120-121). Together, teachers and students are both expanding their knowledge of science and practicing the habits of lifelong learners.

“Teachers must assume a new role in which they are no longer the dispenser of all knowledge in the classroom, but are also active learners along with their students, guiding and supporting the learning environment” (Everett, 2001, p. 23).

“Research indicates that learners benefit from opportunities to articulate their ideas to others, challenge each others’ ideas, and, in doing so, reconstruct their ideas” (as cited in National Research Council, 2000, p. 119). Collaboration is crucial for inquiry-based teaching and learning. Similar to the ways in which scientists conduct their work, learners benefit from the ability to converse with their peers to exchange ideas and learn from one another. “Based on the idea of Bandura’s social learning theory (1977), if science education reform is to be successful for our elementary children, preservice teachers must feel confident in their abilities to teach science as inquiry” (Smolleck & Mongan, 2011,p. 141.).The data collected during this case study proved to be quite useful and encouraging, for both preservice and inservice teachers. In particular, the results may beinspiring for inservice teachers who may have been teaching for many years, without the opportunity to *learn* science as inquiry and are therefore reluctant to *teach* science as inquiry in their science classrooms.

5. Conclusions

5.1 Research, Policy and Practice

Given the data gathered from this research there are many implications that should be addressed. First,in relation to research, it would be advantageous to conduct research that investigates the impact of the relationship between inquiry teaching and learning and student outcomes. Although there is a vast body of research to support the notion that inquiry-based teaching leads to higher academic achievement (Anderson, 1997; Freedman, 1997; Uno, 1990; Von Secker, 2002; Von Secker & Lissitz, 1999), investigating the extent to which students’ achievement may differ with new versionsof inquiry-based units would be useful. If science education reform is to be successful, we must have the data to validate this success.

Additionally, because this research represented a case study approach, similar research studies that involve larger numbers of pre-service and/or inservice teachers would also be beneficial. Including observations of classroom teaching as well as interviews to determine teacher professional growth would certainly add to the findings.

This type of research would also provide further information about how teacher beliefs may transfer into practice and impact the teaching and learning experience provided within a classroom.

Because there is substantial research to indicate that “perceived self-efficacy influences choice of behavior settings,” research concerning beliefs would be quite advantageous in determining and understanding the instructional decisions teachers make (Bandura, 1977, p. 193). Furthermore, because self-efficacy can be changed as a result of experience (Henson, 2001), it is also important to consider including entirely inquiry-based courses for both preservice and inservice teachers. As such, the level of comfort necessary to teach science as inquiry would be greatly improved because the teachers would have had positive experiences to learn science as inquiry (Bandura, 1977).

Next, in relation tothe implications on policy and practice, professional development in the area of inquiry-based science teaching for inservice teachers is a necessity, as are additional resources and support for such reform-based teaching. Furthermore, because science is only taught one fifth of the time as compared to reading/language arts and mathematics (Fulp, 2002), increased time for science in elementary classrooms is also something that must be amended. Universities and Colleges can also contribute to the policy and practice implications by requiring more coursework in science education. At most institutions only one or two lab sciences is required for early childhood and elementary education majors. This lack of exposure to science as a learner can potentially lead to feelings of anxiety, incompetence, or reluctance when it comes to the teaching of science in their future careers.

This research was done on a small population using a case study approach, and as a result, itmay be difficult to generalize the findings. However the results of the interventions were highly positive and indicate that personal self-efficacy and outcome expectancy in relation to the teaching of science as inquiry is malleable and can be improved as a result of positive exposure to the teaching and learning of science as inquiry while a student.

Overall, the data collected during this case study proved to be quite useful and encouraging, for preservice teachers, as well as for inservice teachers who may have been teaching for many years, without the opportunity to *learn* science as inquiry and are therefore reluctant to *teach* science as inquiry in their science classrooms.

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6 Appendix A

6.1 Interview Questions for Unit 1

1. In what ways was your unit developed for your student teaching experience?
2. What considerations did you contemplate while designing instruction?
3. What were your goals for teaching this particular unit?
4. How do you know that the goals were or were not reached by the students?
5. What went well when teaching your unit?
6. What could have gone better?
7. What modifications would you make were you to teach your unit again in the future?

6.2 Interview Questions for Unit 2 (Inquiry-Based Unit)

1. In what ways was your unit developed in light of your learning of the teaching of science as inquiry?
2. What considerations did you contemplate while designing instruction?
3. What were your goals for teaching this particular unit?
4. How did your prior goals change or shift as a result of your learning of the teaching of science as inquiry?
5. How do you know that the goals were or were not reached by the students?
6. How did you incorporate the 5E Model?
7. Did the 5E Model assist you in your planning? If so, in what ways?
8. In what ways did you incorporate the essential features of classroom inquiry?
9. Did the essential features of classroom inquiry add depth or breadth to your unit in any way? If so, how?

10. In what ways was the evidence of student learning different from your first unit?
11. What went well when teaching your unit?
12. What could have gone better?
13. What modifications would you make were you to teach your unit again in the future?
14. What are your overall thoughts and feelings associated with the teaching of science as inquiry?

7 Appendix B

7.1 Participant Characteristics

Number of participants: 1
Age of participant: 1
Academic Year: Senior

7.2 Descriptions of Interviews

Interview 1, December 4, 2014
White female, 21
Wearing brown wool sweater with jeans

Interview 2, February 11, 2014
White female, 21
Wearing long-sleeved black tee shirt layered with teal tee shirt and jeans

Interview 3, March 21, 2014
White female, 21
Wearing black lightweight sweater with tan pants

Interview 4, April 8, 2014
White female, 21
Wearing long-sleeved,V-neck pink shirt with jeans