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Comparing Time Allocation for Teaching Science as Inquiry in Two Educator Preparation Science Methods Courses

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Abstract

How much time an institution allocates to content can indicate its overall importance and intended value to the educator preparation program. For decades there have been calls to integrate more authentic science inquiry experiences into not only undergraduate elementary science courses, but into all elementary educator preparation courses. Many elementary educators do not receive training on effective methods for teaching science, they will not feel comfortable and will likely have low self-efficacy. This study investigated the amount of time allocated to teaching science as inquiry and the knowledge participants had prior to and after taking an elementary teaching science methods course. The critical incidents within two science methods courses that assisted participants in developing a deeper understanding of teaching science as inquiry were also analyzed. Over three academic semesters, a purposive sample of 58 college pre-service teacher candidate participants from the mid-Atlantic region of the United States were surveyed to answer the research question to what extent, if any, does time allocation have on teacher candidates' understanding of teaching science as inquiry? Results suggest it would be of great benefit for educator preparation programs to require a science teaching methods course, with an emphasis on the teaching of science as inquiry. Participants indicated the most useful critical incidents were labs, more assignments that require lesson/unit planning, and teaching lessons to elementary students.

Keywords

Science Education, Inquiry, Elementary Education, Allocated Time

1. Introduction

Elementary school students regularly and naturally interact with their environment, ask questions and try to answer them (National Research Council, 2000). Scientific inquiry has always played a significant part in high quality science teaching and learning. The Next Generation Science Standards (NGSS) have recently "refined, redefined, and interwoven" the concept of inquiry within the new three-dimensional learning framework for science (Surr et al., 2016: p. 1). For decades there have been calls to integrate more authentic science inquiry experiences into not only undergraduate elementary science courses, but into all elementary educator preparation courses (Crawford, 2014; Herranen et al., 2019; Kazempour, 2018, Kite et al., 2021; Tamir, 1983; Minstrell & van Zee, 2000; Welch et al., 1981). Teaching science as inquiry has yet to become an integral part of the traditional elementary educator preparation curriculum for a variety of reasons such as the lack of resources, lack of understanding and training, and program deficiencies (Herranen et al., 2019). Many elementary educators do not receive training on effective methods for teaching science, they will not feel comfortable and will likely have low self-efficacy. The self-efficacy beliefs of both teacher candidates and elementary students have become a common construct of interest within educational research. This interest in self-efficacy is a result of the causal relationship existing between beliefs and practice. Specifically, the actions and or practices of teachers are linked to their beliefs about their own abilities in relation to teaching science. The purpose of this study was to investigate the impact of allocated instructional time on pre-service teacher candidate participants' understanding of teaching science as inquiry in the elementary setting. Additionally, the critical incidents within two science methods courses that influenced the participants' knowledge of teaching science as inquiry are reported.

2. Literature Review

2.1. Science as Inquiry in Schools

In 1996, the National Research Council (NRC, 1996) developed the first iteration of the *National Science Education Standards* (NSES). Four years later in 2000, an addendum was published called *Inquiry and the National Science Education Standards* which outlined the inquiry in the teaching and learning environment. The term inquiry in science has had many definitions over the years such as set of steps and procedures, hands-on and minds-on approach and the five essential features of classroom inquiry, which has led to some confusion in the field and within teaching and learning (Asay & Orgill, 2010; Barrow, 2006; Capps & Crawford, 2012; NRC, 1996, 2012; Settlage, 2003; Surr et al., 2016; Young, 2013). In fact, the term inquiry was first coined by Schwab in 1962, but was spelled *enquiry*. Although inquiry can come in many forms and definitions, for the purposes of this research, the original NRC (2000) definition of inquiry is used "Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (p. 23). Additionally, the NRC's (2000) five essential features of classroom inquiry were utilized, "Learner engages in scientifically oriented questions, Learner gives priority to evidence in responding to questions, Learner formulates explanation from evidence, Learner connects explanations to scientific knowledge. Learner communicates and justifies explanations" (p. 29). In 2012, the NRC released the Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas which rarely mentioned the words scientific inquiry. Yet these foundational concepts of inquiry have been recently "refined, redefined, and interwoven" into the NGSS three-dimensional learning model of science instruction which includes disciplinary ideas, crosscutting concepts, and science and engineering practices (Surr et al., 2016: p. 7).

Elementary students need to have opportunities to engage in scientific inquiry (Surr et al., 2016). There is agreement among science educators that inquiry is essential to scientific practices and not be taught in isolation but rather "interwoven with science learning across all core science subjects and for all crosscutting concepts" (Surr et al., 2016: p. 12). None of these features are new to science education, given they have long been utilized within science instruction.

Inquiry is clearly listed within each participating institution's state standards. Within the State Academic Standards from Institution A inquiry is defined as "an intellectual process of logic that includes verification of answers to questions about and explanations for natural objects, events and phenomena" (Academic Standards for Science and Technology, 2002: p. 4). Furthermore, the standards state that all "Public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to recognize and use the elements of scientific inquiry to solve problems. Generate questions about objects, organisms and events that can be answered through scientific investigations. Design an investigation. Conduct an experiment. State a conclusion that is consistent with the information" (State Standards, 2002: p. 11).

Within the state academic standards from Institution B (State Standards, 2018), the term "investigate" refers to "scientific methodology and implies systematic use of the following inquiry skills to ask questions and define problems, plan, and carry out investigations, interpret, analyze, and evaluate data, construct and critique conclusions and explanations, develop, and use models, obtain, evaluate, and communicate information". However, it is important to recognize that future teachers of primary science may have preconceptions stemming from a teacher-centered rather than a student-centered orientation (Pilitsis & Duncan 2012; Soysal & Radmard, 2017; Yesilyurt, 2022), where science teaching may, in contrast, be conceptualized as the direct transmission of science (Friedrichsen et al., 2010). In such student-centered teaching, children have an active role, and the teaching facilitates learning through diverse means, including activity-driven, discovery, project-based science, or inquiry approaches (Friedrichsen et al., 2010).

Current trends in contemporary science education reform recommend science as inquiry to be interwoven into curriculum but unfortunately inquiry has not yet become a consistent feature of science classroom practice (Kite et al., 2021; Weiss, 2001; Wells, 1995). In order for inquiry to be interwoven into the three dimensional learning framework of learning, teacher candidates need to understand the foundational constructs of teaching science as inquiry.

2.2. Educator Preparation Programs Science Methods Courses

The National Science Education Standards (NSES) and Next Generation Science Standards (NGSS) have emphasized the critical need for teachers to implement more authentic science teaching and learning opportunities. However, elementary teachers have recorded feeling uncomfortable and underprepared for teaching science for decades (Madden et al., 2016; McDevitt et al., 1993; Tobin et al., 1990). Teachers may not be getting the science instructional training necessary in their educator preparation programs to prepare them for the needs of teaching science classroom (Patrick, 2017; Southerland, 2016).

If science reform is going to be successful and our elementary children are to be provided with effective science instruction, teacher candidates must first be provided with opportunities to experience success as *learners* of science (Riggs, 1988; Enochs & Riggs, 1990; Higdon & Sawyer, 2018, Kazempour, 2018; Kite et al., 2021). Teacher candidates need first-hand experiences on how teaching and learning science as inquiry takes place within an elementary school setting.

The level of experience a teacher has with a content area can impact their self-efficacy. A teachers' self-efficacy influences their implementation of inquiry-based instruction (Kafyulilo et al., 2016; Rachmatullah et al., 2023; Wallace & Kang, 2004). Elementary teacher candidates tend to have lower self-efficacy in the area of science than other disciplines and grade levels (Maeng et al., 2020; Rachmatullah et al., 2023). A perception of low self-efficacy in teaching science may provide a rationale for why elementary teachers tend to rarely implement inquiry-based learning (Rachmatullah et al., 2023). Providing high quality inquiry based instructional opportunities in educator preparation programs can provide teacher candidates with more experiences to increase elementary science teachers self-efficacy.

Preparing pre-service teacher candidates to plan, teach, and evaluate their practice of inquiry-based instruction presents several difficulties for educator preparation programs including lack of science experience, low self-efficacy, and misperceptions of inquiry (Higdon & Sawyer, 2018; Maeng et al., 2020; McCullagh & Doherty, 2021; Rachmatullah et al., 2023). Teacher candidates must gain a foundational understanding of teaching science as inquiry in their educator preparation program if we are to expect them to teach science as inquiry in their own classrooms after graduation (Kazempour, 2018). Despite these difficulties, the value of educator preparation programs allocating time to teaching science as inquiry is relevant and helps develop pre-service teacher candidates' science and critical thinking skills (McCullagh & Doherty, 2021).

2.3. Theoretical Framework

Self-efficacy is a powerful construct that is said to have strong predictive power over performance and behavior. In fact, Bandura (1977, 1986) asserts that self-efficacy beliefs play a critical role in human agency. How people behave can often be more accurately predicted by their self-efficacy beliefs rather than what they are capable of accomplishing (Bandura, 1977, 1986). Specifically, "higher levels of perceived self-efficacy correlate to greater levels of performance accomplishments" (Bandura, 1982: p. 127-128).

Efficacy beliefs also have an impact on the amount of effort, persistence, and resilience an individual will expand when engaging in an activity. "The stronger the perceived efficacy, the more likely people are to persist in their efforts until they succeed" (Bandura, 1982: p. 127-128). According to Bandura (1995), "People with high assurance in their capabilities in given domains approach difficult tasks as challenges to be mastered rather than as threats to be avoided. People who have low senses of efficacy in given domains shy away from difficult tasks, which they view as personal threats. They have low aspirations and weak commitment to the goals they choose to pursue" (p. 11). They slacken their efforts and give up quickly in the face of adversity and difficulty. In short, higher self-efficacy results in more effort, persistence, and resilience.

3. Methodology

The purpose of this study was to investigate the impact of allocated instructional time on pre-service teacher candidate participants' understanding of teaching science as inquiry in the elementary setting. The critical incidents within two science methods courses that influenced participant knowledge of teaching science as inquiry are reported. This research sought to answer the following research question:

1) To what extent, if any, does time allocation have on teacher candidates' understanding of teaching science as inquiry?

3.1. Data Collection Site

Data were collected from 58 elementary pre-service teacher candidates using a case study approach (Stake, 2008). Specifically, data was assessed at two Mid-Atlantic Liberal Arts institutions within accredited educator preparation programs over three fall semesters. All participants within the study were enrolled in an elementary methods course during the time of data collection and have been accepted into the institution's educator preparation program. Institution A's elementary science methods course is focused entirely on teaching science as inquiry for a full semester. The course catalog description for the elementary science methods course from Institution A states, "This course reflects best practices for the teaching of science as inquiry outlined by the National Science Education Standards and Institution A's state standards. This fifteen week course provides instructional methods and curricular materials appropriate for teaching science concepts, processes, and skills to young children." Participants enrolled in the fifteen week science methods course at Institution A experienced nine inquiry labs using the 5E learning model and the five essential features of classroom inquiry during class time on campus. This course also includes a science focused 20 hr field placement where students had the opportunity to teach one inquiry unit on the phases of the moon in a local elementary school. The unit was collaboratively constructed by all students enrolled in the class and they taught the unit to seven different first grade classrooms. The total number of participants enrolled in the course at Institution A was 28. The researcher at Institution B used teaching science as inquiry as a five-session mini unit within a general elementary curriculum methods course. The course catalog description for the general elementary methods course from Institution B states, "instructional practice in the elementary classroom. Strategies for effective teaching of content based on state academic standards from Institution B (Prekindergarten through 6th grade) with particular emphasis given to science and social studies. Significant emphasis will be placed on curriculum content, lesson planning, research-based instructional strategies, and assessment." Participants enrolled in the methods course at Institution B experienced 3 inquiry labs using the 5E learning model and the five essential features of classroom inquiry. This fifteen week course also includes a general focused 20 hr field placement. Students taught zero inquiry lessons. The total number of participants enrolled in the course at Institution B was 30. Overall, 58 of the 58 (100%) students enrolled at the two institutions consented to be a participant in this study completing the pre-assessment and post-assessment evaluating their understanding of science as inquiry.

3.2. Design and Data Collection

The Teaching Science as Inquiry Reflection Assessment was designed by Smolleck & Yoder (2008) and administered at both institutions to evaluate the extent to which teacher candidates understood the concepts of teaching science as inquiry. A consent form was given to all participants at the time the reflection was administered. Instructions on how to complete the instrument and the purpose of the study were provided verbally by the researchers before the administration of the reflection at both the time of pre-assessment and post-assessment. All subjects received the same instructions in their respective university classroom settings. The aim of the study was to compare the impact of allocated time on elementary teacher candidates' understanding of teaching science as inquiry.

To develop this understanding, participants responded to three open-ended questions at the beginning of the semester (1) What does it mean to teach science as inquiry? 2) What are the 5 essential features of classroom inquiry? 3) What is the value of teaching science lessons with inquiry?) as a pre-assessment and five open-ended questions at the end of the semester as a post-assessment (1) What does it mean to teach science as inquiry? 2) What are the 5 essential features of classroom inquiry? 3) What is the value of teaching science lessons with inquiry? 4) What components of the course were most useful for your understanding of teaching science as inquiry? 5) What additional experiences would have been useful for you in cultivating a better understanding of teaching science as inquiry?). The questions highlighted participants' experiences throughout the methods course related to inquiry labs, 5E learning model and the five essential features of inquiry.

The Teaching Science as Inquiry Reflection Assessment was used at both institutions to evaluate the extent to which teacher candidates understood the concepts of teaching science as inquiry. With the key difference being allocated time spent on science inquiry, the participants' responses from the reflection instrument from Institution A and Institution B were compared to identify the differences in understanding science as inquiry. Grounded theory and text analysis were implemented to examine the extent to which time allocated for teaching science as inquiry impacted teaching behaviors and practices of pre-service teacher candidates.

3.3. Data Analysis

Participants responded to open-ended questions on the Teaching Science as Inquiry Reflection Assessment. Open-ended questions were analyzed by researchers using a thematic approach to identify participant understanding of science as inquiry. Grounded theory and text analysis were implemented to examine the data. The content analysis involved researchers reading through the open-ended questions and noting any potential emergent themes as understanding science as inquiry. The researchers reviewed the potential themes and discussed redundancies and inconsistencies to formulate the responses for each question. Using these themes, the researchers coded the responses for each question for their prospective institutions. Data analysis from pre-assessment to post-assessment indicates teacher candidates who had the opportunity to focus an entire semester on teaching science as inquiry had stronger understandings and philosophical viewpoints regarding the teaching of science as inquiry.

4. Results

This study sought to compare the impact of allocated time on elementary teacher candidates' understanding of the concepts of teaching science as inquiry. Participants completed the Teaching Science as Inquiry Reflection Assessment as a pre-assessment prior to the methods course and as a post-assessment after the methods course. Due to the open-ended nature of the assessment, participants had to complete the assessment with no support such as a text book, notes and articles, thus identifying their true initial understanding of the content. The questions on the Teaching Science as Inquiry Reflection Assessment are presented in **Table 1**.

To answer the research question, the five assessment questions were analyzed by themes. First, as reported by teacher candidate participants on question 1, what does it mean to teach science as inquiry? **Table 2** provides the representative responses from pre and post assessment question one.

These responses indicate participants who spent more time focused on teaching science inquiry demonstrated greater gains in their understanding of what it means to teach science as inquiry. The highest gains can be found in the responses related to student-centeredness and investigating questions. In every category, Institution A gained more understanding of what it means to teach science as inquiry than Institution B.

The second question on the Teaching Science as Inquiry Reflection Assessment focused on the identification of the five essential features of inquiry, which are the foundation to inquiry-based instruction, and it is critical teachers understand these features in order to teach science as inquiry (NRC, 2000). **Table 3** provides the representative responses from pre and post assessment question two.

Table 1. Teaching science as inquiry reflection assessment.

Question Number	Pre-assessment	Post-assessment	Question
1	X	X	What does it mean to teach science as inquiry?
2	X	X	What are the 5 essential features of classroom inquiry?
3	X	X	What is the value of teaching science lessons with inquiry?
4		X	What components of the course were most useful for your understanding of teaching science as inquiry?
5		X	What additional experiences would have been useful for you in cultivating a better understanding of teaching science as inquiry?

Table 2. Teacher candidate responses to "What does it mean to teach science as inquiry?".

Responses	Institution A pre-assessment	Institution A post-assessment	Gains	Institution B pre-assessment	Institution B post-assessment	Gains
Active Learning	25%	48%	**23%**	0%	5%	**5%**
Student Centered	7%	55%	**48%**	2%	29%	**27%**
Student Developing or Investigating Questions	29%	59%	**30%**	29%	54%	**25%**
Teacher as Facilitator	7%	24%	**17%**	0%	10%	**10%**
Mention of Investigation	29%	52%	**23%**	10%	21%	**11%**
Curiosity/Interest	18%	25%	**7%**	5%	2%	**−3%**
Not Sure/No Answer	14%	0%	**−14%**	66%	2%	**−64%**

Table 3. Teacher candidate responses to "What are the five essential features of classroom inquiry?".

Responses	Institution A pre-assessment	Institution A post-assessment	Gains	Institution B pre-assessment	Institution B post-assessment	Gains
No Answer	25%	3%	**−22%**	87%	12%	**−75%**
Confusion with 5E Model	0%	62%	**62%**	0%	58%	**58%**
Mention of Active Learning	21%	14%	**−7%**	0%	0%	**0%**
0/5 correct	54%	3%	**51%**	87%	71%	**16%**
5/5 correct	0%	14%	**14%**	0%	0%	**0%**

As consistent with the previous questions, these responses indicate participants who spent more time focused on teaching science inquiry demonstrated greater gains identifying the five essential features of inquiry thus deepening their understanding of what it means to teach science as inquiry. No participants at Institution B mentioned active learning, this could be terminology emphasized more by the instructor from Institution A. It should be noted a significant gain was made from participants in Institution B from no answer to answering the question. Few participants were able to identify all five essential features of science inquiry even at the time of the post-assessment. At both institutions participants had difficulty and confused the 5E model with the five essential features in their responses.

The third question on the Teaching Science as Inquiry Reflection Assessment investigates the participants' perceptions of teaching science as inquiry. **Table 4** provides the representative responses from pre and post assessment question three.

Many participants from Institution B left this question blank on the pre-assessment indicating unclear value of teaching science as inquiry. From institution A, participants made gains in response categories student engagement, answering questions, and interest/curiosity. From Institution B, participants made gains in nearly every category. It should be noted, Institution A seemed to have more familiarity with the concept of teaching science as inquiry on the pre-assessment than Institution B at the time of the pre-assessment. Participants from Institution B found teaching science as inquiry to be more student-directed. This terminology could have been emphasized more by the instructor at Institution B. Participants at both institutions found student engagement and answering questions to be of significant value. These responses indicate participants provided similar gains in identifying the value of teaching science as inquiry.

The fourth question on the Teaching Science as Inquiry Reflection Assessment was asked only during the post-assessment. It required participants to reflect on their experiences throughout the course and note the most useful incidents for developing an understanding of teaching science as inquiry. **Table 5** provides the representative responses from the post-assessment question four.

Participants from both institutions found the labs, mini-units, and lesson planning to be the most useful in furthering their understanding of teaching science as inquiry. Participants from Institution B found the labs and lesson planning the most useful but did not have the opportunity to complete presentations, teaching experiences, or deconstruction of labs.

The fifth question on the Teaching Science as Inquiry Reflection Assessment was only asked on the post-assessment. It required participants to reflect on their experiences within the class by asking participants to suggest additional experiences that would improve their understanding of teaching science as inquiry. **Table 6** provides the representative responses from the post-assessment question five.

Table 4. Teacher candidate responses to "What is the value of teaching science as inquiry?".

Responses	Institution A pre-assessment	Institution A post-assessment	Gains	Institution B pre-assessment	Institution B post-assessment	Gains
Critical Thinking	24%	18%	**−6%**	2%	20%	**18%**
Experimentation	32%	31%	**−1%**	2%	2%	**0%**
Student Engagement	18%	29%	**11%**	2%	17%	**15%**
Process of science	0%	0%	**0%**	0%	17%	**17%**
Content Mastery	18%	12%	**−5%**	0%	5%	**5%**
Answering questions	6%	24%	**22%**	0%	24%	**24%**
Interest/Curiosity	12%	24%	**12%**	7%	10%	**3%**
Student Directed	0%	0%	**0%**	4%	20%	**16%**

Table 5. Teacher candidate responses to "What components of the course were most useful for your understanding of teaching science as inquiry?".

Responses	Institution A post-assessment	Institution B post-assessment
Labs	59%	54%
5E Model	24%	7%
Lesson/Unit Planning	34%	44%
Revamp Lesson	9%	10%
Mini Unit	18%	N/A
Presentations	27%	N/A
Teaching	45%	N/A
Reflections/Deconstructing Labs	17%	N/A

Table 6. What additional experiences would have been useful for you in cultivating a better understanding of teaching science as inquiry?

Student Responses	Institution A post-assessment	Institution B post-assessment
Field Placement	0%	2%
More Scaffolding	0%	10%
More Labs	17%	12%
Writing more lesson plans	14%	22%
More time designated to inquiry	0%	20%
Peer Review	0%	7%
More teaching experiences	31%	N/A

Participants from Institution B provided more suggestions than Institution A on how to cultivate a better understanding of teaching science as inquiry. Participants from both institutions agreed writing more lesson plans is recommended. Participants from Institution B desired more time designated to teaching science as inquiry than Institution A.

5. Discussion

Science educators have encouraged the incorporation of genuine scientific inquiry opportunities in elementary science courses for undergraduates (Crawford, 2014; Herranen et al., 2019; Kazempour, 2018; Kite et al., 2021; Tamir, 1983; Minstrell & van Zee, 2000; Welch et al., 1981). The primary goal of this research was to determine how allocated time impacted participant understanding of teaching science as inquiry. This study investigated teacher candidate perceptions and understanding of critical components of inquiry-based instruction including the five essential features of inquiry. It sought to answer the research question: To what extent, if any, does time allocation have on teacher candidates' understanding of teaching science as inquiry?

Educator preparation coursework and field experiences play an important role as educational preparation programs seek to prepare high quality, qualified, and competent teachers. Some institutions have a course dedicated to teaching science methods including inquiry, while others have general instructional methodology coursework. This research supports the offering of a designated course on teaching science as inquiry. Teacher candidates need first-hand experiences on how teaching and learning science as inquiry takes place within an elementary school setting. **Tables 2-4** show participants from Institution A out-gained those from Institution B in their ability to define science as inquiry, list the five essential features of inquiry and explain a rationale for the value of teaching science as inquiry. With an entire course dedicated to science methodology with a focus on inquiry, Institution A had allocated more time toward this content.

On the pre-assessment from both institutions, teacher candidates reverted to their experiences of learning science likely in a direct instruction traditional setting with labs. This is evidenced by responses such as asking questions and completing investigations/experiments and supports the claim, if teachers teach how they were taught, it is logical that pre-service teacher candidates revert to their personal educational experiences (Britzman, 1991). It is apparent many teacher candidates had minimal experience with science as inquiry. As indicated from the results represented in **Table 3**, many participants were unable to identify the value of teaching science as inquiry on the pre-assessment. After completing the coursework, pre-service teacher candidates from both institution A and B were able to better identify the value of teaching science as inquiry through answering questions, using critical thinking, and engaging students. Teacher candidates must gain a foundational understanding of teaching science as inquiry in their educator preparation program where the value of science as inquiry is fostered if we are to expect them to teach science as inquiry in their own classrooms (Kazempour, 2018).

Interestingly, participants from Institution B who did not have the entire semester of teaching science as inquiry demonstrated higher gains from pre-assessment to post-assessment in **Table 4**. This could be because they had minimal exposure to teaching science as inquiry throughout their educator preparation program, recognized the value of teaching science as inquiry through this coursework therefore, later indicated they desired more allocated time toward this topic.

Furthermore, on the post-assessment, participants from Institution B offered additional suggestions that included laboratory experiences, lesson planning, field placements, and peer reviews as the most helpful in enhancing their understanding of teaching science as an inquiry. Each of these suggestions would take more allocated time to teach science as inquiry with fidelity. Knowing this, 20% of the participants from Institution B specifically requested more time to be allocated to teaching science as an inquiry in comparison to 0% from Institution A, emphasizing the significance of incorporating science as inquiry in science methodology coursework. These results support research that teachers may not be getting the science instructional training necessary in their educator preparation programs to prepare them for the needs of teaching science classroom (Patrick, 2017; Southerland, 2016).

Due to the confusion of the five essential features and 5E model found in question three, (It is possible participants were confused because both terms involved the number five), the researchers could use the 7E learning model developed by Eisenkraft (2003). The 7E learning cycle "emphasizes examining the learner's prior knowledge for what they want to know first before learning the new content" (Adesoji & Idika, 2015: p. 9). Earlier known as the 5E learning model, the 7E learning model is an extension of the 5E model and does not differ in content. It merely expands the 5E learning model to ensure that teachers don't omit any essential instructional components. The 7E learning model offers a more detailed approach and simply providing teacher candidates with a different number may help them to differentiate the essential features of science inquiry and inquiry learning cycle.

6. Implications

Elementary students need to have opportunities to engage in scientific inquiry (Surr et al., 2016). There is agreement among science educators that inquiry is essential to scientific practices and not be taught in isolation but rather "interwoven with science learning across all core science subjects and for all crosscutting concepts" into the NGSS three-dimensional learning model of science instruction (Surr et al., 2016: p. 12). It is essential teacher candidates have experience with inquiry. Knowledge regarding the teaching of science as inquiry improved as a result of a course designed completely around inquiry methods. This denotes a strong correlation to the notion that the more opportunities teacher candidates have to *learn* science as inquiry, the more likely they will be to *teach* science as inquiry in their future classrooms (Murphy et al., 2019). For PK-6 students to experience science as inquiry, teacher candidates must first be provided with opportunities to experience success as learners of science (Riggs, 1988; Enochs & Riggs, 1990).

Theory purports that individuals tend to act according to their beliefs. Bandura (1997, 1986, 1989, 1995, 1997) asserts that the decisions people make, and the associated actions are a direct result of one's beliefs. Hence, the beliefs that teachers hold concerning the teaching of science as inquiry are at the core of educational change (as cited in Smolleck & Yoder, 2008: p. 295). Hence, the data and associated analyses demonstrate that a carefully constructed science methods course which allows teacher candidates opportunities to experience the teaching and learning of science as inquiry is critical to not only their development as a teacher but also greatly impacts their future students' science experiences (Murphy et al., 2019). Based on the idea of Bandura's (1977) social learning theory, if teacher candidates can experience success within a science methods course, they may then model effective instruction within their own elementary classroom, which in turn may promote the success of their elementary students within the area of science. Even though many classrooms today give the illusion that inquiry is provided, the reality is that inquiry is not authentically and effectively being implemented within science classrooms.

7. Conclusion

For decades, science research has encouraged the integration of more authentic inquiry experiences into educator preparation courses (Bencze & Bowen, 2001; Tamir, 1983; Minstrell & van Zee, 2000; Welch et al., 1981). While inquiry is no longer a separate content area and instead has been woven into the NGSS standards, it is subsumed under three dimensional learning and is still an important feature of teaching science. The three dimensions of learning continue to "…foster the learning and application of inquiry" (2016, p. 1). This fact will not change: "inquiry is a fluid, integrated, and iterative set of practices that scientists use" (p. 11) and children should learn science the way science is actually done.

This study will add to the current research on the value and importance of allocating time to teaching science as inquiry within educator preparation programs. The participating teacher candidates from institution B who had only 2 weeks of science inquiry instruction clearly indicate the need for more time devoted to teaching science as inquiry. Education preparation programs should re-evaluate their curriculum to ensure teaching science as inquiry has a prominent role and can be interwoven into the NGSS three-dimensional learning model.

8. Limitations

While the research from this study was collected over three semesters to ensure consistency, there was a relatively small sample size. A larger sample size may have produced alternative results. Having two researchers was also a limitation to this research. The researchers did their best to stay consistent and provide similar experiences to the teacher candidates in their courses. Having two different instructors may have impacted the results.

The researchers desire to help teacher candidates better understand how to teach science as inquiry. Therefore, they plan to continue collecting data from their prospective institutions to increase the number of participants over time and identify trends. Researchers also plan to administer the Teaching Science as Inquiry Instrument (Smolleck, Zembal-Saul, & Yoder, 2006) to additionally measure the participant's self-efficacy in relation to the teaching of science as inquiry.

9. Future Research

Elementary teachers have reported feeling uncomfortable teaching science for decades (McDevitt et al., 1993, Tobin et al., 1990), but if educator preparation programs do not allocate time toward the teaching of science as inquiry this broken cycle will continue. The importance and value of a course solely dedicated to the teaching of science as inquiry is necessary in educator preparation programs and could have positive effects on elementary classrooms and student success in science as well.

There is a substantial body of research that asserts that teachers tend to teach their students in the same ways in which they were taught as young learners. With that being the case, teacher preparation programs need to provide pre-service teachers with opportunities to learn science through inquiry as it is *now* defined in the NGSS. Additionally public and private school systems responsible for teaching science to young learners must have more exposure and professional development in relation to the NGSS. Because the NGSS is a fairly new document, professional development is paramount for teachers of science at all academic levels.

Despite the fact that inquiry is no longer viewed as a separate and distinct content area, the notion of inquiry teaching and learning has not completely been abandoned. The NGSS's recharacterizing of inquiry was done to "clarify what is meant by inquiry in science and the range of cognitive, social and physical practices it requires" (NRC, 2012: p. 30). Throughout the years, many researchers have used the term *inquiry* and defined it in a variety of different ways. As such, without exposure to the set of scientific and engineering practices which represent one of the three dimensions of learning in teacher preparation programs, we are doing a disservice to our future teachers as well as the students they teach if we do not assist teachers in transitioning from scientific inquiry to the three dimensional teaching and learning model.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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