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Elementary Preservice Teachers' Experience with Inquiry: Connecting Evidence to Explanation

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Abstract

This study examined preservice teachers' understanding of the syntactic structures of inquiry; in particular, what it means to give priority to evidence and how to use evidence to construct explanations. Data were collected from student journals, the course syllabus, the assignment description, and weekly lesson plans. The use of content analysis methods resulted in three assertions: (1) the students relied mainly on their sense of sight and not on all senses to make observations; (2) they had difficulties giving priority to the evidence gathered to formulate explanations; and (3) they needed multiple opportunities in class to explicitly discuss and reflect on their understandings. This study has implications for teaching elementary science methods and for teacher educators interested in conducting self-study research.

Introduction

Science at the elementary level plays a critical role in preparing students to think about and question science as both a body of knowledge and as a process of interconnected concepts. The *National Science Education Standards* (*NSES*) (National Research Council [NRC], 1996) promotes the use of a Scientific Inquiry approach for the purpose of providing students with the kinds of opportunities and experiences necessary to develop their observation, analysis, and synthesis skills that are needed for scientific literacy (American Association for the Advancement of Science [AAAS], 1993). The *NSES* explain that to promote Scientific Inquiry in the classroom, there needs to be a change in emphasis from "science as exploration and experimentation" to "science as argument and explanation" (NRC, 1996, p. 113).

Anderson (2007) explains that while the act of Scientific Inquiry (i.e., the process of inquiry scientists use) and the kind of inquiry we should expect of students in the classroom may be similar in nature, they have some significant differences with regards to the kinds of questions explored, students' abilities with the process skills, and the purpose of the inquiry for knowledge development. The *NSES* describe the kinds of inquiry students should be expected to engage in as including five essential features: (1) engaging students in the study of science with scientifically oriented questions; (2) having them learn how to give priority to evidence; (3) requiring them to then use this evidence to formulate explanations that address the scientifically oriented question asked; (4) evaluating their explanations in light of alternative explanations, particularly those reflecting scientific understanding; and (5) asking them to communicate and justify their proposed explanations (NRC, 2000). Some research (Gagnon & Abell, 2008) has examined whether it is reasonable to ask elementary students to understand the importance of giving priority to evidence in science and the relationship between evidence and explanation (see studies such as Abell, Anderson, & Chezem, 2000; Kawasaki, Herrenkohl, & Yeary, 2004; Wu & Hsieh, 2006). What we have learned from these classroom-based studies "is that learning to generate and use scientific explanations is a reasonable expectation in elementary science classrooms, but it does not happen automatically without specific scaffolds provided by the teacher" (Gagnon & Abell, 2008, p. 61).

As Duschl and Osborne (2002) explained, for science as inquiry to truly occur in the classroom, it is critical that all teachers are prepared to teach their students "how evidence is used in science for the construction of explanations, . . . [as well as how] to evaluate the selection of evidence [used in the] construction [of] explanations" (p. 40). Therefore, if an emphasis on science as argument and explanation is necessary for promoting inquiry, and the research says it is reasonable to expect that elementary students can understand this relationship through proper teacher scaffolds, then why is it not happening? As Gagnon and Abell (2008) summarized from the research, the key is teacher scaffolding, and if teachers do not understand science as argument and inquiry for themselves nor have they experienced what it means to provide evidence-based explanations, then it is not reasonable for us to expect that they would know how to create the kinds of opportunities and experiences needed to develop elementary students' scientific literacy and knowledge of inquiry.

Therefore, the purpose of this study was to examine the issue of how preservice elementary teachers understand and have the ability to make observations, analyze data, and use the data as evidence to synthesize an empirically based explanation, which AAAS (1993) has indicated are key components to developing scientific literacy. Avraamidou and Zembal-Saul (2005) assert that before we can expect beginning/preservice teachers to think about how to teach science in this way, they must first be given the opportunity to develop these aspects of scientific inquiry and, therefore, their own scientific literacy. Only then can we begin to examine what strategies they use to translate their experience as a learner of science as inquiry into teachers of science as inquiry.

The design of this study is actually three-fold, with the first of three phases reported in this manuscript. With respect to the larger scale study, I am interested in learning how preservice elementary teachers' specific pedagogical content knowledge for teaching inquiry develops as they move through a progression of experiencing science as inquiry to teaching science as inquiry.

For the purpose of this specific manuscript, however, I am reporting on phase one of the study, which takes place during a six-week inquiry entitled "Life in a Square." The overarching question for the first phase of the study was, "What do preservice elementary teachers come to understand about the need for giving priority to evidence and the role of evidence in the construction of explanations after having experienced a structured six-week inquiry entitled, 'Life in a Square'?"

Conceptual Framework

Shulman and his colleagues (as cited in Abell, 2007) explained that teachers develop knowledge about a topic in a way in which they can teach it to others. Therefore, as they teach a particular topic, they develop a particular way to teach that topic to help others make sense of it. This kind of knowledge is referred to as *pedagogical content knowledge* (PCK) and "is influenced by the transformation of three other knowledge bases: subject matter knowledge (SMK), pedagogical knowledge (PK), and knowledge of context (KofC)" (p. 1107).

> Shulman's view of SMK was derived from the work of Schwab (1964), who defined two types of subject matter knowledge: substantive and syntactic. The substantive structure of a discipline is the organization of concepts, facts, principles, and theories, where as syntactic structures are the rules of evidence and proof used to generate and justify knowledge claims in the discipline. (p. 1107)

Examining both Schwab's explanation of the syntactic structures of science (as cited in Abell, 2007) and the NRC's (2000) description of the essential features of inquiry, it is clear that there is a direct relationship between inquiry as an aspect of science subject-matter knowledge and the kind of scientific inquiry we want students to experience and learn about. For example, the NRC's description of classroom inquiry as incorporating the need to give priority to evidence corresponds to Schwab's syntactic structure description of understanding the "rules of evidence" (as cited in Abell, 2007, p. 1107) and the NRC's description of the role of evidence in the construction of explanations relates to Schwab's syntactic structure of using "proof to generate and justify knowledge claims" (p. 1107). Thus, for this first phase of the study, the view that these two features of classroom inquiry are necessary components of subject-matter knowledge for teaching and learning about science as inquiry were adopted.

Description of Inquiry Experience

In the course syllabus (Park Rogers, 2007), the purpose of the "Life in a Square" assignment was described as

> To help you (the preservice teachers) think about your teaching of science through thinking about yourselves first as a learner of science. In this activity you will record data through both observation and inference and use this data to develop possible explanations for *how things change over time*. You will begin to develop an understanding of how elementary children observe the natural world around them and the need for explanations to be supported with evidence in science.

The guidelines for setting up the "Life in a Square" assignment, as well as how to organize the weekly journal entries, were outlined in the assignment description which was distributed to all preservice teacher participants. (See Appendix A for an overview of the list of directions included in the assignment description.)

In addition to these details, a criterion-referenced scoring rubric (see Appendix B) was developed and used to assess the preservice teacher participants' Life Square journals. The journals were collected twice for grading during the six-week period. The first time was after week three for the purpose of detailed feedback on how to improve data collection methods and/or formulate evidence-based explanations rather than opinion-based explanations. The second collection was at the end of week six for the purpose of summative evaluation.

Research Questions and Design

As I examined the ways in which my students (i.e., preservice elementary teachers) developed their subject-matter knowledge about the syntactic structures of inquiry (as cited in Abell, 2007), I began to realize that having assumed the role of both teacher and researcher in the study made it difficult to separate my students' learning experiences from my own learning experience about how to support their learning of inquiry. Therefore, what I was gathering about my students' understanding of science as inquiry made me rethink my instructional methods of how to develop their PCK for inquiry. This reflective process led me to the use of self-study as a methodological approach and the development of a third research question. A *self-study* perspective has the researcher/teacher using students' understanding of the learning objectives as a lens through which to reflect on their own teaching practice (Loughran, 2007; Zeichner, 2007).

According to Russell (1998), "Self-study is about the learning from experience that is embedded within teachers' creating new experiences for themselves and those whom they teach" (p. 6). While there are some parallels between self-study and action research, Zeichner (2001) identified self-study as one of the five major traditions of action research, but emphasized that the difference between self-study and action research is the context. Action research traditionally occurs in school settings, with classroom teachers searching for ways to improve their instruction for the sake of improving student achievement (Ferrance, 2000). Contrary to this, self-studies are situated in the context of academia, where faculty are challenging their own teaching methods as well as modeling the reflective practices they preach to their students. Therefore, the outcomes of self-study not only have the potential to improve teaching and learning of a specific concept, but they can also have implications for changing teacher preparation programs. This study has the potential of addressing both of these issues.

Research Questions

As previously mentioned, the overall design of this study consists of three phases, and this article reports on the findings from the first phase only. Considering both the conceptual framework and methodological approach guiding this phase of the study, the following three research questions were developed to organize both my data analysis procedures and the reporting of my findings:

1. In what ways did the preservice teachers' methods for collecting evidence change throughout the six-week "Life in a Square" inquiry-based investigation?
2. In what ways did the preservice teachers use the evidence they collected to formulate explanations for what was happening each week in their square?
3. What sort of modifications need to be made to the design of the "Life in a Square" assignment so that it better supports students learning of science as inquiry?

Participants

Thirty-three students from two sections of an elementary methods course were recruited to participate in this study, and nearly one-third provided consent for me to copy their journals. Of these ten students, all but one were female. The students were first-semester juniors at the time of this study and took the methods course in a cluster along with their mathematics methods course and a weekly field experience designed to support their teaching of science and mathematics in an elementary classroom. With regards to science content courses, all students had completed at least two of their four required content courses—(1) Science as Inquiry and (2) Physics for Elementary Majors—as they were prerequisites for the methods course. They would complete their other two science content courses over the two remaining semesters but prior to their student teaching. For some, this meant taking one of their science content courses simultaneously with their science methods course.

Data Collection and Analysis

The primary data source used for this phase of the study consisted of the ten participants' "Life in a Square" journal (with six entries each), for which I employed a content analysis method (Patton, 2002). Although only one source of data was gathered with respect to the first two research questions, I feel I am able to ensure the validity of my claims because of my use of a multilayered content analysis process. Through repeated readings of the participants' journals, I first looked for their understanding related to research questions one and two as a representative sample of the whole class's understanding. Next, I reviewed each participant's journal to determine their individual overall understanding of research questions one and two. Finally, I reviewed their journals a third time to look for particular instances in growth in their understanding as they progressed from week to week.

With regards to research question three—which developed as a result of my decision to follow a self-study methodology—I took what I learned about the students' understanding of the two syntactic structures of inquiry described in my conceptual framework and examined instructional artifacts such as the course syllabus, "Life in a Square" assignment description, and my personal weekly lesson plans. Taking what I learned about the participants' understanding of the syntactic structures of inquiry science along with my review of the instructional artifacts, I was able to determine possible points within the "Life in a Square" assignment where modifications could be made to better scaffold the participants' knowledge development of what it means to give priority to evidence and how to use evidence to formulate explanations.

Through my multilayered analysis process, I scanned the ten participants' journals looking for the kinds of evidence they gathered, how the evidence related to their guiding inquiry question, and their ability to decipher between evidence that was observation-based or inferential. The information I gathered from this initial level of analysis was used to specifically address research question one. I noticed some participants held similar understandings and skills about collecting and representing their data. Therefore, those with similar understandings were grouped together and one was selected to report on as a representative sample of the group.

With regards to research question two, I focused my data analysis on the participants' use of evidence to construct explanations. This time I scanned their journals looking for references to the evidence they had recorded in their data section for each entry and explicit statements on how their data supported their explanations. Once again, I found that some participants used similar methods when constructing explanations and depicted similar levels of understanding about how to use evidence in support of their explanations. Therefore, I grouped those demonstrating similar understandings and abilities with response to research question two into the same group and chose to report on one group member's understanding as a representation of the whole.

Finally, having gleaned from my analysis of the journals the kinds of difficulties the participants had with regards to their knowledge development of the syntactic structures of science, I then approached my analysis of the course artifacts looking for opportunities to insert possible scaffolding strategies to support their knowledge development more explicitly. It is this aspect of my analysis that addresses research question three: determining possible modifications to the "Life in a Square" assignment.

Findings, Interpretations, and Modifications

Section One (Collecting Data) primarily addresses research question one, and Section Two (Using Evidence to Explain) addresses research question two. In response to the third research question, however, comments are embedded in my discussions of the findings in both Sections One and Two. Also, at the end of each section is a summary of the modifications made to the assignment, which directly correspond to research question three.

Collecting Data: Only Seeing, Not Truly Observing

One of the foci of this assignment for students was to learn how to collect data that they could observe both directly (i.e., using their senses) and indirectly (i.e., inferring). I found that the students' reports of what they observed varied across the ten participants because of their use of their senses and that they often inferred solely on their past experiences but not from data that they were directly observing as well.

Three of the students' descriptions and illustrations each week included data they gathered from more than one sense. However, another three students were less consistent in using multiple senses and occasionally only reported data observed through one of their senses. The remaining four students only referred to their sense of sight for nearly all of their journal entries except for the week when I gave direct instruction to use a tape recorder in order to record data based on their sense of hearing. Examples of each of these cases are presented below. Case One is a representative sample of the kind of journal entry that participants provided who consistently used multiple senses to make direct observations of their square and who refrained from combining inferences and sensory observations as being one in the same. Case Two represents participants' who occasionally used multiple senses but reported what they observed with only one sense most of the time. These students also sometimes embedded inferences in with their direct sensory observations. Case Three shows the kind of limited description provided by students who relied only on their sense of sight each week. In this third case, students demonstrated more difficulty in deciphering the differences between direct sensory observations and inferences. This kind of limited and mixed description continued throughout their six-week inquiry project.

Case One

As I walked toward my square this morning, my feet were sinking a little bit in the ground. It is a bit slippery as well. Last week, I scattered the 23 peanuts across my square. Now, there are only 16 peanuts in the square, eight of which are broken or cracked and seven of which are left whole. After I *touched* one of the whole peanuts, I noticed that the shell was now soft. All of the shells of the peanuts were a darker color brown than they started as, there is no snow or ice on the ground, and grass is accompanied by dirt and mud. The tree is still bare, and the area surrounding the tree is damp dirt and wet grass. I *heard* a click and rumbling noise behind me as well as an engine noise (three times) over the hill. A person walking by was talking but was on her cell phone, and I heard her laughing. There were also patches of damp dirt among the grass. A bird flew into my square, pecked at one of the peanuts, and flew away. Beneath the tree on the right-hand side, there were 11 leaves scattered in a not very straight line down the hill. On four leaves, I was able to *see* water droplets. The leaves were a dark brown color and smaller than maple leaves but longer than the blades of grass. They had a point at one end and a rounded base at the other end. (Extracted from Abigail's journal, entry 3; italics added)

Case Two

I can see so much of my square now. The plot of land is not completely flat; it's really bumpy in spots. There are small patches of dirt with no grass, and I can *see* some moss in it. The grass is all different shades from the lightest brown to dark green. There seem to be spots of grass that are much lighter than others; the similar colors are grouped together. There are lots of leaf pieces throughout my square as well. They are all smashed into the ground. These also range in color. Some are so dark they look black, and others are a pretty light golden color. It's windy as I *observe* the grass swaying a little, especially the taller blades. I *see* two small pieces of something black on the lower left side of the square. I *touch* it to *see* what it is, and it's just hard plastic from something that broke. Most of the grass in the square is matted down. Also, all of the peanuts I laid down last week are gone. The grass was very wet. (Extracted from Tabitha's journal, entry 3; italics added)

Case Three

During the last week, the snow has completely melted. The grass is brown but has been trampled down. I can tell that the ground is soft because the footprints are indented in the ground and are fairly clear. Also, the sticks that were on top of the snow are now just lying on the ground. The weeds are still lying on the ground coming out of the stump. I did realize there was a concrete block in the bottom of the stump. Finally, I put 18 peanuts in my square. (Extracted from Sam's journal, entry 3)

Summary of Modifications Made

Comparing these three representations, it was evident that the students in my class have had various past experiences with learning how to make observations and decipher these from inferences. I cannot assume, even if it is outlined in the assignment description to do so, that they will consistently report direct observations using multiple senses and know when it is appropriate to use inferences as part of their evidence. Therefore, I realized that one modification that needed to be made to the assignment was some sort of activity that would require the students to reflect back on their weekly journal entries to determine when they were reporting data that was a direct observation and when it was an inference developed out of previous experiences or observations. They also needed experience with learning what were good data and poor data to collect in response to their research question. Having the opportunity to explicitly reflect on these aspects of science will provide them with information to think about other data they should have collected.

The problem was assuming that providing detailed written guidelines for the journal entries would suffice in developing their understanding of what science as inquiry is, and, from my analysis of their journals, I learned that I needed to be more explicit and hands-on in my scaffolding process. In response to this, I revised the assignment to include an explicit and reflective Post-it® note task each week. Some of these tasks included interpreting the difference between observations and inferences in their data, what evidence they used in formulating their explanations, and how they determined which explanation(s) answered their original question of investigation better than others. (See Table 1 for further details on the weekly Post-it® note tasks.)

Table 1. Weekly Discussion Schedule Based on Modifications to Assignment

Week	Task
1	"Life in a Square" assignment explained in class and first journal entry made this week
2	First class discussion on Week One's journal entry POST-IT® NOTE TASK #1 – Our discussion will focus on the kinds of data you collected and your use of observations vs. inferences in your data collection.
3	Second class discussion on Week Two's journal entry POST-IT® NOTE TASK #2 – Our discussion will focus on how you pieced data together to help you formulate your explanations this week.
4	Third class discussion on Week Three's journal entry – Journals collected for grading! POST-IT® NOTE TASK #3 – This week, I will give you a cue card to use instead of a Post-it® note for you to reflect on how you feel your skills in collecting data and using that data to formulate explanations have changed from the first week to now.
5	Return of "Life in a Square" journal and preparation for journal entry four
6	Fourth class discussion on Week Five's journal entry POST-IT® NOTE TASK #4 – Our discussion will focus on how you used evidence you gathered from talking with your peers to help you rethink your own explanations.
7	Fifth class discussion on Week Six's journal entry POST-IT® NOTE TASK #5 – Our discussion will focus on how you decided what explanations to accept or reject in your small group discussions.
8	Sixth class discussion on Week Seven's journal entry – Journals collected for grading! POST-IT® NOTE TASK #6 – This week, I will give you a cue card to use instead of a Post-it® note for you to reflect on the following three things: 1. Describe how your ideas of the criteria of characteristics of "What makes something evidence?" changed over the course of this assignment. 2. Describe the path that scientists take in an investigation to determine a logical answer to the scientific question they ask. 3. On a scale of 1 to 5 (least to most), would you say it is important for elementary students to learn about the ideas discussed in #1 & #2? Explain your rating.

Using Evidence to Explain: Learning to Give Priority to Evidence

When the student participants did attempt to generate some explanations for the changes they were observing, they did not consider how to group data together to form a stronger argument. Instead, they made leaps in their thinking from what they observed to naming the object, with no connections made between sources of data. At some point in time during the inquiry experience, this was an issue for all ten participants; however, I did note that participants identified as Case One or Case Two made improvements in their understanding of this syntactic structure of science by the end of the six-week inquiry, whereas those students classified as the Case Three group continued to have some misunderstandings over the six weeks.

The following excerpt represents how all participants in the first three weeks of the inquiry made unsupported assumptions to rationalize what was going on in their square rather than following a path of deductive reasoning to support their thinking:

> *Observations:* On Wednesday afternoon, I had placed 17 peanuts in my square. To my surprise, after approximately 11 hours, all my peanuts were gone with no evidence of them even having been there. My square was no longer covered in snow. I could now see the grass and leaves. The leaves were no longer laying on the surface where the wind could easily carry them away. They were more flattened into the ground and only three were left as whole leaves.
>
> *Explanation:* I believe that all my peanuts were carried away by squirrels. Based on the area and the number of trees, there is a large squirrel population living among us. I have not seen any of the squirrels carry them away, but I did send my children on a hunt to look around the trees in our backyard and the surrounding area. They found the remains of a peanut shell that was still intact but missing a part of the center of the shell (where the meat of the peanut is). . . . This was under a tree that I have seen squirrels inhabiting before. (Case One – Elizabeth's journal, entry 3)

Elizabeth was identified as a Case One participant because of her frequent use of multiple senses for reporting direct observation. However, in the beginning, Elizabeth's use of this varied data to formulate evidence-based claims was weak like many of her peers. After the first collection of the journal when I gave all students written feedback in their journals on how to consider evidence when formulating explanations, I noticed that students like Elizabeth who had consistently recorded observations using multiple senses were able to make the necessary changes in their development of explanations for entries four, five, and six. Thus, this growth occurred for students identified as Case One and Case Two only. To illustrate this, the following excerpt was taken from a Case Two participant's fourth journal entry showing how she combined evidence she had gathered of cigarette butts in her square as a means of rejecting one of her possible explanations for the missing peanuts:

> I can think of three reasons for why the peanuts are all gone. My apartment complex may have picked them up. This is unlikely, though, since there are [so] many cigarette butts and if they don't pick those up, why would they pick up the peanuts? (Case Two – Ella's journal, entry 4)

Summary of Modifications Made

I learned that the students were initially having difficulties developing an understanding of this syntactic structure of science because they were not sure of the process. Although I felt it was clearly stated in the scoring rubric under the explanation/hypothesis section, they needed direct and individual feedback from me to see how it applied to their particular "Life in a Square" data. Therefore, I realized that more explicit scaffolding was needed in class for the students to reflect on this process. Such explicit scaffolding should include modeling of the process as well as opportunities to explicitly discuss with me and their peers how they worked through the process of giving priority to evidence to formulate explanations. This discussion piece (refer to Table 1) would afford them the opportunity to verify their thinking with others and determine if their line of thinking was coherent.

Conclusion

Schwab's (1962) notion (as cited in Abell, 2007) of the syntactic structures of science (i.e., rules of evidence and proof used to justify explanations) provided the conceptual framework for this study, with the specific purpose of this study to examine how elementary preservice teachers understand the relation of evidence to explanation in science. From a teacher educator's perspective, the findings from this study contribute to the field of elementary science teacher preparation as it illustrates the need for science teacher educators to consider explicit and reflective scaffolding techniques with mock inquiries, like the "Life in a Square" assignment, so preservice teachers have the opportunity to consider what they are learning with regards to both the knowledge and abilities to do scientific inquiry (NRC, 1996, 2000). In addition, the use of an explicit and reflective approach (see Table 1 for an example) affords preservice teachers with the opportunity to consider how to approach this kind of inquiry experience with their future students.

From a researcher's perspective, the self-study approach employed in this study provided significant insights into my own teaching practice. I now realize that some techniques I was using with this assignment in the past were not enough as they were actually more implicit than I originally thought. For example, previously, I simply listed my expectations related to syntactic knowledge development in the scoring rubric (see Appendix B) but did not take the time to address these ideas in class. I assumed that by working through the journal as outlined in the rubric, the students would make connections to these concepts on their own. What I forgot to consider was their previous science learning experiences may not have matched the kind of experience I was expecting them to work through independently. For most, their previous science experiences consisted of collecting data in such a way as to match the data they collected to a predetermined outcome. Rarely, if ever, were they challenged to think about how to interpret a variety of data sources to propose several possible explanations. This kind of unscripted approach to science as required in the "Life in a Square" assignment was a whole new experience for the preservice teachers involved in this study. Therefore, it was evident that several of them did not feel comfortable nor were they knowledgeable about how to best interpret their data to formulate evidence-based explanations.

Using a self-study approach helped me to realize that my students needed weekly practice and continual formative assessment with regards to developing their syntactic knowledge of science. Developing and implementing a weekly discussion component, such as the one outlined in Table 1, has the potential of providing the kinds of metacognitive experiences (Bransford & Donovan, 2005) elementary preservice teachers need to learn how to teach these ideas of science as inquiry to their future students. In addition, the constructivist approach modeled in the discussion tasks incorporates the kind of scaffolding techniques Gagnon and Abell (2008) claim are necessary to develop teachers' and students' understandings of the syntactic structures of science.

Implications for Future Research

While it is understood that it is reasonable to ask elementary students to understand science as a form of knowledge grounded in argument and explanation (Gagnon & Abell, 2008) as well as have them work through this process for themselves, we must realize that this will only occur if teachers know this too (Avraamidou & Zembal-Saul, 2005). For this realization to occur, more work needs to be done in exploring various methods for developing preservice elementary teachers' epistemologies of syntactic structures of science before we can reasonably expect them to teach it to their students. However, studies such as this one provide only one layer of understanding about this complex issue. It is for this reason that I have designed a second phase to this study. The focus of the second phase is to explore the effectiveness of the modifications made to the "Life in a Square" assignment as a result of what was learned from the first phase of the study.

Implications from this study, however, extend beyond improving elementary preservice teachers' syntactic knowledge of science. There is a need for science teacher educators to be proactive in conducting self-studies of their own teaching practice and for them to report on this experience in order to begin a dialogue about this type of pragmatic research practice. As a community, we need to embrace the kinds of reflective and evaluative practices within our own practice that we are teaching our preservice teachers to use in order to be quality science teachers. Conducting self-studies on our own practice and sharing these stories will not only improve our practice, but it will model to our students how to be responsible, reflective practioners. The importance of this process on continuing to improve science teacher education and science learning is immeasurable.

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Appendix A. Overview of "Life in a Square" Assignment

- Create and design your own observation notebook. It can be either typed or handwritten.

- Find a piece of ground that is accessible for weekly recordings for the next two months (e.g., a section of your backyard; a plot just off of a trail, a pond, a creek, a pasture; or in some wooded area). Mark off a 1 meter × 1 meter plot using sticks (e.g., popsicle sticks) as the four corners and string as the four sides (i.e., boundaries) wrapped around the sticks.

- Each week, record what you observe and don't observe in your square. Make notes on living and nonliving things, draw pictures, and categorize items (e.g., using tally/frequency charts, taking measurements, and creating tables or graphs).

- Based on what you observed (or didn't observe), begin to develop some explanations and/or propose hypotheses for what you think is happening in your square—why and how things are changing. Remember to use the data you gathered through your observations as evidence to support your explanations.

- Next, develop questions about things that you want to find out more about with regards to your square. From your explanations, what questions do you now have about what or why something is happening in your square? Choose one of your questions at the end of the three weeks of data collection and devise a plan for answering it.

- Finally, considering your explanations, hypothesis(ses), and questions you have proposed, provide a prediction for "What you think may happen" over the course of the week until your next data collection day. You will begin your data collection for the following week by first addressing the accuracy of your prediction.

Appendix B. Criterion-Referenced Scoring Rubric for "Life in a Square"

Requirement	Points/ Recording	Total Points
QUANTITY: Are there three separate entries (one each week)?	1	3
ORGANIZATION: Each entry includes your name, date, and is organized using the following headings: Summary of Last Week, Data Collection/ Observations, Explanations and Hypotheses, Questions I Now Have, and Predictions of What I Think May Happen	1	3
SUMMARY OF LAST WEEK: Provide a short three- to four-sentence summary of what you learned about your square last week. **Note:** For entry #1 ONLY, you have no information to base your summary on, so, instead, provide a brief description of the geographical location of your plot—where it is located, what does the area around it look like, is it in a high traffic area or not, etc.	1	3
DATA COLLECTION/OBSERVATIONS: You must include at least two different kinds of observations for each entry. Examples of possible ways to represent your data: • A hand-drawn diagram or photograph of the square with labels and/or a legend identifying the items in the drawing • A chart/frequency table/graph of some sort showing a mathematical representation of the items you observe (this can also be an ongoing chart you add to each week) • Written descriptions of what you see, hear, smell, or feel in your square	2 pts/entry × 3 entries	6
EXPLANATIONS/HYPOTHESES: During this section of your journal, you will begin to make sense out of your data and, using your data as evidence to support your thinking, begin proposing possible explanations (i.e., hypothesizing) about what is happening in your square and why. Always remember to support your explanations with specific pieces of data you have collected. You can also infer what may be happening. **For Example:** *If you see markings in the soil, what do you think they are and what evidence do you have to support this explanation? What did you see, hear, smell, or feel in your square this week that was different and the same from the previous week? Using evidence to support your thinking, why do you think some of these differences occurred, why do you think there are similarities?*	3 pts/entry × 3 entries	9

Appendix B (cont.)

Requirement	Points/ Recording	Total Points
QUESTIONS: In this final section, you are to generate questions that you have about what is going on in your square based on the hypotheses you constructed. You need to develop at least two questions each week, but more are certainly encouraged.	2 pts/entry × 3 entries	6
You are to select one question from all of the questions you have written over the past three weeks. Using journals, texts, the Internet, or by asking an expert in that field, research possible answers/solutions/reasons for what you observed. *Highlight the question you have chosen to research, providing your research findings to it in a different color pencil/ink either in the margin or underneath the question section of your log report for that week, and list your resource from where you got your information.*	2 pts for highlighting, researching, and answering one question from the 3 entries	2

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