The Home Inquiry Project: Elementary Preservice Teachers' Scientific Inquiry Journey

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Abstract

This article discusses the Home Inquiry Project which is part of a science methods course for elementary preservice teachers. The aim of the Home Inquiry Project is to enhance elementary preservice teachers' understanding of the scientific inquiry process and increase their confidence and motivation in incorporating scientific inquiry into learning experiences they plan for their future students. The project immerses preservice teachers in the process of scientific inquiry and provides them with an opportunity to learn about and utilize scientific practices such as making observations, asking questions, predicting, communicating evidence, and so forth. Preservice teachers completing this project perceive their experiences favorably, recognize the importance of understanding the process of science, and reflect on the application of this experience to their future classroom science instruction. This project has immense implications for the preparation of a scientifically literate and motivated teacher population who will be responsible for cultivating a scientifically literate student population with a positive attitude and confidence in science.

Introduction

In the past two decades, there have been continued calls for elementary teachers to encourage children's natural curiosity by providing opportunities for children to be actively engaged in various aspects of scientific inquiry including making observations, developing questions, performing investigations, collaborating with peers, and communicating evidence and findings (NGSS Lead, 2013; NRC, 2007; NSTA, 2002, 2012). The National Research Council's utilization of the term 'practices' is aimed at providing a more comprehensive elucidation of "what is meant by 'inquiry' in science and the range of cognitive, social, and physical practices that it requires" (NRC, 2012, p.30). Engaging students in these scientific practices through experiential learning opportunities enables them to "to deepen their understanding of crosscutting concepts and disciplinary core ideas" (NRC, 2012, p.217). Regrettably, the reality of science instruction in the early grades is contrary to the recommendations. In addition to the obstacle of lack of instructional time, elementary teachers' own inadequate scientific knowledge, inaccurate beliefs about the nature and process of science, and negative attitude and low self-efficacy with respect to science and science teaching (Kazempour & Sadler, 2015; Fulp, 2002; Keys & Watters, 2006; King, Shumow, & Lietz, 2001) are all major contributing factors accounting for the minimal and mediocre coverage of science witnessed in the early grades (Banilower, Smith, Weiss, Malzahn, Campbell, & Weiss, 2013).

Prior studies have indicated that elementary preservice teachers view science as a rigid and linear process, the scientific method model, that is solely focused on experimentation, proving or disproving hypotheses, and accumulating facts (Kazempour, 2013, 2014; Kazempour & Sadler 2015; Plevyak, 2007). Many in this group believe that scientists mainly work individually and isolated from their peers except to communicate their findings with the scientific community. Furthermore, they possess stereotypical images of scientists as mainly aging, white male figures, with lab coats, glasses, and other such features, whose work involves the use of beakers, Bunsen burners, microscopes, and chemicals to perform experiments and advance level research in their laboratories (Barman, 1997; Driver, Leach, Millar, & Scott, 1996; Kazempour & Sadler, 2015; Moseley & Norris, 1999; Quita, 2003). Consequently, elementary preservice teachers typically view science as a tedious, irrelevant, and boring process that they find uninteresting and out of reach (Kazempour, 2013, 2014; Kazempour & Sadler 2015; Tosun, 2000)

As highlighted in a number of studies (e.g. Adams, Miller, Saul, & Pegg, 2014; Chichekian, Shore, & Yates, 2016; Kazempour & Sadler, 2015; Lewis, Dema, & Harshbarger, 2014), for many preservice teachers, particularly elementary preservice teachers, their beliefs about the process of scientific inquiry and the scientific community stems from their prior experiences with science, especially as part of their K-12 science education. Elementary preservice teachers often describe their previous experiences with science as inadequate, unmemorable, or negative (Kazempour, 2013). Their recollections of school science commonly include teacher-led lectures or whole-class discussions, heavy reliance on the textbook, infrequent labs and activities that were often completed to confirm ideas discussed by the text or the teacher, and, of course, fact-based tests that would often conclude their science chapters and units (Kazempour, 2013; Kazempour & Sadler2015)

Elementary preservice teachers' prior K-12 encounters with science not only shapes their beliefs about science, but also significantly influence their attitude toward the subject and level of confidence in learning or teaching science (Appleton, 2006; Avery & Meyer, 2012; Hechter, 2011; Kelly, 2000; Tosun, 2000). According to the 2012 National Survey of Science and Mathematics Education, only 39% of elementary teachers indicate feeling "very prepared to teach science" in comparison to 81% in literacy and 77% in mathematics (Banilower, et al., p. 41). The combination of negative attitude and low self-efficacy with respect to science and science teaching often influence elementary teachers' instructional practices; either avoiding science altogether or relying on brief, scripted, and text or worksheet focused strategies.

Achieving the goal of developing young children's understanding of the scientific process will depend extensively on the type of educational experiences they encounter in the classroom. Hence, it is critical that teachers be provided transformative and reflective opportunities that lead to changes in their beliefs, attitudes, confidence, and ultimately their science instructional behaviors (Mullholland & Wallace, 2000). Elementary science content and methods courses which account for and address preservice teachers' prior experiences,

beliefs, and attitudes through alternative science experiences have been shown to lead to positive changes in these domains (Morrell & Carroll, 2003; Tosun, 2000). This article focuses on a project, the Home Inquiry Project, that I have implemented in my elementary science methods course so that preservice teachers have an opportunity to experience and be immersed in the process of scientific inquiry in order to gain a more accurate and complete understanding of the process.

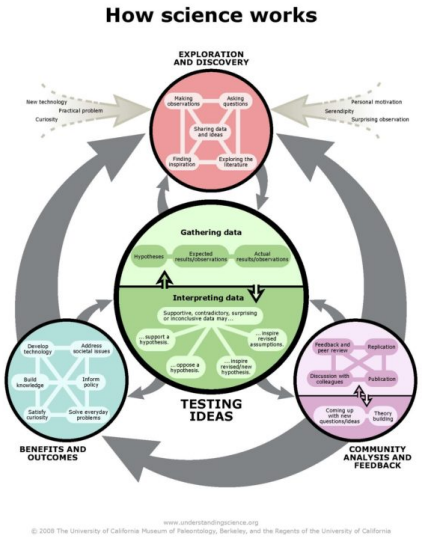
Context

The Home Inquiry Project is a component of the science methods course that I teach at one of the campuses of a large Northeastern university. The elementary teacher candidates enroll in the science methods course during the fall semester of their senior year in the program. They are concurrently enrolled in the social studies and mathematics methods courses and the two-day field experience in the local urban school district. Most of the students in the course are female, Caucasian students from either the small towns or urban cities in the approximately 50-mile radius of the campus. During the first two years of the program, they are required to enroll in three science content courses, one from each discipline of life, physical and earth science.

The Origins of the Project

The Home Inquiry Project originated from an idea I had come across in several articles dealing with engaging preservice teachers with their own authentic inquiry investigations as a component of their science content or methods course. However, the authentic experiences described in these examples only focused on the design and implementation of scientific investigations with emphasis on hypothesis testing and identification of variables. As Windschtill (2004) suggests, preservice teachers may still hold on to their longstanding views of science as the step-by-step and linear scientific method and that such investigation experiences may “do little more than confirm these beliefs through the course of investigative activity” (p. 485). In my methods courses, I introduce students to the cyclical and complex model of scientific inquiry as depicted in Figure 1. This model is comprehensive in that it encompasses the scientific practices emphasized by the NGSS, underscores the importance of community analysis and feedback, and emphasizes the interdependence of science, engineering, and technology, and the influence of science, engineering and technology on society and the natural world (NRC, 2012). Therefore, I wanted to design a project that would provide my students an experience which would more genuinely mimic this cyclical and more complex process of scientific inquiry, including the components of the process that typically receive less attention such as the connection of science to society, community feedback, role of serendipity and creativity in science. Since 2011, I have implemented the Home Inquiry Project in my methods courses and the impact on the preservice teachers’ views about and attitude toward science has been remarkable (Kazempour, in press).

Figure 1. (Click to Enlarge) Flow Chart Depicting the Process of Science. *Source: The University of California Museum of Paleontology – Understanding Science – www.understandingscience.org*



Phase 1: Introducing the Project

The various components of the project are introduced in segments throughout the semester in order to better demonstrate the process of scientific inquiry. Students are given the initial instructions for the project early in the semester as soon as they are introduced to the scientific practices of developing questions and making observations. The initial prompt is simple and instructs them to choose one of the three options and generate questions and make observations for several consecutive days. The three options that students may choose from to focus their observations include the following:

Option 1: Daytime Sky

On a *daily* basis, observe the sky and record your observations. Try to do so at the same location. Include the date and time, location, a description of what you observe, a drawing or a photo of what you see, questions you wonder about, etc.

Option 2: Nighttime Sky

On a *nightly* basis, observe the sky and record your observations. Try to do so at the same location. Include the date and time, location, a description of what you observe, a drawing or a photo of what you see, questions you wonder about, etc.

Option 3: Field/Site

Pick a site (same location each day). It could be your backyard, a local park, on a beach, next to a pond, in a field, etc. On a daily basis, observe the area (choose a smaller area within that location to focus on if the location is too large) and record your observations.

Include the date and time, location, a description of what you see, a drawing or a photo of what you see, questions you wonder about, etc.

During the next class session, they are introduced to different types of observations (qualitative vs. quantitative), inferences, and predictions, and are asked to extend their inquiry to include different types of observations, inferences, and predictions.

Phase 2: Initial Connection to Scientific Inquiry

During the following week, a segment of the class is devoted to discussing their initial observations, questions, and inferences as well as their thoughts on the process up to that point. The team and subsequent whole-class discussion prompts students to think about possible questions that they are interested in or ways they can extend their observations. For example, they point out that their initial observations were limited to what they could “see” and how after our discussion they were incorporating their sense of smell, hearing, and even touch. Some of them indicate during the first discussion session that they are already losing interest in what they were initially making observations of and have found themselves wondering about other things that they were noticing. For example, students who observe the daytime sky, often speak about becoming interested in the birds that flew by or the jet contrails they could observe in the sky. We discuss the fact that they can make observations of and ask questions about anything that interests them and are not confined to a particular aspect of the sky or the field.

During the next two class sessions, they are introduced to the scientific inquiry model through a number of collaborative activities, discussions, and the video, *Science in Action: How Science Works*, by California Academy of Sciences, about the accurate model of scientific inquiry and its connections to authentic scientific work. At this point, I have them work in small teams to discuss the components of the inquiry model they have already been involved with in the Home Inquiry Project and ways they could engage in more components. They are instructed to make another week’s worth of observation, as frequently as they deem necessary, and explore how they may want to extend or redirect their projects. We discuss the flexibility of the process and how they are not confined to the original options they had selected which were meant to simply provide them an initiation point.

Phase 3: Independent Explorations

During the next class session, after we briefly discuss their ongoing experiences and possible modifications in their project, I provide the final set of instructions for the project. They are instructed to continue with their projects in any way they wish to as long as they are engaged with the components of the scientific inquiry model. I explain that they can refine their investigations, continue gathering data, search the literature, reshuffle their project at any time, and so forth. Some may wish to gather evidence while others may want to restart with an entirely different question or simultaneously investigate several related questions.

Similarly, some many want to explore societal connections of their topic or search the literature to expand their understanding of the concepts or issues they encounter. At this point, they are informed that the project will culminate in approximately six weeks with individual presentations of their projects during week 10 of the course.

Phase 4: Presentations and Reflections

Depending on class size, students are allotted approximately ten minutes to present their projects. Presentation must be in the form of narrated PowerPoint, narrated Prezi, or an iMovie or other format video. Regardless of the format, the presentations must address: (a) a thorough description of their journey, (b) connections to the process of scientific inquiry, and (c) implications for future teaching.

In describing their journey, students are instructed to explain what observations or questions they started with, how their questions may have evolved, evidence they gathered, transitions they made along the way, and any other aspect of their experience. They are reminded that each individual will have a different journey and that there is no “correct” path that they have to take during the project or explain during their presentation. As part of their descriptions they need to include photos, drawings, videoclips, charts, and other pieces of evidence that would aid in understanding their projects. Second, in describing their project, they are instructed to clearly make connections to and describe the specific components of the scientific inquiry process that they were engaged with throughout their project. Finally, students are asked to reflect on the implications of their experiences for their future classroom teaching. In doing so, they could either discuss their own specific projects or the Home Inquiry Project in general.

Reflecting on the Project

Each presentation is followed with a brief question and answer session where students can engage in conversations regarding specific questions they may have for each presenter or items they found interesting. Afterwards, the class engages in a reflective class discussion about the Home Inquiry Project, their experiences, and overall understanding of science that they gained from the experience. Students’ presentations and verbal comments during the reflection session suggest an overall positive perception of the project and an improved understanding of the process of scientific inquiry.

In the beginning of the semester when the project is first introduced, students continually ask about more specific instruction or check to make sure that they are “on the right track.” It is often strange for them how open ended the instructions are at first, but as we proceed through the project and they learn about the cyclical process of scientific inquiry and through continued in-class discussion and reflection they begin to recognize the rationale for the open-ended nature of the project as suggested in this student reflection except.

The first night I began my observations, I wasn't sure what I was looking for. I simply went outside and looked up at the sky. I didn't have any questions I was looking to answer. As time progressed, a very natural curiosity began to develop. I initially began to wonder why I couldn't always see this moon. This soon expanded to 'why can't I see the moon OR stars on many nights?'

In their final reflections, students comment on the flexible nature of the project and how they felt interested in what they were investigating and motivated to do the project because they chose the path rather than being dictated what to do. Furthermore, they comment on the improvement in their observation and questioning skills and how they find themselves asking questions and making observations more routinely throughout their daily lives and how they are increasingly aware of their surroundings.

The actual experience of being involved in the process of going back and forth between the various components, such as tweaking questions, searching in the literature, making additional observations, and communicating and collaborating with their peers, allows them to notice the resemblance of the process to the fluid nature of scientific inquiry as opposed to the scientific method model.

> *I have found that the skills developed through science inquiry are skills that are essential in everyday life. There is value in understanding the "why" and "how" in unfolding events. These skills are vastly different from the traditional scientific method, where conclusions are based on the accumulation of facts. Creative thinking and problem solving skills innately develop from the nature of the process found in scientific inquiry.*
>
> *What is exciting about the inquiry learning is the unknown direction that it will take you. I never thought staring at the night sky could lead me to learn about the different spectrums of light.*

Their experiences not only allow them to utilize scientific practices and witness the fluid and iterative nature of scientific inquiry, but it also allows them to better experience and understand cross cutting concepts (NRC, 2012) such as patterns, stability and change, cause and effect, similarity, and diversity.

Finally, they reflect on the numerous implications of the project for their future teaching. Some indicate how a similar project could be done with their own students by asking students to perform similar explorations in their backyards or location of their choice. Teaching in an urban area, they recognize the flexibility of the project in allowing students to focus on even the simple things in their surroundings. They also discuss, as suggested in the excerpts below, the importance of being able to utilize their improved understanding of science in more accurately depicting the scientific process in their science lessons and units.

> *This experience will follow me into my future classroom and into my future science lesson plans. Inquiry based learning will not only be a part of my science curriculum but also a majority of other subjects with incorporating interdisciplinary objectives.*
>
> *In my future teaching, I want to help my students feel the way I have come to feel about science. I realize now that science is more about the journey you take. Finding answers or possibilities (or maybe nothing at all!) are just the end products of that process.*
>
> *I learned it does not take much to find something amazing relating to science. I don't think this is specific to the area we live in but I do think there are so many resources in this area that could be utilized by an elementary class to extend science learning to the outside world. There are waterways, nature trails, ample wildlife, even their own backyards, etc. The options are endless for relating lessons in the classroom to locations very close to the school.*

Conclusion

Authentic experiences, such as the Home Inquiry Project, which immerse preservice teachers in the various aspects of the process of scientific inquiry have the potential to influence preservice teachers' understanding of science as well as their attitude and confidence toward doing and teaching science. If the ultimate goal is the development of scientific literacy through engaging K-12 students, particularly those in the early grades, in authentic inquiry experiences, then we need to better prepare the teacher population that will be responsible for implementing this type of instruction in the classroom. Elementary teachers will continue to either avoid teaching science altogether or do so in a superficial, test preparation and coverage-focused manner that does not accurately depict the reality of the scientific process unless science content and methods courses begin to actively engage them in these forms of inquiry and reflective practice.

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