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Kerri Donohue, Gayle A. Buck, Valarie Akerson
Indiana University Bloomington

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Where's the Science? Exploring a New Science Teacher Educator's Theoretical and Practical Understandings of Scientific Inquiry

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Abstract

The purpose for this self-study was to explore the theoretical and practical understandings of scientific inquiry inherent in our elementary teacher preparation program, specifically those of new instructors. Although scientific inquiry and inquiry-based learning are emphasized in our program, several new instructors, doctoral students hired to teach undergraduate courses, expressed some discomfort with the lesser amount of traditional science content that could be found in the course syllabi. To support their development and our own understandings of how to guide them as they begin teaching in higher education, it was important that we understood the transition in regard to teaching scientific inquiry and using inquiry-based pedagogy. Thus, we conducted this collaborative self-study on how a new instructor, experiencing such discomfort, was experiencing a transition in which her epistemology of science was being challenged. The implications of the findings, which derived from critical friend meetings, journal entries, and student artifacts from the scientific inquiry course she taught, serve to inform the field of science education in terms of new science teacher educators moving from a traditional teacher-centered science classroom into a student-centered classroom.

Introduction

To be effective science instructors, teachers must understand the conceptual underpinnings of scientific inquiry. Science education research, however, has shown that teachers often lack such understandings (Lederman, 2007). Thus, the development of science teachers who have an adequate theoretical and practical understanding of scientific inquiry is a worthy goal of science teacher preparation programs. This is the reason for the course, *Introduction to Scientific Inquiry*, in the school of education where one new instructor, a doctoral student, was transitioning from a science teacher to science teacher educator. As a new instructor for this course, she was informed that she was not only expected to foster an understanding of science and scientific inquiry for the preservice teachers, but also serve as an inquiry teaching role model. She noted that when she first began teaching this course, she would leave class with a feeling of uncertainty as to whether she was actually teaching science. Although prepared for the familiar feeling of unease that exists when you teach a class for the first time, she was unprepared for the feeling of anxiety that came along with teaching a science course that focused on science and scientific inquiry. In fact, she had never thought of those things as a part of course curricula. This feeling of anxiety became a major source of tension as she began to teach this course, which in her mind, did not fit in the category of science. This course had presented her with new challenges that she was attempting to navigate her way through while still maintaining what she hoped was a worthy science class for her students.

The term "scientific inquiry" was admittedly unknown to her both in terms of her own education and traditional university science teaching prior to beginning a doctoral program in science education. Llewellyn (2002) defined it as "the scientific process of active exploration by which we use critical, logical, and creative thinking skills to raise and engage in questions of personal interest." Schwartz, Lederman, & Crawford (2004) extended this definition to "…the characteristics of the processes through which scientific knowledge is developed, including the conventions involved in the development, acceptance, and utility of scientific knowledge" (p.8). The U.S. national science standards, The Next Generation Science Standards (NGSS Lead States, 2013), defines the scientific process as 'science practices,' which they define as the various ways that scientists gain knowledge and include such activities as evaluating evidence, analyzing data, constructing explanations, and communicating findings. These practices have been stated to be vital to students having greater success and motivation to learn, appreciate, and persist in science (Akcay & Yager, 2016). Science practices engage students in inquiry and aid in student learning and understanding of science. As a new doctoral student teaching a course titled *Introduction to Scientific Inquiry*, she found herself, for the first time, reading these definitions and

realized a need to further explore her own understanding of scientific inquiry and how it relates to her conceptions of a university science classroom. Over the past several years she had taught a variety of heavily content focused science courses using traditional teacher-centered instructional methods with little to no explicit emphasis on scientific inquiry. Consequently, as someone who had not previously been part of a classroom experience where the nature of science or scientific inquiry were explored through inquiry-based activities, this type of content and teaching, while she believed it to be worthwhile, quickly proved to be quite challenging. Thus, she became an ideal primary participant/researcher for this self-study group.

As the students that are accepted to our doctoral program and hired for these teaching positions all have a strong background in science, we assumed they all would possess a high level of comfort and understanding in the course and could jump right in. We came to realize that this assumption was surprisingly flawed. Thus, we turned our attention to working with this new instructor as she explored her epistemology of science and the ways in which it was influencing her theoretical and practical understandings of science and scientific inquiry. The purpose of this self-study was to support one new instructor's efforts to find comfort with science inquiry and to further develop her identity within the field of science education. This effort has followed a pathway of personal meaning making that progressed through the ten phases of Transformative Learning (Mezirow, 2000) and highlighted three areas in which breakthroughs in personal and professional growth occurred along the way. The guiding research questions for this self-study were (1) What does science and scientific inquiry mean to a new instructor in this program?, How do these meanings change over the course of the first year? and (2) What does a new instructor believe is a teacher educator's role as a teacher of scientific inquiry? How does this belief change over the course of the first year?

Theoretical Approach

Transformative Learning

A reflective process can lead to personal and professional growth that would be related to one becoming their more authentic self (Mezirow, 2000; Mezirow, 2009). How we look at our own experiences comes through a lens, a frame of reference, which is based upon our personal history including our education, socioeconomic status and family composition, amongst others items, and through which our point of view is focused (Mezirow, 1997; Mezirow, 2000). Transformative Learning is defined as the process of affecting change in one's frame of reference by challenging and reflecting upon one's own assumptions. It occurs when one's values and sense of self, a comfort zone based on background, is challenged by a disorienting dilemma that is followed by an alteration of one's frame of reference and succeeding point of view (Mezirow, 1997). As stated by Mezirow (2000), this disorienting dilemma can cause transformation in four ways: the frame of reference may be elaborated, a new frame of reference may be learned, a point of view may be transformed, or a habit of mind, described as how our point of view is shaped, may be transformed (Mezirow, 2000). In terms of this study, subjective reframing was looked at because it includes a critical self-reflection of one's own assumptions, ideas, and beliefs about the workplace and may lead to personal growth (Mezirow, 1997; Mezirow, 2000). Examining the background of how we know, reflects our knowledge base and why we hold core interests (Habermas, 1984). Recognizing one's view of the world in terms of adult education only aids in moving both society and individuals forward while leading to better educational practices (Christie, Roberstons, & Grainger 2015; Hoggan, 2016). In order to explore epistemology and the alteration that is occurring, Hoggan (2016) pointed out that depth, breadth, and stability must be considered. Transformational Learning Theory provides a means in which an alteration of epistemology may be contemplated in terms of examining transitions between careers (Mezirow 2000; Snyder, Olivera, & Paska, 2013).

Identity

For preservice teachers, understanding that being a lifelong learner is part of their newly constructed teacher identity, is valuable for a successful career that should include reflective practices and a high sense of self-efficacy (Bandura, 1977; Graham & Phelps, 2003). This is also valuable for teacher educators in a transitional phase, who must also construct a new meaning of what their educational practices are and examine their sense of self. Looking back at one's past experiences and influences can aid in seeing where beliefs about the role of teacher began and inform one in how to expand, modify, or change that role through altering our beliefs (Eick & Reed, 2002; Kagan, 1992; Adams, 2015). The process of becoming must also be considered when discussing a career transition that requires the integration of two identities (Dinkelman, Margolis & Sikkenga, 2006). Dinkelman (et al 2006) further spoke of teachers retaining parts of their former identity as a teacher while

constructing a new identity as a teacher educator while Newberry (2014) brought up that a resistance to merging competing identities in the field of education, may cause the processes of growth and construction to stall. Teachers who become teacher educators also have struggles with this identity shift as Garbett (2012) stated, while also discussing how the work on her self-study and the allowance for the merging of identities altered her view on what she, as a teacher educator, would focus on in her classroom. It was found in a study by Varelas, House, & Wenzel (2005) that scientists transitioning to science teachers also found challenges with identity constructs but that tension between identities caused a push for growth and there was no complete overhaul of self, but instead a modification. Looking at the self as a teacher and exploring one's identity as a means for growth within a new educational role, may lead to challenges, but also may lead to the emergence of a newly defined role.

Literature Review

Challenging one's own assumptions and beliefs concerning teaching is key to growth as an educator. Coleman & Leider (2014), designed a science curriculum that aligned with their personal beliefs about teaching. During the process of working with this new curriculum, they had to face their own fears concerning the possibility that it would not work out like they had thought it would. While moving toward a more student-centered classroom, they needed to deal with the fears of relinquishing control and appearing vulnerable to their students. By moving out of their comfort zone and designing a curriculum that aligns with their beliefs concerning teaching, the researchers were able to work on improving their practice as learners alongside their students. Through a self-study where Garbett (2011), challenged her own assumption that knowledge of science content was enough of a basis for effective science teaching practice, it was found that this was not the case at all. The researcher felt that her confidence with science might have caused a loss in terms of having a dialogue with preservice teachers about their understanding of learning to teach. Krajewski & Schwartz (2014) found that challenging their assumptions of how to run a college level student-centered classroom by incorporating the nature of science, may lead to a classroom where there is more student understanding. Through the process of self-study, the instructor was able to successfully incorporate science process skills into her science class, which altered her own views on science education and how she teaches science. Using self-study to challenge one's own teaching beliefs and values can be uncomfortable and cause tension (Coleman & Leider, 2014; Garbett, 2011). However, this also serves to illuminate areas for growth as an educator.

Transitioning from one career or educational experience to another may bring both positive and negative aspects into full view. Gatzke et al. (2015) discussed the internal tension associated with how she viewed herself as an environmental educator navigating her way through a science education doctoral program. She found that by examining the tension in her transition, she was able to define her role as an educator and her role within her graduate program. Garbett (2012) found that by continuing to develop as a teacher educator that considers the added complexity of teaching about teaching, she was able to go beyond and enhance her value as a former classroom teacher. Similarly, Trauth-Nare et al. (2016) spoke of her confidence with didactic teaching from prior professional experience as a science educator and uncertainty when fostering relational pedagogy in the classroom as a teacher educator. The struggle to fully relinquish control of the classroom was noted along with the overall trajectory of allowing students to discover the scientific process and an increase in effectiveness of class discussions. Adams (2014) spoke of the initial fear when faced with transitioning from a teacher to a graduate student to a teacher educator and the "joyous awakening" that occurred during this period. Transitioning from one professional role to another is a complex journey that benefits from thoughtful reflection in order to successfully navigate through it.

After one challenges their own beliefs and values concerning teaching or negotiating the tensions associated with a professional transitional period, one must also make meaning out of what is occurring. Gatzke (et al 2015) discussed that a past identity does not have to be the only identity. Through identity questioning, one may be able to find a common thread between their former role and their new role. Garbett (2012) spoke of how her self-study highlighted a disconnect between her former role as a science teacher and her new role as a teacher educator. This disconnect led to the author having a new vision of herself in a newly defined role. Making meaning out of journey can also be served by looking back at inspiration for entering the teaching profession as stated by Adams (2014). For Trauth-Nare (et al 2016), the meaning-making journey led the instructor to acknowledge their newfound comfort with sharing authority in the classroom. A college science instructor found that she was able to make meaning out of her role in the classroom as someone who had the ability to convey the nature of science to her students even in a tightly packed curriculum (Krajewski & Schwartz, 2014). Coleman & Leider (2014) discussed how their decision to try a new curriculum led to them viewing themselves as lifelong learners along with their students.

The literature reveals that in order for a new instructor to transition into a science teacher educator, it is imperative for that person to unpack her understandings so that she can make meaning out of it and use that knowledge going forward. Though there have been studies on transitioning between roles and challenging one's own beliefs and assumptions concerning education, there is little discussion of how a science teacher's theoretical and practical understanding of science affects their role and their potential for growth in an inquiry-based classroom.

Methodology

The purpose of this this study was to explore how a new science education instructor, noting discomfort with contemporary practices emphasizing scientific inquiry and inquiry-based instruction, experiences the educational transition into science teacher education. As the instructor's theoretical and practical notions were being explored, it was essential that she be the primary participant and lead researcher, thus we took a self-study approach.

Methodological Approach

John Dewey (1910) pointed out that there is no need to reflect if the path is smooth, but when there is a dilemma, or a situation that causes discomfort, our need for a solution requires reflection. Discomfort caused by mismatches between beliefs and practices require reflective research as a foundation to highlight the opportunities for growth and the curative effects of a resolution (Loughran, 2011; Lovin et al 2012). It was a sense of discomfort that initiated this journey and the need for a reflective research approach was imminent. In addition, identity issues with transitioning between careers also serves as an opportunity for professional growth as identity is entwined with the how and why of teaching about teaching (Davey, 2010). Thus, in order to examine the internal conflict she was experiencing during the transition from running a teacher-centered science classroom to a student-driven science classroom while also questioning her own understanding of scientific inquiry, a self-study methodology was chosen for this research. LaBoskey (2004, p. 18), stated that "Self-study researchers are concerned with both enhanced understanding of teacher education in general and the immediate improvement of our practice" which is what the purpose of this study was: to find her identity in this new educational setting and enhance her teaching efforts. A rigorous self-study methodology with a clear purpose, the scholarship of practice advances the field of teacher education through development of new insights into teacher education practices (LaBoskey, 2004; Loughran, 2007; Loughran & Berry, 2005).

Context and Participants

The primary participant in this self-study was a first-year doctoral student beginning her second semester on an appointment as an instructor for an undergraduate course. Prior to entering the doctoral program in science education, she completed a Bachelors and Masters degree in biology and a second Masters degree in adolescent education. Secondary participants included two science education professors. The professors served as her critical friends (Schuck & Russell, 2005). As critical friends, they supported the construct validity of the self-study process, aided her in identifying assumptions, challenged her assumptions and supported her in ultimately reframing her perspective as a science teacher educator (Loughran, 2007; LaBoskey, 2004). Also serving as secondary participants were the undergraduate students enrolled in her course. The participating students enrolled in the course (N=22) agreed to serve as participants in the study.

This self-study focused on the new science teacher instructor's experience in teaching a university course on scientific inquiry. There are typically 7-10 sections of this course offered every semester. The majority of the undergraduates who enroll in this course are freshmen and sophomores from a variety of education majors such as elementary education and early childhood education. The goals for this course include: (1) examine the nature of science, (2) enhance understandings of scientists and scientific careers, (3) experience creating scientific understandings from inquiry-based interactions, 4) develop/refine the lab skills necessary to be successfully engaged in scientifically-oriented questions, 5) develop a thorough understanding of scientific inquiry, 6) experience science inquiry through the theme of environmental science, and 7) refine skills at making relevant life decisions based on evaluating credible scientific evidence.

Data Collection

Data collection for this self-study included:

Journaling. The instructor maintained a reflective journal over the course of this study in order to facilitate and capture reflection-in-action (thinking while doing the task) and reflection-on-action (thinking after the task) (Schon, 1983). Over the course of the semester, approximately five journal entries a week were completed: one before and after each class, and one summary journal entry encapsulating the entire week. Journal entries reflected her thoughts on the course material, teaching method, and background in teaching and learning.

Critical Friend Meetings. Critical friend meetings occurred throughout the self-study process . A strong focus was placed on discussing the journal entries, although input was also provided on the interpretation of the discussions and the surveys. Critical friend meetings were used to challenge her interpretations throughout the course, and to challenge her reflections in subsequent journaling. A total of five 60-90 minute critical friends meeting occurred over the course of the study.

Student Surveys. The students were given a brief short-answer survey to fill out, approximately two weeks before the end of the semester. The purpose was to determine if they felt they were learning science, how they were defining science, and if they felt that their overall viewpoint of science was changing. Sample questions included: 1) When you think of science, what are the three words that come to mind?, 2) What does science mean to you? and 3) Did you feel that you learned the same/more science in this class compared to others you have taken in high school or as an undergraduate?

Course Documents. Although the following documents are used in the course to assess students' understandings of scientific inquiry, we used the students' responses on them to explore the instructor's thoughts/actions in regard to scientific inquiry and teaching. Thus, they are used as descriptive data for this study. ***VOSI-2.*** As a part of this course, students complete the Views of Scientific Inquiry-2 (VOSI-2). The modified course questionnaire of eight items was developed from questions in the pool of Views of Scientific Inquiry items (Schwartz, Lederman & Lederman, 2008) that specifically address the aims of the course. The students completed the modified VOSI-2 in partners to stimulate discussion and search for consensus. Individuals then submitted reflections of the experience. Sample questions included: 1) What types of activities do scientists do to learn about the natural world, 2) How do scientists decide what to investigate? and 3) What does the word 'data' mean in science? ***Reflections on the Myths of Science.*** This course worksheet, Reading Reflection for McComas (1996) *Ten Myths of Science,* was given out early in the semester. After reading the article, Ten Myths of Science: Reexamining What We Think We Know… (McComas ,1996) on their own time, the students submitted their reflections and took part in a class discussion. This served to aid in gaining perspective on what types of myths about science students generally hold, and their overall view of science as a subject. ***Photovoice Project.*** Photovoice has been defined by Wang & Burris (1997) as a process by which people can identify, represent, and enhance their community through a specific photographic goal. For this course assignment it was used to establish a connection and an understanding of views of science, as described by Whitfield & Meyer (2005) who found it valuable to include discussion as well as student reflection on their photographs. Students were asked to take up to five pictures over one week's time that represented their answers to the following questions: 1) What is science? and 2) How do you feel when you think about science? Each student then presented the photographs to the class and explained their meaning.

Data Analysis

Data analysis occurred in two phases. Phase one took place during the course. The instructor analyzed her journal, student surveys and course documents based on the three research questions prior to each critical friends meeting. During these meetings, the group would critique her epistemological and pedagogical understandings, as well as analysis. She would then reflect on this intermittent analysis in her journal. These reflections then became a part of the data set in the form of transcripts of critical friends meetings and additional journal entries. This progressive analysis was critical for changing and directing emerging understandings. The second phase occurred once the data collection was complete. We compiled all documents and then analyzed them using thematic analysis (Glesne, 2006). Data were coded based on the questions for this self-study: (1) What does science and scientific inquiry mean to a new instructor in this program?, How do these meanings change over the course of the first year? and (2) What does a new instructor believe is a teacher educator's role as a teacher of scientific inquiry? How does this belief change over the course of the first year?

Once data were coded, segments of data were then segregated by codes for further analysis and description. The keywords that emerged from this process, along with their derivatives, were: fun, bored, sad, average, difficult, easy, natural world, creative, stressed, annoyed, baking/food, turmoil, sometimes (positive or negative), procedural. Any sentences or phrases that contained these words or their synonyms were ultimately pulled out of the artifacts and coded. During this second phase of analysis, we reviewed the data sources, instructor's analysis, and the codes that emerged. Together, we added additional codes and conducted further analysis.

Findings

This self-study focused on one new instructor's practice in an elementary science teacher preparation program that emphasizes scientific inquiry and inquiry-based pedagogy. As such, the new instructor is the primary participant and first author. In light of this, we feel it is essential that she provides the narrative that emerged from our collaborative exploration. We now switch to the use of 'I' throughout the findings section in order to allow that narrative to be conveyed.

What Does Science and Scientific Inquiry Mean to Me? How Did These Meanings Change Over the Course of the First Year?

In terms of my own epistemology of science, a struggle to fully alter my point of view still exists, but personal transformative growth has occurred directly as a result of the examination during this self-study (Mezirow, 2000). Critical friend meetings were the primary sources of growth in terms of my views of science, along with the journaling that occurred when reviewing my notes from the meetings. During these meetings, my assumptions were challenged, thereby reframing my perspective (LaBoskey, 2004). Excerpts from notes from the critical friends meetings highlight the importance of using a critical friend in a self-study and the value of having a qualified individual to both challenge and question your thinking (LaBoskey, 2004; Loughran, 2007).

> *Author 2 kept commenting that when I was speaking about how much I loved science it was when I was speaking about actually doing science (lab work, field work…) but when I spoke about what science actually is, I kept mentioning that it was content and memorizing many chapters worth of difficult material. So… what is science?? I completely contradicted myself and I didn't even realize I was doing so. So it seems I need to find where the 'two' sciences meet in my mind. Is it both, one or the other, I have no idea. I need to figure out what my definition of science is.* Critical friend notes 1/29/2016

Slightly further along in the semester, I was still struggling with my definition of science and how I viewed the discipline of science. I no longer saw myself as a **science** teacher and felt lost in terms of my role in the classroom. My critical friends noted that I should explore my own background in science and my attitude towards science. After that meeting, I noted:

> *I also want to know where my attitude towards science came from as I have absolutely NO recollection of any science before 9th grade when I took earth science.* Journal Entry 2/18/2016

This journal entry went on for over four pages detailing the science courses I took in high school, my experiences with science throughout undergraduate and graduate school, as well as my informal learning experiences. Unfortunately, there was no discovery as to where my positive attitude towards science originated. I realized that my educational background is a mixture of courses where I memorized facts and courses where I was able to explore concepts more freely. Adams (2004) pointed out that looking back at inspirations to become a teacher is valuable for making meaning of journey and I found that here. Reflecting on my personal history as a science learner did not elucidate why I have a passion for the field of science but it did aid me in remembering that I do posses that passion and that is precisely why I am in the field of science education. Prior to the next critical friend meeting, I journaled that I had an epiphany while working at a biomedical lab that required the use of frogs:

> *Major epiphany!! While I was cleaning the frogs, it literally just popped into my head that this is what science is – doing. This is science-working at labs, fieldwork, actual activity. The content needs to be there as a foundation but what we're missing in classrooms is 'DOING' that is science!* Journal entry 3/17

I did not have a full definition of science but I finally realized how it was more than scientific facts, laws and theories. At this juncture, I knew that the way I had subconsciously been defining science was not an accurate portrayal of the field of science and it was most likely contradictory to why I have enjoyed science since childhood. During the next critical friend meeting, they once again pushed me by challenging my thoughts on a separation between my understandings of content and inquiry. I was understanding the 'content' of science to only be those facts, laws and theories and 'inquiry' as a merely a type of pedagogy to deliver them. We discussed whether understanding inquiry is actually a critical part of understanding science itself? My critical friends asked me how this relates to the course I am teaching and to expand upon whether or not I feel like a science teacher when I teach about scientific inquiry. At this point, I still did not fully feel like a science teacher as the discomfort from merging identities of my former career with my current career was still present.

Mezirow (2009) discussed how "discourse is the forum in which 'finding one's voice' becomes a prerequisite for full participation" and discourse was what I was experiencing. Although I cognitively knew my new purpose in the classroom, I still hadn't fully reconciled the identity shift. As the semester went on, I had resolved that the identity shift would take longer than a semester. I knew that my overall view of science as being driven by traditional content standards was evolving to include science also being a process and a way of knowing, but I felt I still had a long way to go. I believe I reached the point of no return to my traditional understandings when I found myself referring to Barton's (1998) statement; "Scientific knowledge is reflective of nature's holistic, interactive, and complex existence". For me, science became more than those facts, laws and theories.

Even though I knew that my view of science had changed, I found it hard to state that my epistemology of science had fully changed. This became quite evident during two critical friend meetings that occurred after the semester had concluded. Through these meetings, I found that although I felt confident in what science was not, I was not confident it what it was. I felt that I was just ever so slightly distant from having a definition of science that really connected with my background in science and where I wanted to go as an educator.

> *Okay, so I still can't really call inquiry content. I feel beyond frustrated as I know where I want to be but I just can't get there. I cannot say 'Yes, that's it!'* Critical Friend Notes 5/8/2017

At the moment where I felt the most stalled in my growth, unable to define science and fully separate it from my traditional understanding of content, I turned to the simple act of looking up the definitions of 'science' and 'content' in a dictionary. Reading the dictionary definitions of the terms I had been struggling with allowed me to expand my personal thoughts on science. Perhaps how I've viewed science all this time had been a personal misconception of the field that I've been holding onto since I was in grade school. A critical friend who had been listening to my comments on definitions of science suggested that I may need to examine my views on the nature of science. Nature of science was yet another term that should have been obvious for me, but was something I was unfamiliar with before joining the graduate program. As discussed by Lederman (2007, p. 833) "NOS (nature of science) typically refers to the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development." Karakas (2008) found that the majority of participants in a study on college science faculty held naïve conceptions regarding the nature of science: notions I realized I held. During this same meeting, my critical friends tried to get me to once again elaborate on how I defined science. Throughout the meeting, I felt very frustrated and began questioning my entire self-study and how I've been teaching. Again, I had felt so close to reaching some type of understanding when the brick wall appeared. My critical friends pointed out that even though I could define the nature of science, and had in fact taken a course on it, I was still having trouble letting go of long held beliefs about what science.

In a study by Akerson, Abd-El-Khalick, and Lederman (2000), it was shown that there is tenacity in which learners hold onto those beliefs. My beliefs took over twenty years to develop and they weren't easily changing. Upon reflecting on this conversation, I decided that I was not hitting a brick wall but realizing I needed to keep examining my beliefs regarding the nature of science. For me, my epistemology of science was evolving with the new knowledge and realizations I have gained through this self-study. I know that this growth will continue as I move through this doctoral program and my career. Being a reflexive educator requires a commitment to lifelong learning that is often accompanied with uncomfortable periods of growth. However, as a result of my struggles, I truly believe I became a better educator. In addition to fostering an evolution in my own understandings of teaching science, I am now better able to communicate what science is to my undergraduate students.

What Do I Believe Is a Teacher Educator's Role as a Teacher of Scientific Inquiry? How Did This Belief Change Over the Course of My First Year?

During the self-study process, I also had a breakthrough concerning the relationship between my epistemology of science and my role in the classroom. In the beginning, I believed my role was to be engaging, but only while conducting a very teacher-centered classroom where I provided my students with the facts, theories and laws. I believed I should create classes with many activities: ones in which I took the lead role. I was extremely comfortable with giving science content to students of a variety of learning abilities. However, after my first semester teaching about scientific inquiry, I did not feel comfortable at all. My self-efficacy lowered to a point that I was no longer comfortable. Bandura (1977) noted that self-efficacy in one area can generalize self-efficacy in another, similar area. I came to realize that although I was struggling with my teaching role and wondering about my career decision, I had a high self-efficacy in the fact that I could find a way to grow and learn from this discomfort. Overall, this was a disorienting dilemma (Mezirow, 2000) that I journaled about extensively in the first few weeks of the semester in which this research was conducted. Each journal entry was guided by questions decided upon prior to the beginning of the semester.

> *I do not feel like a science teacher at all. By that I mean that I am not teaching the content I feel is real science. No taxonomy, no formulas, no identifications, definitions, dissections, anatomy and physiology…I am so used to science courses being amount mass amounts of information and structured labs that I am struggling a bit with the inquiry based method. I enjoy guiding my students but I feel like I'm not that needed in the classroom.* Journal Entry 1/19/2016

About a week later, I was still struggling with feelings that I was not needed in the classroom and I wasn't giving the students a large amount of content. However, I realized I was enjoying my students and their level of participation in the class. I realized that although the tension between how I viewed science content and the new view of science content was present, the level of enjoyment with being an educator was not in question.

> *I definitely do not feel like I had enough to do. I didn't like the tops activity last semester and still do not. They're adults so there is only so much you can facilitate while they are building tops. Quite honestly, I was bored. This group really seems to be getting comfortable with one another and the fact that this class is interactive. They actually give opinions and participate which is great so early in the semester* Journal Entry 1/27/2016

A few weeks later, I assigned my students a photovoice project. At this point I was still feeling conflicted in terms of the amount of content I was teaching and trying to figure out how I viewed science. Subsequently, I came up with an assignment that would allow me to get to know my students' views about science and what it means to them. Each student was required to answer two questions by taking two to three photographs that expressed their answer. They were then to explain these photos to the rest of the class. This project turned out to be a tremendous, unexpected breakthrough for me in terms of how I view my role as a science teacher educator. According to Wang and Burris (1997, p. 382), "Photography provides the medium through which people's visions and voices may surface"; the students' voices in relation to how they feel about science certainly surfaced. Prior to this assignment, I had no idea how students felt about science as a subject and this served as a connection point between myself and my students (Meyer, Helen, & Kroeger, 2005). The work the students produced along with their explanations were eye opening and individualistic (Schell et al., 2009). When I posed the question 'How do you feel about science?' thirteen out of twenty students communicated their negative view toward science while six had mixed views, leaving one with a positive view of science. Through this assignment and the classroom discussion that followed, I learned that my students overwhelmingly had a poor view of science and did not enjoy it. This alone illuminated my new role: someone who doesn't necessarily need to feed students large amounts of content, but someone who may work to aid them in appreciating science and becoming more scientifically literate. While my other breakthroughs took more time and are still a work in progress, this one came almost in an instant with one assignment. This new role has come along with a new goal: guide students in dispersing their misconceptions concerning science, highlight that science is a creative process and way of knowing, and advance their scientific literacy. Yager (2009, p. 117) stated that " inquiry is a way for individuals to investigate and critically think about science with the goal of developing viable understandings and a positive, meaningful relationship with science" which exemplifies my emerging understandings of scientific inquiry. I have found where I fit in as an inquiry teacher with this goal as my guide to the purpose of how I run a classroom. This newfound sense of purpose was evident in my journal entries that followed from this point onward.

> *Changing the stigma associated with the definition of science will make it more accessible to kids and less meh as demonstrated by my students. This is fun!* (While working on an outdoor lab activity). Journal Entry 3/04/2016

While I felt more and more comfortable having a student-centered classroom, however, inquiry as content was still a source of discomfort for me as an educator. How can inquiry be two different things in one classroom? How can I call inquiry content? It was brought up by Lederman (2007) that the nature of science can be melded with scientific inquiry, which resonated with me. I was struggling with finding a base point in which to understand the nature of science, scientific processes, and inquiry as pedagogy as separate but related and how to make sense of it in my own classroom. One critical friends meeting comment made the connection that I was looking for in how to consider inquiry content when I was used to content being laws, theories, and formulas.

> "*This course is adding the piece of content that's missing"* Author 2 5/11/17

At this point, a great sense of relief washed over me as I knew my purpose in the class and how to use my role to best serve my students as both a student-centered teacher and one who teaches inquiry as content. The connection was finally made. Although I knew that science was more than what I had previously called content, I needed to find a way to place it in the classroom that made sense to me. Although an understanding of educational theories and practices may have existed, in order for me to direct change in my classroom, I needed to make meaning out of where they fit with my students and myself.

Overall, Am I Still a Science Teacher If I Am Teaching about Scientific Inquiry Through Inquiry-Based Instruction?

Science, as I understood it, was a tremendous passion and driving force that had shaped my identity for many years. Subsequently, thoughts that I would lose that part of my identity caused stress. Through this journey, however, I have discovered how to maintain that part of my identity while still moving forward as an educator. I found guidance from the artifacts my students produced as well as through the process of tracing my journey through the 10 phases of Transformative Learning (Mezirow, 2000). As part of the coursework, the students read an article that outlined 10 common myths in science, filled out a reflection worksheet regarding those ten myths, and then participated in a class discussion which was followed by an extension of that discussion in an online forum (McComas, 1996). The following sampling of excerpts from the online discussion allowed me to gain some perspective as to my student's backgrounds in science education, prior to university.

> *Did reading Ten Myths change your viewpoint concerning science? Is any of it different than what you already know?*
> *"The fact that teachers crammed these ideas down our throats throughout school really made science zero fun for me"*
> *"I believe that by emphasizing the idea of creativity in science could really help students engage and not make it seem so structured and boring"*
> *"Science was so boring for me in middle and high school just because it was so tedious and procedural and overall just not fun at all"*
> *"More students would think about making a career out of science if they knew how interesting it can be"*

Understanding that the students were not science majors, I didn't expect the majority to discuss how much they enjoyed science. However, I also did not expect that they would begin discussing how boredom, tediousness, and the procedural aspect to their lab activities played such a large role in how they viewed science. This discussion was a turning point for me. If I, with my background and interest in science, was struggling with my own ideas about the nature of science, my students were most likely struggling as well. I realized that if I want to enhance their scientific literacy, then fostering their understanding of the nature of science is vital (Lederman, 2007). The need to expose my students to every science fact, theory and law is dissipating as I now find a sense of purpose in sharing with them what makes science so engaging. They have many teachers exposing them to the facts, those that are missed can be looked up, but becoming a science educator that can show them what science is; a way of knowing with its own foundations in creativity. This was the first time that I felt purpose in my new classroom, as one part of my role is to guide students to become more scientifically literate. At this juncture, the merging of the two identities first began to take place. As was previously mentioned, my transformation is still a work in progress and will most likely be one for quite some time. While recording my journey through Mezirow's ten phases of Transformative Learning (2000), it was clear that I perceived my new role to comprise a loss in personal value; all of my study in science seemed to me slightly worthless if I wasn't

teaching science content. Upon further examination, I was able to view myself as a science educator through a new lens, my habit of mind had tentatively altered my point of view (Mezirow 1997, 2000). This growth occurred at approximately phase eight, which is a provisional trying of new roles, and is where I find myself at the completion of this study (Mezirow, 2000). The cause of dilemma has been identified, an exploration of my former and present roles has occurred, skills have been acquired to move into the new role, and a course of action has been thought out to move beyond this dilemma (Mezirow, 2000). However, I find myself not ready to completely move into the last two phases of transformative learning as I still am working on the merger of my competing identities.

Toward the end of the semester, a survey was administered to the students that asked them whether or not their view of science had changed. Thirteen out of seventeen respondents indicated that their view of science had changed in a positive manner with the other respondents indicating no change. This survey was an additional reinforcement that perhaps this is my new purpose as an educator, which is thereby shaping my new identity as a science teacher. As Garbett (2012, p. 42), so aptly put it, " I can blame self-study for destabilizing my sense that the role of a science teacher educator should be grounded on teaching science concepts, or I can thank self-study for providing liberating opportunities to develop a new vision of myself as a teacher educator." As personally demanding as this self-study was, the ability to reflect upon my beliefs and practices, have my assumptions challenged, and to examine my professional purpose and identity has proven to be invaluable.

Conclusions

Before entering into our program and taking this teaching position, there was not a mention of the nature of science or scientific processes in her classes: nor was there an explicit discussion concerning the creative aspects of scientific endeavors. The main focus was always preparing her for the next courses and making sure she left with a solid foundation of content. At the beginning this self-study, she thought that this was the only way to get the information across in a college classroom. However, as Lederman (2007) pointed out, she came to understand that in order to be scientifically literate one must understand the very nature of science. Not explicitly teaching this to one's students could hamper their ability to be scientifically literate citizens. Krajewski and Schwartz (2014) showed that aspects of the nature of science may be successfully incorporated into a college science course which illustrates that her notion that there not being enough time for anything but traditional content was a misconception. This misconception was spoken of in a study by Karakas (2008) where undergraduate science faculty were more concerned with covering traditional content and the majority held naïve conceptions of the nature of science. Through this self-study, she learned that she not had naïve conceptions of the nature of science, as well as scientific inquiry.

We will seek to take what we learned from this self-study and enhance their abilities to prepare future science teacher educators. Through this process, we have come to better understand how to convey the importance of professional growth to new instructors. In her self-study, Garbett (2011) spoke of her confidence with science perhaps causing her classroom to possess less of an emphasis on the discussion of learning to teach. Garbett (2012) approached this subject again and stated that "teaching about teaching is more complex than teaching a subject itself." Together, we captured the experience of this new instructor as she moved from an area where she felt supremely confident to having that confidence completely shaken. Dealing with this loss of self-efficacy in the classroom has been difficult but she came to understand how moments of transition that occur in reflective practices are often uncomfortable (Dewey 1910). According to Mezirow (2000), the better understanding we have of our self, the more authenticity we find in our experiences. He also noted that is not just a matter of allowing the time to participate in reflection, but also choosing to act on the subsequent understandings that leads to personal growth. Therefore, through what she noted as an uncomfortable self-examination of her place in the classroom and her thoughts on what science is, we witnessed this new science teacher educator develop.

At the start of this self-study, the new instructor journaled many times about not feeling like a science teacher anymore and how that feeling left her with a sense of uncertainty in regard to her professional trajectory. While she fully acknowledged that there is an ongoing merging of her identity as a science teacher and her identity as a teacher educator, by the end of this process she no longer felt anxious about her professional path. It was discussed by Kagan (1992) that professional growth by novice teachers, what we came to consider her new educational role, is both behavioral and conceptual with past and present experiences merging. The image of self as teacher plays an important role in professional growth. Image of self as teacher may also play a role in terms of how one perceives their fit in a career. One study (Snyder et al; 2013), spoke of those transitioning from STEM to teaching careers and how they needed to view this process as a social rebirth rather than social

death. In addition, Newberry (2014) mentioned how being resistant to identify as part of a new profession, may delay not only the merging of past and present identities, but also a sense of belonging to that profession. Coming from a non-traditional teaching background has added an additional layer of complexity in this journey to view myself as a future science teacher educator but it was pointed out that "Developing an identity and a set of successful practices in teacher education is best understood as a process of becoming" (Dinkleman, Margolis, & Sikkenda, 2006).

According to Mezirow (2000) a transformative learning experience will occur only when one acts on their newly gained insights. Altering your frame of reference and habit of mind are just pieces of the puzzle when transformative learning is the overall goal of a reflective process. Additionally, reflection is just a part of a self-study where one must possess a rigorous methodology and a focus on scholarship. It must also exist to transform yourself and your students (Laboskey, 2004; Loughran, 2007). Using the cognitive dissonance that often occurs during a self-study, one may push through the tension of professional growth, shed misconceptions about identity and epistemology of science, and act to align their teaching intentions with their teaching actions (Loughran, 2007).

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Author Information

Kerri Donohue
Indiana University Bloomington
USA

Gayle A. Buck
Indiana University Bloomington
USA

Valarie Akerson
Indiana University Bloomington
USA
Contact e-mail: *vakerson@indiana.edu*