J Sci Teacher Educ (2013) 24:1357–1379
DOI 10.1007/s10972-012-9330-z

The Influence of Informal Science Education Experiences on the Development of Two Beginning Teachers' Science Classroom Teaching Identity

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Published online: 27 December 2012

Abstract In case studies of two first-year elementary classroom teachers, we explored the influence of informal science education (ISE) they experienced in their teacher education program. Our theoretical lens was identity development, delimited to classroom science teaching. We used complementary data collection methods and analysis, including interviews, electronic communications, and drawing prompts. We found that our two participants referenced as important the ISE experiences in their development of classroom science identities that included resilience, excitement and engagement in science teaching and learning–qualities that are emphasized in ISE contexts. The data support our conclusion that the ISE experiences proved especially memorable to teacher education interns during the implementation of the No Child Left Behind policy which concentrated on school-tested subjects other than science.

Keywords Science teacher education · Informal science education · Identity development

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Introduction

Research into the use of informal science experiences within science teacher professional development has shown promise in moving toward science education reform goals (Anderson et al. 2006; Chesebrough 1994; Ferry 1995; Jung and Tonso 2006; Kelly 2000). Science education reform documents speak consistently to the importance and need for quality science teacher preparation (Australian Science Teachers Association 2009; National Research Council 2007; Osbourne and Dillon 2008). Yet, many elementary teacher candidates report that they feel unprepared to teach science (Kelly 2000). This issue is of particular importance given that primary school is the first time elementary students are formally exposed to science instruction. Research has shown that elementary teachers generally continue to lack the confidence and comfort from their own prior science learning to guide the science learning of their students (Eick 2009). Appleton (2007) concluded that there was sufficient evidence the teachers often avoid science teaching altogether. ISE puts an emphasis on affect and can encourage participants to enjoy science (NRC 2009). Our National Science Foundation (NSF) project (Project Nexus) was constructed to expose teacher preparation students to ISE to enable us to study their developing identities as teachers of science, even if they had begun with prior negative experiences. During the study, the No Child Left Behind (NCLB) act, with its language and mathematics accountability, came to limit the classroom science these teacher candidates might otherwise have experienced.

Gaining insights into and supporting elementary teachers' science teaching identity is crucial to defining how and with what attitudes they will envision the possibilities of what they can do (Settlage et al. 2009). Luehmann (2007) posited that teachers who develop an elementary classroom science teaching identity consistent with reform-based recommendations are more likely to implement teaching practices that better support their students' science learning. She said further that practice teaching in informal science settings was supportive. It appears critical then that new elementary teachers of science come to see themselves and are regarded by others as interested and enthusiastic, as well as knowledgeable, members of the science teaching profession and that experiences in ISE settings may be helpful in this process. There is some evidence that participation in an afterschool science enrichment program provides a place for novice teachers to try out reform teaching techniques (Cox-Petersen et al. 2005). Considering prior research we wanted to include in our study the proposed benefits of ISE participation and to study the effects on the science teaching identity of elementary teachers who are responsible for multiple disciplines in their classrooms.

Identity Development as a Theoretical Lens

The research on identity development in education has been a fruitful window for gaining insights into classroom science teachers' development. Gee (2001) described a "modern identity", as something fluid, a continuing, reflexive process of the way one sees oneself and the way in which one is regarded by others as a certain sort of person in a specific context (p. 112). In our context, teacher education provides a means by which university students come to participate as teachers as they transition to school communities where they may be regarded (or not) as successful professional science teachers. We see a theme of continuous tension in the evolving identities of teachers as they contend with how they are regarded in their school communities. (Brickhouse and Bodner 1992; Smagorinsky et al. 2004; Varelas et al. 2005). The tension (which was especially evident during the years that the NCLB policy was implemented emphasizing language and mathematics assessments over science) may well pull teachers toward job security and away from recommendations to effectively teach science that challenge status quo practices (i.e., a focus on information delivery). Eick and Reed (2002) found that teacher candidates with stronger inquiry role identities prior to student teaching benefited from a teacher education program that advocated an inquiry approach in teaching science. We wondered if ISE experiences could provide some of this prior knowledge before the Methods course. Walkington (2005) advocated for teacher identity development by encouraging teacher educators to move from a supervision model of teacher preparation that encourages socialization to a mentoring model stressing individualization. Our ISE internship provided an opportunity for more mentoring than the standard program. Wilhem et al. (2010) found differences in self-perceived science teaching competencies based on identity differences in science, pedagogy and curriculum expertise. Would our teacher candidates develop a greater sense of science competency after participating in ISE? Settlage et al. (2009) found teacher candidates did not focus on who they were and how differences between the teachers and learners might be considered in the teachers' approach to their teaching. Through our use of self-generated drawings, teachers reflected on these differences. Other researchers investigated programmatic changes affecting identity development. Graham and Phelps (2003) reported on a teacher preparation course in Australia designed to make identity development overt in teacher education. The course successfully emphasized that teacher candidates reflect and become metacognitive about themselves as expert learners. Beauchamp and Thomas (2009) concurred that teacher candidates would benefit from consciously focusing on how their identities were changing to become teachers within the supportive environment of their teacher preparation programs. Thus, the study of identity development to enhance teachers' success has become a fertile window of investigation on both individual and institutional levels.

In an earlier study, we drew upon identity development theory to examine how an internship in an informal afterschool science program impacted on teacher candidates as they moved through their teacher preparation program (Katz et al. 2010). Their identities generally shifted in varying degrees towards capable, reform-oriented science teachers. In the present study, we continued to investigate how the ISE innovations in the elementary teacher education program affected our participants as they began their professional lives as classroom teachers of science. Identity development theory again guided the research reported in this study, in which we sought to gain insight into the question, *how did the inclusion of an informal science internship and an informal science infused science teaching methods course influence beginning teachers' elementary classroom science teaching identity development?* By utilizing the emerging strands enumerated by the National Research Council (NRC 2009), we are drawing upon the designers of the Next Generation Science Standards to gain insights into how our teacher education graduates assume identities (or not) so that they will be regarded as successful reform-based classroom science teachers.

Context of the Study

This study took place as part of a National Science Foundation (NSF) funded project, Project Nexus (see, www.DrawnToScience.org), located at a Mid-Atlantic Research University. The project included an optional afterschool ISE internship followed by innovations in the required elementary science methods course emphasizing ISE resources. Descriptions of these components follow here.

Afterschool ISE Internship

The informal science internship that was offered and studied in this project was chosen because it provided opportunities for sustained co-teaching with experienced informal science teachers (known as adult leaders to avoid confusion with classroom teachers) in a low risk environment. The afterschool science program was designed for small groups based on age/grade to take into account children's general prior experience and physical development. A session typically continues over 3 months, providing spaced learning time for activities, conversation at home, and reflection for both children and those working with them. The activities could be aligned with National Science Education Standards to observe how they could support children's elementary school science learning (Katz and McGinnis 1999). See "Appendix 3" for the outline of grade 2–3 geology session.

The NSF project's teacher candidates interned in a weather and geology session, Some classes were outside, weather permitting. A typical class begins with a question that can be answered through the use of playful activities and simple materials. Along with adult leaders, interns asked questions that related fun to science exploration. The interns practiced answering with thought-provoking questions for the children. At the end of the activity time, children are gathered to consider the relevance of their play to decision-making or other questions in their lives. There are educators and scientists who have long connected the importance of play in developing skills and learning about the world (Ackerman 1999; Pramling-Samuelsson and Fleer 2010). The informal science internship occurred at the end of the teachers' second university year, prior to their science methods course. The interns were provided with the adult leader activity guides emphasizing inquiry (questions, discussions, and reflective time), manipulation of materials, and ways in which to capitalize on student interest. They took part in an adapted version (without programmatic paperwork) of the afterschool science program training and then participated alongside adult leaders during afterschool sessions with student groups of nine to eleven children.

Elementary Science Methods Course

The project's elementary science methods course is a required three credit course during the senior year of the preparation program. The project's sections of the elementary science methods course included sessions devoted to ISE. We invited informal educators to visit as guest speakers to discuss and demonstrate their perspectives on science education and focus on the unique characteristics and resources of ISE. We also devoted a class session to a virtual field trip with the *Marian Koshland Science Museum of the National Academies of Science*. We discussed how virtual field trips might be used by the teacher candidates as well as other potential advantages of connecting with ISE resources. There was also a global climate change module in which we used ISE resources. We promoted characteristics of ISE such as freedom of choice in selections of readings materials that connected with teacher candidates' interests. We demonstrated alternative forms of assessments. The details of this methods course can be found in an earlier paper (Riedinger et al. 2011).

Rationale and Purpose for the Study

We sought to continue investigating the longitudinal impact of our informal science infusion into the teacher preparation program as our students became full-time classroom teachers. We continued to use identity development as our theoretical window. We wanted to compare visual, as well as verbal data, and to explore a tool that we were designing for measuring the first year teachers' identity development within the strands/goals put forth in emerging reform documents, used as the "regarded by others" component of identity (Gee 2001). Thus, our study builds upon prior work in identity development, practice and the general improvement of elementary science teaching and learning by measuring itself through recent field-generated goals. Our previous report on the use of an ISE internship to assist in elementary science teaching identity found that participants benefited from the ISE experience by coming to think of themselves as more knowledgeable and confident in reform based pedagogy—inquiry techniques, active science, collaborative work, and the use of a variety of formal and informal resources (Katz et al. 2010). We also found that they modeled enthusiasm for science. We wondered if their emerging identities as classroom teachers of science with ISE experience would persist when they experienced the reality of being first-year elementary teachers.

Our participants had to transition from their familiar identities as university students to a less familiar role of a professional teacher (Danielowicz 2001). There are unique and broad challenges in this phase of a teacher's career (Kardos and Johnson 2007; Liston et al. 2006). The research on challenges for new teachers has been summed up by Davis et al. (2006). They found evidence that new elementary teachers tend to instruct less reform-oriented science than science education advocates would like to see, perhaps because they are at first focused on classroom management. The researchers further report in their meta-analysis that what matters most are personal characteristics of reflectiveness, personal history, self-efficacy and identity. They note that "there is little research on how some of these characteristics *develop* or *interact* with other factors" (p. 633). Based on their review, these authors suggest, among other things, that teacher educators provide opportunities for teacher candidates to engage in reform-oriented practices as learners, to perhaps co-teach, helping them improve their understanding and attitude toward science, including enthusiasm. This report is on first year teachers who were exposed to such opportunities and experiences as suggested by Davis et al. (2006) and by Luehmann (2007), who specifically considered ISE settings helpful.

Methods

Sample Selection

As a means to provide the voices of participants on the influence of the project innovations on beginning elementary teachers' identity development, we decided that case study methodology was most appropriate (Merriam 1998; Stake 1995; Yin 2009). We report here on the induction year experience of two project graduates (pseudonyms used). We selected these two teachers because they had notable commonalities and differences. They were both in their early 20 s. Both had stated that they had negative prior experience in their own science learning, a common barrier to successful science teaching (Appleton 2007; Eick 2009; Kelly 2000). The two teachers differed in their cultural backgrounds. Rachel is African American. She accepted a placement in a third grade class in a large suburban school district, with broad ethnic diversity. Renee is Caucasian and began her teaching career in a mid-Atlantic city school system that draws mainly from an African American population. They were working geographically close to the researchers' university to be accessible, and they were welcoming to research that focused on their thinking about teaching science. We wanted to gain insights into whether and to what extent the positive ISE influence found before graduation persisted, considering their similarities and differences.

Data Collection

We used both qualitative and quantitative analysis to gain insight into our central research question (Creswell 2003). In our study, we wanted to give voice to participants to learn their perspectives on the project's influence and their first year teaching science. Table 1 shows the schedule and types of data that we collected.

Qualitative Data

The initial open-ended questions via email were intended to elicit teachers' expectations of their induction year. We then formed a Facebook group as a method

Table 1 Data and collection schedule

May 2009	Interview and drawings at end of teacher preparation program
August 2009	Initial 1st teaching year open-ended questions (email)
Fall 2009	Facebook discussion
Winter–Spring 2010	Phone interviews and mid-year drawings
April 2010	Focus group
July 2010	Final interview and drawings

to collect further data from case participants. As a means to initiate a conversation between the participants, we posted the following discussion thread to our Facebook page: *As a new elementary school teacher, could you please share an example of how you have taught science this school year? Successes? Challenges? Questions?*

We also continued to collect drawing data in our study. As qualitative data, the drawings were used to stimulate conversation during interviews. Drawings were used earlier in the twentieth century as one social science data source (Goodenough 1926; Mead and Metraux 1957). Science education researchers have investigated students' scientist stereotypes and have also used drawings to assess interventions aimed at attitudes (Barman 1996; Beardslee 1961; Chambers 1983; Driver et al. 1983; Flick 1990; Huber and Burton 1995; Mason et al. 1991; Rosenthal 1993; Schibeci and Sorenson 1983; White and Gunstone 1992). The scientist stereotype exploration prompts came to be known as the DAST (Draw-A-Scientist Test), although one benefit of the method is that the participants did not view the procedure as a test. Thomas et al. (2001) developed and validated a checklist for the Draw-A-Science Teacher Test (DASTT-C) while exploring mental models and teacher beliefs. Finson (2001) presented preliminary findings indicating that teachers' self-efficacy and their self-images were correlated. Carnes (2009) used this visual data collection method with preservice teachers to find that they represented not only episodic memories but also educational philosophies.

Drawing is both appealing (White and Gunstone 1992) and supplementary to other kinds of data (Schibeci and Sorenson 1983). Katz (2002) altered the DAST to explore adult leader professional development in this informal science program. In our current research, we asked teachers to respond to the following drawing prompts: *Draw yourself teaching science* and *Draw your students learning science* at both mid-year and at the end of their first teaching year. They were provided with pencils and crayons and no other instructions.

The individual interviews were either conducted in person or over the telephone. Sample interview questions included*: To what extent, if any, do you identify as a teacher of science; How close are you from your ideal vision of a teacher of science; What type of induction program are you experiencing at your new school; What of your undergraduate teacher preparation program do you remember and use; and Do you receive any type of support for science instruction?* For the individual interviews, we also created personalized questions based on participants' previous responses to drawing and interview prompts.

The focus group interview questions included: *How do you see yourself as a teacher of science; how do you think others see you as a teacher of science; and what would strengthen your identity as a teacher of science?*

Quantitative Data

The quantitative analysis of the drawing data provided a means to apply emerging science education field standards as we considered the "regarded as" component of our beginning teachers' identity development. For the current research, we developed a new analysis tool that incorporated new perspectives on quality science learning presented by NRC (2007, 2009). We wanted to apply this new way of thinking to our research. We developed a rubric to do this based on the six goals/strands presented in recent reform documents (NRC 2007, 2009). As a means to address validity, we operationally defined our construct, professional identity development, by use of these six goals for measurement. Our coding scheme consisted of five discrete scoring levels within each goal. Each level was defined using observable drawing evidence to determine the extent to which the goals were illustrated. Our intent was to minimize inference by reference to agreed upon evidence in the drawings. Refer to "Appendix 1" for the drawing coding rubric and to "Appendix 2" for the explanation of the coding descriptors. The more evidence identified in the drawings, the higher the rating. As a way to enhance inter-rater reliability and reduce bias, three members of the research team coded each drawing individually, then met to negotiate discrepancies as a way to reach consensus. Once consensus was reached for scoring, the drawings and coding scheme were sent to a fourth member of the research group for further confirmation. Any discrepancies found during this second round were discussed until consensus was reached among the group. Following each iteration of coding the drawings, we modified the coding instructions for greater clarity. By comparing participants' first and final "*Draw your students learning*" and "*Draw yourself teaching science*" drawings using this rubric we had another way to analyze changes in identity. To examine any differences, we summed the teaching and learning scores for each case participant's drawing for the four strands we agreed could be analyzed by examining drawings for their initial and final drawings. We decided to do this as another way to consider each person's perspective of the two ways she drew her thinking about what was happening in her classroom. We recognize that alternative interpretations of professional identity development may result from application of a different choice of goals and coding scheme.

Member Check

When we had the first draft of our research report we contacted our participants by email and asked them for their reaction to it. We provided two questions: "What is your overall reaction to how you are presented in the text (data and interpretation of your identity as a teacher of science)?" And, "Are there any other things you would like to state about how your identity as a classroom teacher of science has developed over time, including what you believe it is presently?"

Data Analysis and Insights

Data Analysis

A qualitative methodology was used to interpret interview data, responses to open-ended questions and drawings. In analyzing the data we collected, we considered the goals or strands for science learning from *Taking Science to School* (NRC 2007) and *Learning Science in Informal Environments* (NRC 2009); both documents were published by the National Academy of Science in the USA. The earlier document

(NRC 2007) used four learning strands. The later document (NRC 2009) increased the number of strands by two to six, including an affective goal and one about identity as a science learner. We utilized the six statements of the NRC (2009) document on informal science learning because our project blended formal and ISE, because we believe that to teach science is to identify as a lifelong science learner, and because the teachers' science teaching work included encouragement in science learning for their students. The learning goals or strands are grouped somewhat differently in the two documents, but we view the *Learning Science in Informal Environments* (NRC 2009) document as inclusive of the strands in *Taking Science to School* (NRC 2007) while adding what we believe are important contributions to learning/teaching from informal science educators. The strands state that, "Learners who engage with science in informal environment… 1: Experience excitement, interest and motivation to learn about phenomena in the natural and physical world. 2: Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science. 3: Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world. 4: Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena. 5: Participate in scientific activities and learning practices with others, using scientific language and tools. 6: Think about themselves as science learners and develop an identity as someone who knows about, uses and sometimes contributes to science." (NRC 2009, p. 43). We found that the teachers' drawings provided useful data for strands 1, 2, 3 and 5. We used written and verbal data for information for strands 4 and 6 which center on mental activities not easily illustrated.

Members of the research team used methods of discourse analysis to conduct a line-by-line analysis of interview data, initially using the same six reform based goals. Three of us coded the interviews individually for each of the six goals identified and then met to discuss any discrepancies between coding. The larger research team provided more feedback, which was discussed and resolved for the final coding analysis.

We then we re-examined the data for additional themes that surfaced and were different from the six goals already identified. We also used analytical induction methods to interpret the responses to open-ended questions and drawing data. We grouped similar comments under thematic constructs.

Insights

Renee

Renee taught first grade at an urban public school in a large city. She prided herself on her organization skills and strove for success during her coursework at the university as well as in her classroom teaching. Prior to the informal science internship, Renee remembered her own experiences as a learner and stated "…as a student I never liked learning science or teaching it. It was one of the subjects in high school that I took the least amount of—I hated—and I think it was because of my experience." She continued, saying that she "wanted to experience something [the afterschool science internship] that sounded like it was a little different." (August 2010).

The afterschool ISE internship influenced aspects of Renee's identity as a beginning teacher of science. Renee had reflected on her own surprise just after her afterschool science program experience: "I was really impressed at how the program kind of changed that view of science for these kids because I was just so surprised about how excited they were to come to another class after being at school for eight hours." (September 2008). She drew on her internship memories when she described herself as a successful teacher of science:

> I think without the afterschool science program I wouldn't have …been kind of stimulated to get *into* science teaching. It's what really got me interested in science teaching, and I think it just kept growing and growing through this project and then through my student teaching and then, you know because I used a lot that I learned in the afterschool science program in student teaching. (August 2010)

An important change in Renee's identity as a beginning elementary classroom teacher of science is that she came to see herself as a teacher who makes an effort to provide science experiences for her students every day even with the school's emphasis on reading and mathematics. Renee noted, "… it's *always* about reading or math. It's almost like you would probably think science didn't exist… You *never* skip reading, *ever*. You have reading every day. It would be so nice to say you *never* skip science, *never ever*…" (March 2010). As her identity as a beginning elementary teacher of science developed over the school year, she came to see the need to make time to include science every day. "I think in the middle of the year I was still thinking of science as something extra in my day, whereas at the end of the year, during my planning I imagined science as an *important* part of our day that was not *extra*…. I think that was my main shift in focus between January and the end of the year." (August 2010).

Later, she reflected on changes that she intended to make in her teaching the following year. Renee said, "I hope to kind of establish that *interest* in science at the beginning of the year…it's not just something you incorporate after you get the management and the math and reading down and then it's like "oh, let's do science!" …we're going to do it and I think it will hold me more accountable to keep up the engaging science lessons throughout the year." (August 2010).

Renee illustrated notable changes in her techniques of teaching and learning science in her drawings as she underwent her teacher preparation experience. Renee came to align her teaching with reform-based practices, specifically the use of exploratory and more student-centered strategies. As we see in her teaching drawing before she participated in the NSF project, Renee viewed herself as leading the class and having control of the activities that were taking place (Fig. 1). Although she saw the activities as being inherently hands-on and engaging, she saw herself as prominently in control of the learning activities. In her drawing, we see a student engaged in a science activity as the teacher stands over him and directs.

Renee noted that when she first began teaching, she felt that younger students needed more structure, and as the teacher, her role was to provide this structure. In

Fig. 1 Renee's pre-informal science internship "Draw yourself teaching science" drawing

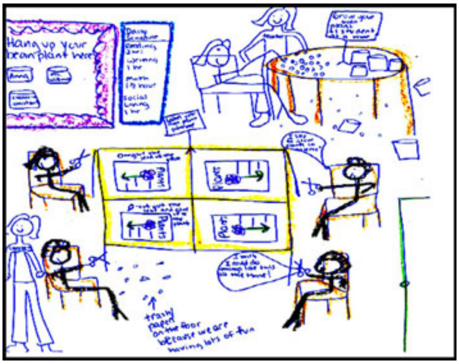

Fig. 2 Renee's pre-science methods course "Draw your students learning science" drawing

describing her beginning year student learning drawing, she pointed out that she still presented herself in a classroom in which the teacher was a dominant presence in the classroom (Fig. 2). Renee commented that the teacher would write an objective on the board and then teach a science topic as a whole group while students listened. Following the teacher's instruction, students would work independently or in small groups to apply the information that was taught by the teacher.

After her participation in the project's teacher preparation program and her first teaching year, Renee's views of science teaching and learning shifted to include student centered methods of teaching science. Renee notes this shift over the year when she comments, "I think that I found that when I did teach the direct teaching and the shared learning and exploring, I felt like exploring was the *only* part that my students were interested in. And I kept expanding that exploration part of our lesson until by the end of the year it was just practically our whole lesson" (August 2010). Our interpretation was that as Renee's identity as a teacher of elementary science developed, she began to align her teaching practices with those of reform-based science teaching. Renee continued, "I hate telling them how something's going to work. I did Legos at the end of the year and it was the coolest thing I've ever done with them—seeing them explore how to build things and figuring out things themselves." Renee specifically pointed this out as she reviewed her drawings and stated, "I see a pattern of *more* students being involved in the learning and less of me as it goes on—like I'm really big and front and center in the first picture and then at the end it's like the students are just as much a part of the learning as I am. So I feel like I'm in this shift from when I started."

Renee came to see herself as the type of person who enjoys science and is particularly enthusiastic about teaching science to her students. Her identity became one where she saw herself making an effort to include science every day in her classroom, even when the climate of her specific context discouraged her from doing so. Furthermore, we saw Renee aligning her teaching practices with those of reform-based science teaching. Over time, Renee came to see her students as capable of initiating learning and as such, began to favor student centered science learning in her classroom. Renee has already begun her graduate work with science courses in astronomy, satellite imagery, geology and meteorology. She has prepared the science curriculum for her next year based on her observations of her students' interests and has told us that she is willing to take the risk to support this approach, feeling more confident.

Rachel

Rachel's first teaching position was as a third grade teacher in a large suburban school system in the mid-Atlantic region of the USA. Prior to her participation in the NSF project, Rachel, like Renee, saw herself as fearful of teaching science. Before her science methods course she said, "I think just, in general, *I* personally have a fear of science I guess, because it's not my strongest subject" (September 2008). She illustrated and annotated her discomfort in her first drawing of herself teaching (Fig. 3). While she drew herself smiling, she is in front of a classroom where the students are not visible and where there is no activity. Rachel did not express a desire here to learn more about science as a discipline, but to be prepared to fulfill the next day's demands to teach a science lesson.

As Rachel looked at her last drawing of herself teaching (Fig. 4), she and we interpreted it as showing that she had come to see herself as an elementary classroom teacher of science who was involved with her students, and felt comfortable guiding them to explore on their own. Discussing her drawings, she said, "In the original one, I don't have my students in the picture at all and I have written a note at the bottom saying that is because I don't know much about science. I see myself reading instructions to teach myself about the experiment before attempting to teach the students. In the most recent one I am guiding the students, which is more of what I wanted to get to. I am not directly standing up and teaching them, which, I don't want to say is a bad thing for me to do, but I guess it's me letting them be more independent and explore on their own." (July 2010). Rachel talked about what she saw as a lack of support for science teaching on our Facebook thread. "I am finding that there aren't enough lessons in the guides provided to teach science as often as we should, so I am having to create or find a lot of supplemental materials." (Fall 2009). She now sees herself among her students, having given

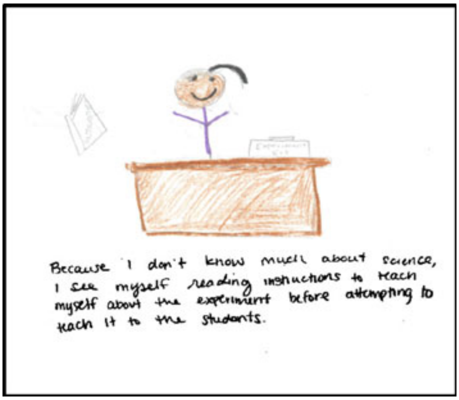

Fig. 3 Rachel's pre-informal science internship "Draw yourself teaching science" drawing

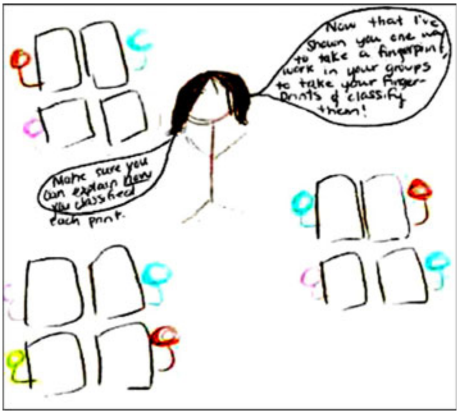

Fig. 4 Rachel's post-beginning teacher study "Draw yourself teaching science" drawing

them some basic instruction and asking them to continue independently in groups. She also asks them to be able to explain their decisions.

Rachel did not yet identify as a teacher of science. When asked directly about this, after her first year of teaching, she said,

Honestly. I would say that I *do* teach science, but I wouldn't call myself a reading teacher or a math teacher either. I just kind of blanket everything. As a general education teacher I do teach science, but I'm not at the point where I feel comfortable saying I'm a science teacher. (March 2010).

However, Rachel had begun to see science in a broader context. Later in her first year teaching she said, "Science is part of who we are, and I guess a way of life. And it is always changing" (March 2010). At the end of the study, she said, "Honestly I don't know how much I really consciously think of the world and then say 'oh this is science,'… maybe subconsciously I'm thinking of things that are related to science, but I don't necessarily make the direct correlation. (July 2010).

As Rachel completed her first professional teaching year, she drew her students present, grouped at a table, allowing for the possibility of collaborative work. Her drawing of her students learning illustrates one of the afterschool science program

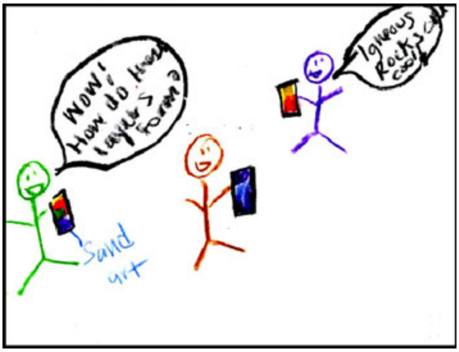

Fig. 5 Rachel's post-informal science internship "Draw your students learning science" drawing

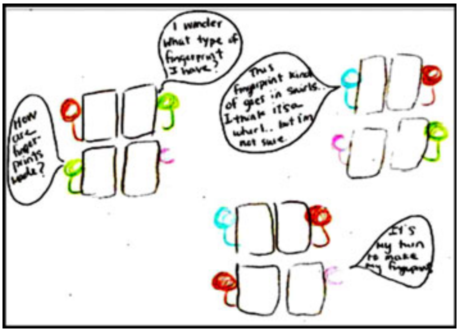

Fig. 6 Rachel's end of induction year "Draw your students learning science" drawing

activities from the Rocky Road session for 2nd and 3rd graders, where they were making and exploring layers of soil and rocks (Fig. 5). These children are not seated at desks in a formal manner. She shows excitement, a creative way in which to physically model layers in geology, and a child questioning within the activity, along with another child's use of a scientific term for a rock sample—"igneous."

Here we saw evidence that Rachel remembered the positive facets of learning science in which the afterschool science program students were involved. Prior to her methods class and after her internship, when she was asked what she remembered most, she said, "They learned, but it was really hands-on so they just seemed to be really excited to have something like that to do after school." (September 2008). When asked about the internship's influence on her teaching, at the same interview, she replied, "Definitely. They just seemed more eager to learn that way. And it was fun for me too!" At the end of first teaching year, her students are working in groups, wondering, taking turns. She has given them an active role that was not present in her earlier thinking, but she indicated was influenced by her ISE internship (Fig. 6).

In the middle of her first teaching year, she told us, "The ISE is having– being able to teach students about the world and things around them in a fun way… I know I personally learned better…by just being able to see it and actually *do* it, not just hear about it or watch someone else do it" (March 2010). And when her first teaching year was completed she said that she had changed by "just being enthusiastic about wanting to teach it [science]," a persistence of what she stated that she had experienced in the afterschool science program (July 2010). At the end of her first year of teaching, her illustrations had changed to reflect her changing classroom science teaching identity.

Reform documents recommend teaching in ways that encourage students to use materials, to inquire, and to collaborate as scientists do. Rachel provided evidence in her drawings that she sees herself facilitating a classroom where students ask questions, use manipulatives and work together. Her interview comments corroborate and clarify our interpretations of her drawings. In the middle of her first teaching year, she said, "it's [science] more fun because it's hands-on and I feel like the students really are more engaged when I'm doing a lot less talking and they can figure things out on their own" (March 2010). In reflecting on her approach to science teaching after her first year ended she said, "I think it's very important for students to be able to have discourse amongst themselves… they can rely on each other and have ideas bouncing off of each other and I think that's the best way for them to learn… we talked a lot about inquiry-based learning in our methods class…" (July 2010).

And yet, Rachel continued to claim that science teaching was not her strength. When asked where she would see herself in her identity as a teacher of science, she answered, "At the beginning of the continuum. I still have a lot to learn and that I want to be able to do and make time to incorporate. I think once I get a handle on being able to deal with the pressures of having reading and math and getting that organized where it needs to be, then I can start bringing in science more frequently and the way I'd like to." (March 2010). In her final interview, she was explicit about an identity of herself as empowered to proceed, while continuing to learn. And while *science teacher* is not a mantle she feels ready to don, she does not see herself as frightened by the prospect of teaching science:

> I know we've talked about this…that teachers are lifelong learners and we want our students to be lifelong learners, so I feel like I'm at the beginning of my learning stage and I'm really excited, especially after this year. I can say I *taught* third grade science and I need to work on it, but I don't know if I consider myself a science teacher… I mean that's definitely an area that I need to build my confidence in. (July 2010)

When Rachel read the research report, she reiterated her own negative experiences and said that things have changed for her over time. She had started to place more attention on her students' thinking and asking questions. She believes her students "express a stronger desire to learn," when she teaches science with an increased concern for their thinking and asking questions. Even though she acknowledged the demands to teach reading and mathematics, she stated that she has "grown to appreciate the importance of routinely including science." Of her teacher preparation components, she said, "… after actually doing the afterschool science program, realizing that the kids can be more independent and I didn't really have to do much *talking* while they were experimenting and I guess question answering, so I wasn't there at first and then here– was this the beginning?" (Fall 2010)

Table 2 Analysis of changes in case participants' initial and final drawings by strand

Strand	Rachel	Renee
Strand 1: Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world		
Initial combined teaching and learning score	7	6
Final combined teaching and learning score	3	8
Difference	−4	2
Strand 2: Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science		
Initial combined teaching and learning score	0	0
Final combined teaching and learning score	5	1
Difference	5	1
Strand 3: Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world		
Initial combined teaching and learning score	5	4
Final combined teaching and learning score	7	8
Difference	2	4
Strand 5: Participate in scientific activities and learning practices with others, using scientific language and tools		
Initial combined teaching and learning score	5	5
Final combined teaching and learning score	6	8
Difference	1	3

The quantitative analysis we conducted on the drawings helped us observe the changes. In Table 2 we examined the participants' drawings as they related to the goals for science learning.

With the exception of Rachel's score on strand 1, over time, the two project cases illustrated positive gains. We speculate that the decrease in Rachel's drawings score from strand 1 may be explained by two possibilities. Rachel reported that she came to see that science was not as highly valued in her school as reading and mathematics, two subjects which were annually tested. It is possible that this realization is reflected in her decreased score for strand one. Another possibility for her decreased score in this strand is that in redirecting her emphasis from herself to her students, she chose to illustrate their active engagement with science rather than show her or her students' own expression of excitement, interest, and motivation.

The combined evidence from the different data sources led us to conclude that the afterschool science program internship and informal science infused methods course in our project was a memorable influence in the two project participants' classroom professional identity development as beginning teachers of science.

Discussion

We found, just as Luehmann (2007) had suggested, that our two project participants had moved toward developing identities as elementary classroom teachers of science, with the help of ISE experiences that included reform-based characteristics. This supports previous findings of researchers who investigated ISE settings for professional development in either pre or post service contexts (Anderson et al. 2006; Chesebrough 1994; Ferry 1995; Jung and Tonso 2006; Kelly 2000).

By using the six strands from *Learning Science in Informal Environments* (NRC 2009), we found both qualitative and quantitative evidence that suggests that the ISE infusion was an influence in the development of participants' identities as classroom teachers of science (the focus of Strand 6). Specifically, the affective benefits (the focus of Strand 1) derived from the infusion of ISE contributed to developing how they came to see and enact reform-oriented science teaching practices (i.e., Strands 2, 3, 4, and 5). Our two case studies provide examples of how the persistence to teach science is in part due to how they learned to think of themselves while engaging in ISE activities, especially lacking a larger variety of other science teaching examples during the NCLB years.

As Dewey (1938, 1997) stated,

> We can be aware of consequences only because of previous experiences….we cannot tell just what the consequences of observed conditions will be unless we go over past experiences in our mind, unless we reflect upon them and by seeing what is similar in them to those now present, go on to form a judgment of what may be expected in the present situation. (p. 68)

Although attributing sole cause to the informal science education internship for the changes we found in our interns' professional science teaching identities would be a convenient interpretation, our research does not make that claim. We recognize that identity development is a complex process that defies simple answers. Instead, our research does suggest that the ISE internship contributed, in a way that we found discernible, to the direction it took in our interns during the time we studied them, which was positive. Certainly, in the context of the NCLB in which USA classroom science education has diminished and when it does occur is typically more direct instruction in style than investigative, the ISE provided our interns a strikingly different model of science education to attempt to include in their science teaching in formal contexts. As such, it makes sense that they came to view it as serving as a meaningful experience in their thinking about how they themselves could learn and teach science to their students.

Previous research has also indicated that a lack of confidence, little or negative prior experience with science and science teaching, and the constraints of the classroom context deter elementary teachers from teaching science (Kelly 2000). The focus on ISE in our project appears to have had a part in the development of the two case participant teachers' confidence and enthusiasm to teach elementary classroom science. Both teachers began their elementary teaching programs with a stated fear of teaching science, attributed to their own negative school experiences. Renee convinced us that she was now a confident and enthusiastic science learning advocate. Rachel is more hesitant at the term "science teacher," admitting that she was a work in progress. How much of this difference is the term itself or the result of many different, and perhaps confounding variables, remains a question for further investigation.

And, just as Brickhouse and Bodner (1992), Volkmann and Anderson (1998), and Watson (2009) reported, we found that the first year of elementary classroom science teaching was challenging to our two case participant teachers. Confidence in teaching science may lead to resilience (Graven 2004). Previous studies provided evidence that teacher candidates' confidence grows as a result of participation in ISE experiences (Anderson et al. 2006; Ferry 1995; Jung and Tonso 2006; Kelly 2000; Luehmann 2007). Our data adds to their findings.

Our methodological use of drawings to gain insight into participants' elementary classroom science teaching identity was useful to our study. The quantitative comparative coding analysis method we developed allowed us to analyze the changes in identity as related to emerging strands of science learning published by the NRC (2009). The ISE goals built upon and included the formal education goals. We believe our carefully developed coding rubric may be useful to other researchers in their investigations of teachers' teaching of science.

In conclusion, we believe our empirical study adds to the growing evidence that the inclusion of ISE experiences in elementary teacher preparation contributes memorably to new teachers' classroom science teacher identity for the twenty-first Century.

Acknowledgments This material is based upon work supported by the National Science Foundation under Grant No. 0455752. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. The Project Nexus research team at the University of Maryland wishes to thank the participants for their time and cooperation in this study.

Appendix 1

See Table 3.

Table 3 Drawings of science teaching and learning scoring rubric

Score	Description
Experience excitement, interest and motivation to learn about phenomena in the natural and physical world. [affective] (Goal 1)[a]	
4	Smiling figures and specific indicators such as the use of descriptive words "fun" or other exclamations of excitement, interest or motivation
3	Smiling figures or comments that indicate excitement, interest or motivation
2	Figures with facial expressions but ambiguous in regards to excitement, motivation, or interest
1	Negative facial expressions or comments suggesting lack of interest or motivation
0	No evidence (facial expression or comments) of excitement, interest, or motivation in the drawing
Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science (Goal 2)	
4	Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, or facts (4 or more present)
3	Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, or facts (3 present)

Table 3 continued

Score	Description
2	Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, or facts (2 present)
1	Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, or facts (1 present)
0	No evidence of concepts, explanations, arguments, models, or facts present
Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world. (Goal 3)	
4	Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing, or sense-making (4 or more present)
3	Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing, or sense-making (3 present)
2	Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing, or sense-making (2 present)
1	Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing, or sense-making (1 present)
0	No evidence of manipulating, testing, exploring, predicting, questioning, observing, or sense-making
Participate in scientific activities and learning practices with others, using scientific language and tools. [Collaboration] (Goal 5)[b]	
4	Evidence of learning with others, using scientific language and using scientific tools. (3 or more present)
3	Evidence of learning with others, using scientific language and using scientific tools. (2 present)
2	Evidence of learning with others, using scientific language and using scientific tools. (1 present)
1	Students not participating in a science activity or practice
0	No evidence of learning with others, using scientific language, or using scientific tools

[a] These goals are from *Learning Science in Informal Environments*, Washington, DC: NRC (2009). Goals 4 and 6 were outside illustration

[b] Goals 4 and 6 are not easily illustrated nor analyzed from drawings

Appendix 2: Drawings of Science Teaching and Learning Scoring Rubric Supplemental Information Sheet

Experience excitement, interest and motivation to learn about phenomena in the natural and physical world.

Look to the mouth on the figures present. If anyone is smiling, give credit (that is, if only the teacher is smiling but the students are not, give credit for smiling or the reverse). If faces are not visible, look for specific indicators of excitement, interest and motivation in thought bubbles or comments.

Excitement—thought bubbles or comments expressing excitement (e.g., exclamation marks)

Interest—thought bubbles or comments about what is occurring
Motivation—thought bubbles or comments expressing eagerness (e.g., "I can't wait to do this", "Let's get started")

Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science.

Identify concepts, explanations, arguments, models and facts using these descriptions:
Concepts—thought bubbles or comments about bigger science ideas (e.g. energy, evolution)
Explanations—thought bubbles or comments about how things are happening
Arguments—thought bubbles or comments that compare or respond to alternatives
Models—a visual model of three dimensions related to scientific phenomena (not classroom management)
Facts—A statement of science learning (e.g. deciduous trees lose leaves in the fall here)

Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world.

Identify manipulating, testing, exploring, predicting, questioning, observing, and sense-making using these descriptions:
Manipulating—each learner has access to materials in reach or is shown actually touching items (note: manipulating variables for an experiment, see *testing* below)
Testing—thought bubbles or comments that illustrate a trial ("what will happen if…"); presence of testing tools (manipulating variables for an experiment)
Exploring—engaged in active science (not only reading books and writing)
Predicting—thought bubbles or comments stating what might happen
Questioning—students have question marks or actual questions visible
Observing—looking intently as individuals or groups at an object or phenomena
Sense-making—thought bubbles or comments that indicate students or the teacher are trying to "figure things out," phrases that begin with "maybe…"

Participate in scientific activities and learning practices with others, using scientific language and tools.

Identify participating in scientific activities and learning practices with others, using scientific language, and tools using these descriptions:
Participate in scientific activities and learning practices with others—students grouped for interaction
Scientific language—use of terms associated with science (such as, comparisons, questions about how))
Tools—clearly drawn or unclearly drawn (squiggles) materials available to all learners

Appendix 3

See Table 4.

Table 4 Sample description of Rocky Road (grades 2–3) hands-on/minds on activities (within a context of play, explorations)

Investigation questions Guiding leaders, parents and children playfully	Summary/relevance questions Connecting to the children's lives	Activities, data collection and analysis through fun
1. What is fool's gold? What is a streak test? Where are the major deposits of gold?	Why do you think gold is so valuable?	Examination of pyrite as a gold "look-alike." Streak tests and comparisons. Maps
2. What is halite? What do salt crystals look like? How can you make a model?	How do you use salt in your home?	Observations of halite and comparisons to table salt; building a salt cube model
3. How can you make dirt from a rock? What happens to streams when it rains? Is there erosion at your site?	How can erosion be a problem?	Water play. Comparison of water splash measurements from different heights. Comparison of simulated steam bed angles and erosion patterns
4. How are sedimentary rocks formed? What do we find when we examine a piece of sedimentary rock?	Do you think sandstone would make a good building material? Explain.	Making sand-art layers and noticing their irregular patterns. No two exactly alike!
5. How do we simulate the foamy rock of pumice? Where are volcanoes found? How do obsidian and pumice compare?	How do you think you might use obsidian and pumice rocks? What things would pumice be better for than obsidian and vice versa?	Making a model volcano and eruption. Discuss the usefulness of models. Comparison of igneous rocks
6. What objects attract magnets? What are some forms of iron and their uses?	How do magnets help us?	Magnets, movement and finding out what attracts or repels. Examination of hematite and items attracted to magnets
7. What do chalk, limestone and marble have in common? How do we test for calcium carbonate? What are the buffering effects?	Can you think of any ways that we could help prevent the damage caused to statues and buildings made from marble by acid rain?	Play with and compare chalk, limestone and marble and their reactions to vinegar
8. How do we put all of our rock and mineral samples together and begin to classify them in a collection?	Which of these rocks do you think is the most useful to you? Why?	Similarities and differences while beginning an individual rock sample collection in a tray that goes home. Summary, analysis and categorizing of rock data from class series

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