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Intersections of life histories and science identities: the stories of three preservice elementary teachers

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ABSTRACT

Grounded within Connelly and Clandinin's conceptualization of teachers' professional identity in terms of 'stories to live by' and through a life-history lens, this multiple case study aimed to respond to the following questions: (a) How do three preservice elementary teachers view themselves as future science teachers? (b) How have the participants' life histories shaped their science identity trajectories? In order to characterize the participants' formation of science identities over time, various data regarding their life histories in relation to science were collected: science biographies, self-portraits, interviews, reflective journals, lesson plans, and classroom observations. The analysis of the data illustrated how the three participants' identities have been in formation from the early years of their lives and how various events, experiences, and interactions had shaped their identities through time and across contexts. These findings are discussed alongside implications for theory, specifically, identity and life-history intersections, for teacher preparation, and for research related to explorations of beginning elementary teachers' identity trajectories.

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Science identity; life-history; preservice elementary teachers

In August 2015, the European Commission published the *Science education for responsible citizenship* report, which offers a twenty-first century vision for science for society within the broader European agenda. The report places emphasis on the process of aligning research and innovation to the values, needs and expectations of society, referred to as 'responsible research and innovation'. Four of the six main objectives of the report are summarized into the following:

- Science education should be an essential component of a learning continuum for all, from pre-school to active engaged citizenship.
- Science education should focus on competences with an emphasis on learning through science and linking science with other subjects and disciplines.
- The quality of teaching, from induction through preservice preparation and in-service professional development, should be enhanced to improve the depth and quality of learning outcomes.

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- Collaboration between formal, non-formal, and informal educational providers, enterprise, and civil society should be enhanced.

These objectives and recommendations are multi-facetted and reflect how global competition and technological development as well as societal challenges have shaped this vision for science for society. These include, among others, demographic change (e.g. political refugees, economical migrants), food security, well-being, gender inequalities, climate changes, and the need for more inclusive, innovative, and reflective societies. These challenges place new demands and raise high expectations from formal education. To meet these challenges, formal education is required to make significant transformations at different levels: policy, curriculum, research, and teacher preparation. Central in these transformations is the HORIZON 2020 priority of connecting science to society and making scientific careers attractive for young people.

These calls for reform, and HORIZON 2020 priority especially, set high standards and pose great challenges for science teacher preparation programs aiming at addressing a wide range of goals related to teacher knowledge, understandings, beliefs, skills, abilities, and orientations toward science and scientific careers. In order to address this challenge and support teachers to embrace reform recommendations we need to better understand how they learn and develop and what kinds of experiences are critical to their development. To do so, we need to use comprehensive, multifaceted, and multidimensional frameworks that go beyond cognitive aspects of development. In this study, I argue that the construct of science identity provides us with such a framework, which has the potential to capture the intersection of a teacher's knowledge and skills, understandings, beliefs, positioning, orientations, and emotions (Avraamidou, 2014a, 2016a; Hammerness, Darling-Hammond, & Bransford, 2005; Luehmann, 2007; Moore, 2008; Saka, Southerland, Kittleson, & Hutner, 2013; Varelas, 2012). Using the construct of identity and through the lens of life history, in this study I aim to trace three different preservice elementary teachers' formation of science identities. The research questions that guided this study are:

(a) How do three preservice elementary teachers view themselves as future science teachers?
(b) How have the participants' life histories shaped their science identity trajectories?

Theoretical framework

The theoretical framework of this study is bounded within Connelly and Clandinin's (1999) conceptualization of teachers' professional identity in terms of 'stories to live by' (p. 4) which is based on the premise that as human beings we come to understand and give meaning to our lives through stories. To examine stories or experiences, Clandinin and Connelly (2000) developed the *Three-Dimensional Space Narrative Structure*, which is defined by three major dimensions: (a) interaction; (b) continuity; and (c) situation. *Interaction* refers to two aspects of experience: (a) personal, looking inward to internal conditions such as desires, feelings, and hopes; and (b) social, looking outward to existential conditions in the environment with other people and their intentions, purposes,

assumptions, and points of view. *Continuity* refers to the idea that experiences have a past, a present, and a future reference. As described by the researchers, when examining continuity, one should look at the following: (a) past, look backward to remembered experiences, feelings, stories from earlier times; (b) present, look at current experiences, feelings, and stories, relating to actions of an event; and (c) future, look forward to implied possible experiences and plot lines. Last, *situation* places an emphasis on the context where events take place and experiences take hold. This framework was used as the basis for the design of this study and the analysis of the data about the participants' lives. Goodson (1992) and Knowles (1992) argued about the value of employing data on teachers' lives in educational research studies and suggested that life experiences are key ingredients of our sense of self, and that there are critical incidents in teachers' lives which may crucially affect perception and practice.

In conducting this study I was interested in the participants' narratives that tell stories of *becoming* science teachers; essentially, stories of forming science identities. These narratives are examined through a life-history lens and are grounded within literature, providing evidence of the interactive relationship between individuals' lives, their perceptions and experiences, and historical and social contexts and events (Goodson, 1992). I position myself alongside other scholars and I conceptualize identity as a tentatively shaped and socially situated construct, which is constantly under development, and always subject to change (Clandinin & Connelly, 2000; Gee, 2000; Varelas, 2012). More narrowly, as described elsewhere (Avraamidou, 2014a) I use 'identity' to refer to the ways in which a teacher represents herself/himself through her/his views, orientations, attitudes, knowledge, and beliefs about science teaching, the kind of science teacher she/he envisions to be, and the ways in which she/he is recognized by others. These attributes (i.e. views, orientations, knowledge and beliefs, actions) were used in this study to characterize each of the participants' science identities.

Empirical underpinnings

There is a growing interest in the construct of science teacher identity with an increasing number of studies exploring science teachers' identities and experiences that impact their formation (e.g. Avraamidou, 2016a; Forbes & Davis, 2008; Luehmann, 2007; Moore, 2008; Rivera-Maulucci, 2013; Varelas, 2012). In a review study, I summarize the findings of existing research on science teacher identity in the following:

- Identity offers a powerful and multidimensional lens to studying teacher learning and development.
- The construct of teacher identity highlights the role of the context in teacher learning and development.
- The construct of teacher identity has the potential to shed light on teachers' personal histories in relation to science.
- The construct of teacher identity allows us to examine the impact of social markers on teacher learning and development (Avraamidou, 2014a, p. 164).

Varelas, House, and Wenzel (2005) used identity as a multidimensional lens to explore the ways in which beginning secondary teachers saw themselves as scientists and as science

teachers during and after 10-week summer apprenticeships at a science lab. A qualitative analysis of interviews with the participants showed that the participants developed understandings about the practice of science and the work of scientists as a community of practice. Exploring similar research questions, Katz et al. (2011) examined the ways in which an afterschool informal internship supported preservice elementary teachers in viewing themselves as teachers of science. In this study the researchers aimed at understanding four participants' mental models of teaching and learning and how those might have changed with experience through an analysis of drawings, interviews, and written reflections. The findings of this study showed that the participants were able to see themselves as enacting key reform recommendations including: sensitivity to diversity, facilitating hands-on science participants, inquiry, and collaborative work.

Following a similar methodological approach, Siry and Lara (2012) examined the development of a preservice elementary teacher's identity through her participation in a field-based science methods course. Data were collected through videos and conversations between the researcher and the participant over the period of an academic semester. The analysis of these data showed that the participant engaged in a process of making and remaking herself, and that this process was complex and interconnected with social relationships with others and participation in specific activities. Adopting a case study approach and situated in the elementary context as well, Madden and Wiebe (2015) examined the identities of three experienced elementary teachers using Gee's (1999) framework of identity. However, teacher identity was described using a modification of Gee's framework incorporating three perspectives: the teachers' self-described identity, the researchers' view of teacher identity, and the students' views of teacher identity. An analysis of classroom observations, teacher interviews and questionnaires, science notebooks, and students' interviews showed how each teacher approached science in a unique way, and their instruction was tied closely to various facets of their identities. As the researchers concluded, these identity differences highlight the variety of backgrounds elementary teachers bring to their careers, their influence on classroom practice, and confirm that more content preparation can lead to more confidence in using reform-based science teaching.

Following a single case approach too, Luehmann (2007) examined the ways in which the affordances of a weblog supported the development of an urban middle-school science teacher's professional identity over a one-year period. Through posts the participant shared stories about herself and her classroom, reflected on her practice, shared problems and dilemmas, and received feedback from others. The content analysis of these posts showed that the participant developed new understandings and dispositions about science teaching and that her main professional identity was also enriched. Data from blogs to examine teachers' identities were also used in Hanuscin, Cheng, Rebello, Sinha, and Muslu's (2014) study, which examined the ways in which 36 ninth-grade science teachers' participation in blogging within the context of a year-long professional development program provided them with identity resources and afforded opportunities for identity work as teacher leaders. A content analysis of the participants' blogs showed that there was a strong alignment between key areas of leadership development, teachers' blogging practices, identity resources provided by blogging, and opportunities to engage in identity work.

Taking a feminist poststructural stand, other researchers have used 'positional' identity in order to examine how teachers' emotions, personal, political, and cultural ideologies intersect with their developing identities (i.e. Moore, 2008; Rivera-Maulucci, 2013).

Through a qualitative case study informed by narrative and life-history perspectives, Moore (2008) examined three high school teachers' identities of self and teaching and how those intersected with social markers. Data were collected in a period of five months through interviews as conversations where the participants were re-telling narratives and life stories from their lives, drawings, and other sources of data. The analysis of these data illustrated how various social markers influenced the participants' identities, and their views of teaching, science, and students: race, ethnicity and religion, gender, and age. Adopting a similar methodology based on interviews as conversations, Moore (2012) carried out a qualitative case study with three preservice elementary teachers in the context of a 16-week science methods course. Through a card sort activity about positionality and interviews held with the participants at the end of the course, the researcher explored their ideas, personal meanings, understandings about positionality, and the construction of a science teacher identity. The findings of this study, similarly with the one conducted with high school teachers, illustrated how the preservice teachers viewed themselves as teachers and how their positional identity could be leveraged to develop stronger relationships to teaching science and students.

Building upon the construct of positional identity in relation to social justice, Rivera-Maulucci (2013) argued that emotions are central mediators of teachers' identities for social justice. In a qualitative case study with an African-American Caribbean preservice chemistry teacher, Rivera-Maulucci explored the historical development of this teacher's social justice stance with the use of various biographical data (i.e. oral and written autobiographical responses to questions in interviews or prompts in the course assignment) collected over a period of an academic semester within the context of a methods course. The analysis of these data showed the central role of the participant's emotions to her identity, and illustrated how she navigated between emotional ambivalence and her positional identity in framing her beliefs about science and teaching, and her science teaching identity as a preservice teacher. In the same context, chemistry education, Volkmann and Anderson (1998) used a hermeneutic phenomenological research perspective to examine the yearlong teaching journal of a first-year chemistry teacher in order to characterize the nature of her professional identity. Analysis of the participant's journal illustrated how the participant's professional identity was connected to her history, the expectations of the school, her content knowledge, and her own vision of what it means to be a teacher.

Similarly to Moore (2008, 2012), Rivera-Maulucci's (2013), and Volkmann and Andreson's (1998) studies, this study aims to explore the ways in which three preservice elementary teachers' developing science identities were connected to their life histories. In doing so, the study offers insights into specific experiences through time and across contexts that shaped the participants' science identities, and it sheds light on teachers' identity needs and to what universities can offer to address these needs. This study follows on the findings of a longitudinal study on science teacher identity with a first-year elementary teacher as a participant (Avraamidou, 2014a). The purpose of that case study was to examine the participant's development of identity for science teaching from her first year at university, her field experience, and through her first year of teaching. Several kinds of data were collected over a period of five years through different sources: interviews, journal entries, drawing assignments, biographical assignments, lesson plans, and classroom observations. The findings of the study illustrated how different kinds of events, experiences, and

interactions situated in a variety of contexts (i.e. family, schooling, university, field experience, first year of teaching) impacted the participant's science identity.

This current study expands this notion and reveals how the life histories of three preservice elementary teachers intertwine with their identities. As such, it adds to three gaps in research on science teacher identity: (a) the majority of the studies are situated in the secondary education context, leaving a gap of knowledge regarding elementary teachers' identities; (b) the majority of the studies are short in duration, generally limited to a few experiences over a semester or a year (Avraamidou, 2014a); and (c) we do not know much about preservice teachers' identities as they enter teacher preparation. An exploration of how life histories intertwine with the formation of preservice elementary teachers' science identities remains missing. It is at the intersection of this literature on preservice elementary teachers' science identities' formation and what life experiences might influence their formation that this study seeks to make a contribution. This study differs from previous work on identity and life history in that: (a) it presents data about three preservice elementary teachers' identities and life histories, and it offers opportunities for comparing and contrasting cases; and (b) it presents data about the participants from their childhood through their teacher preparation.

Methods

Context

A teacher preparation program of a private university in a Southern European country following a two-semester and a summer-semester academic calendar defined the context of this study. Each course is 13 weeks long and includes 3 instructional hours per week. Preservice teachers enrolled in this program are required to take three science content courses during the first three years of their preparation and an elementary science methods course in the first semester of their fourth and last year of studies. All four courses (three content courses and a methods course) are designed in collaboration by science educators (three young females with doctoral studies in science education) and are offered through the School of Education. Following the three science content courses, the elementary science methods course aims at supporting the development of preservice elementary teachers' knowledge for teaching science at the elementary school (Avraamidou, 2015). This course, for which I served as the instructor, defined the main context of this study. All three courses are design based on reform recommendations emphasizing scientific inquiry. The methods course includes a model-lesson, an outdoor field-study, a visiting scientist's presentation, and a microteaching experience. Preservice teachers' assignments (all used as research data) included 11 reflective tasks (one per week with the exception of the first week and the last week) about 2 pages long, a biographical assignment, the design of 2 lesson plans, and a self-portrait. Outside the courses, two interviews were conducted with the participants one at the beginning and one at the end of the semester. In addition, the participants were asked to develop a personal science teaching philosophy a week after the course ended. The data collected are presented in Table 1.

Research design and participants

This study manifests the characteristics of a single case study (i.e. preservice elementary teachers' formation of science identities) (Merriam, 2009; Stake, 2010). A life-history

Table 1. Data collected.

Data collected for each participant	Time of collection	Description of data
Interview 1	Before the semester started	An hour-long interview was conducted with each of the participants to explore their orientations toward science and the prior science learning experiences (i.e. family, elementary school, high school, and University content courses)
Science biography and drawing	First day of the semester	The participants draw their best science experience and construct a one-page-long written science biography
Eleven reflective journals	Throughout the semester	One- to three-page long journal entries after each lesson where participants reflect on the methods course activities
Two science lesson plans	In the semester	One lesson plan about the properties of light and one lesson plan about waste management
One school classroom observation	In the semester	Prospective teachers, as a group, implement the lesson they prepared in a previous meeting to a group of elementary school students at a local school
Self-portrait and accompanying narrative	End of the semester	The participants draw themselves teaching science at the elementary school and write a one-page-long descriptive narrative
Science teaching philosophy statement	A week after the semester ended	A six-page-long personal science teaching philosophy statement responding to a main question: How do you think children learn best science?
Interview 2	Two weeks after the semester ended	An hour-long interview was conducted with each participant in order to examine the nature of their identities after the course was over and the experiences that impacted their formation

perspective also informs the design of this study. As such, the study was designed upon a narrative inquiry approach focusing on the collection of personal stories, which builds on Dewey's philosophy of personal and social experience (Clandinin & Connelly, 2000; Merriam, 2009). For the purpose of this study, three individuals (Maria, Evelyn, and Alex – pseudonyms) were purposefully selected and investigated within the larger case of 25 preservice elementary teachers enrolled in the science methods course. All three participants were typical Southern European preservice elementary teachers. They were middle-class Caucasians, 22 years old with no science-specific background. As a group, at the time they entered this study, the participants were positioned toward science in different ways (i.e. enthusiastic, neutral, low motive) and illustrated a range of content knowledge, views about teaching, attitudes, and orientations to science and science teaching. The main selection criteria used were the participants' performance and orientations towards science, for which I had information through their transcripts and an initial interview I had with the larger group of preservice teachers for the purpose of a larger research program. In applying these criteria for the selection of the participants I aimed to achieve a range of performances, orientations, experiences, and life histories. These three individuals were chosen because I assumed that their representativeness (as a group) would lead to main assertions (even though not generalizable in the conventional paradigm) about preservice teachers' formation of science identities (Merriam, 2009).

Data collection and analysis

In order to characterize the participants' formation of science identities over time, I collected various data throughout the period of sixteen weeks; however, these data concerned their life-biographies in relation to science. The data were analyzed based on the constant comparative analysis (Merriam, 2009), which allowed for themes and patterns to emerge.

These themes and patterns were examined through the use of Clandinin and Connelly's (2000) *Three-Dimensional Space Narrative Structure* defined earlier in the introduction, to reveal the characteristics of the participants' science identities. In order to explore the dimension of *Interaction*, the data were analyzed for the personal experiences of the participants that relate to their identities as science learners and as future science teachers as well as for her interactions with other people. The categories developed were as follows: (a) experiences related to visions of self as a future teacher; (b) experiences related to how participants view their role as science teachers; (c) experiences related to participants' views about the purpose of teaching science; and (d) experiences related to the participants' understandings about how children learn science. *Continuity* was examined through an analysis of the data for information about past experiences of the participant as well as for present experiences illustrated in actions of an event, or actions to occur in the future. The main categories for this dimension were the following: (a) childhood experiences outside of school; (b) experiences as a science learner through schooling; and (c) experiences as future teachers in teacher preparation.

Lastly, in order to examine *Situation* the data were analyzed for specific situations in the participants' landscape, which involves physical spaces such as, home, school, university, field experience, or the sequence of the participants' places. Framed within the major contexts of this study, the categories constructed were: (a) family context; (b) elementary school context; (c) high school context; (d) teacher preparation context; and (e) elementary science methods course context. In the data, these ideas surfaced in the form of descriptions that the participants offered about themselves as learners and how they viewed themselves as future teachers. An example of data analysis with sample codes is offered in Table 2. The description of each of the cases is offered in a narrative format given the intertwined nature of interaction, continuity, and situation – the dimensions used for the analysis. Following this, a cross-case analysis is done in order to exemplify commonalities between the three cases.

Establishing trustworthiness

The concept of trustworthiness, according to Lincoln and Guba (1985), contains fours aspects: credibility, transferability, dependability, and confirmability. In order to achieve credibility I chose a case study design, which is well-established, I was familiar with the culture of the teacher preparation program and experienced with the design and teaching of the elementary methods course, and I used various triangulation techniques. First, I used member check as I had asked each participant to review my interpretations about the data. In addition, I had asked an external researcher, a lecturer in science education who is familiar with the context of the study, to review the coding scheme and use it to code randomly selected data (i.e. one interview and three journal entries for each participant). We then discussed her analysis alongside mine and we negotiated our analyses until we came to an agreement. Moreover, for triangulation purposes I collected data for the same purpose through various sources (i.e. written biography and interview to explore experiences with science in childhood). In order to address the issue of dependability I provided detailed descriptions of the research design and its implementation (i.e. selection of participants, data collection, and analysis processes).

Table 2. Example of data analysis and procedures.

Dimension (Clandinin & Connelly, 2000)	Procedures	Categories	Sample codes	Sample of data
Interaction	The data were analyzed for the personal experiences of the participant that relate to her identity as a science learner and as a future science teacher as well as for her interactions with other people	• Experiences related to visions of self as a future teacher • Experiences related to how participants view their role as science teachers • Experiences related to participants' views about the purpose of teaching science • Experiences related to the participants' understandings about how children learn science	• Strict science teachers at high school • Young female instructors serve as role models • University-scientists' partnerships in methods course	*I believe that students learn best when they learn in outdoor environments, in nature. I developed this view through our visit to the environmental park.* (Alex, journal entry 11)
Continuity	The data were analyzed for information about past experiences of the participant as well as for present experiences illustrated in actions of an event, or actions to occur in the future	• Childhood experiences outside of school • Experiences as a science learner through schooling • Experiences as future teachers in teacher preparation	• Negative science learning experiences in high school • Negative views about science teacher • Positive experiences in the context of the science methods course • Positive interactions with university instructors • Design and enactment of inquiry-based lesson plans	*My relationship with science is a traumatic one. This is because of an experience I had with a really crazy science teacher at the elementary school.* (Evelyn, interview 1)
Situation	The data were analyzed for specific situations in the participant's landscape, which involves physical spaces (home, school, university, field experience) or the sequence of the participant's places.	• Family context • Elementary-school context • High school context • Teacher preparation context • Elementary science methods course context	• Opportunities to engage with science in family settings • Nature of the learning environment during schooling • Nature of the learning environment in methods course • Nature of school context during microteaching experiences	*I was a bit disappointed when we visited the elementary school. It was an old building, with no science or technology lab. Experimentation and the use of technology are two approaches that I'd like to use when I teach in the future, but if I am placed in a school like this one, I do not know what I could do.* (Evelyn, interview 2)

Findings

The case of Maria: emphasis on scientific inquiry

In responding to a question 'who I'd like to become' Maria drew a self-portrait as a science teacher emphasizing inquiry-based science:

> This is how my classroom looks like: it has a TV, computers for all students, recycling bins, and a science laboratory. The students are excited about science! They are working in small groups to design investigations to collect data that will help them construct explanations about the posed question. (Maria, narrative accompanying self-portrait)

Maria viewed her role as one of supporting students' excitement about science in a fully equipped classroom where she implements inquiry-based approaches to science teaching. In her description, students work in small groups to design inquiry-based investigations for the purpose of constructing scientific explanations. Similarly, in one of her journal entries, when elaborating on the purpose of teaching science at the elementary school, Maria emphasized supporting students construct scientific explanations:

> I believe that the purpose of teaching science at the elementary school is to support students in understanding how the world works, to be able to provide explanations about scientific phenomena. (Maria, journal entry 10)

Consistent with the above was Maria's personal teaching philosophy where she emphasized children's engagement in inquiry-based investigations for the purpose of constructing scientific explanations:

> Children learn science best when they engage in inquiry-based investigations … when they actively collect data through experimentation in order to construct scientific explanations. (Maria, personal philosophy statement)

When analyzing Maria's lesson plans, it became evident how these ideas were applied in the design. For example, when teaching a lesson on waste management to a group of elementary school students, Maria organized the lesson around a driving question: *is there a waste management at your school*? In providing students with directions, she even used the discourse of scientific inquiry:

> You will go outside the classroom and collect some information that can be used as evidence to support your argument. You will have to collect different kinds evidence such as photographs and observations in order to construct a *valid* (emphasis placed by the participant) argument. (Maria, classroom observation)

The emphasis that Maria placed on the role of evidence and argument in science is apparent in her words. Evidence and argument are central in inquiry-based science, which featured centrally in Maria's personal philosophy as well as the narrative that accompanied her self-portrait, which provides evidence of consistency and continuity.

Maria's life history: a few but positive science learning experiences

In describing experiences with science as she was growing up, Maria pointed that she grew up in the city center with minimal experiences in nature:

> I grew up in the city center so I did not really have many experiences with science or nature outside of school. (Maria, interview 1)

Elaborating on this, Maria described walks in the park with her father talking about various plants:

> I only remember the walks we used to do on Sundays at the inner-city park and my father naming all the different plants, and explaining where their names came from! (Maria, interview 1)

It is interesting to note in the above how Maria remembers her father, also a teacher, naming the different plants during their walks. The influence of her father was evident also in her stating that as one of the reasons why she decided to become a teacher. This provides evidence of the impact of this interaction on her identity trajectory.

In narrating her life history in relation to science, Maria stated that one of the most memorable experiences she had was a visit to a museum with her family:

> I also remember a family visit at the Natural History Museum in London, I was about ten years old at that time but I remember how excited I was to be there. I did not want to leave, I remember running from one exhibit to another, I wanted to see it all (laughs)! (Maria, interview 1)

The above words are important because they provide insights into the opportunities Maria had to experience science in an out-of-school setting during her childhood. This sheds light on all three dimensions (i.e. continuity of experiences, interaction with family, situation) of her identity trajectory.

A similar excitement was also evident in Maria's descriptions of her experiences as a science learner in elementary school. Maria was able to recall many positive experiences:

> I remember the experiment we did with planting different seeds and observing their growth every day, I remember waking up in the morning and being excited about going to school just to see my seeds growing. (Maria, Interview 1)

Similarly, elaborating on her experiences with science in high school, Maria, again, shared positive memories:

> I loved Physics, Biology and Chemistry even though I did not like the teachers all that much. They were all very strict and not friendly at all. My memories include experimentation and interesting concepts such as buoyancy and energy! (Maria, Interview 1)

Important in Maria's words is that she did not lose interest in science despite the fact that she did not like her instructors. In other words, it looks like even though the *interaction* was negative, the *continuity* of experiences was strong and positive, and overcame the negative feelings toward the instructors.

As evident in Maria's words, most influential to her identity trajectory were the experiences she had at teacher preparation. Maria emphasized the inquiry-based investigations in one of her science content courses:

> The inquiry-based lessons we had about sound and light and shadows were very influential to my thinking about teaching science at the elementary school … central in my personal philosophy of science teaching is scientific inquiry. (Maria, interview 2)

Elaborating on this, Maria explained how influential those were to her thinking because she was actively engaged:

> I feel that I learned a lot because *I* (emphasis placed by the participant) had to think about what experiments to design and what data to collect in order to respond to that question. (Maria, interview 2)

Moreover, Maria described in her journal entry as well as in her interview how the methods course helped her view herself as a successful science teacher. Below is an excerpt from her journal describing how the microteaching experience, as part of the methods course, supported her self-confidence as a teacher:

> It was a very positive experience for me … I felt confident to teach because I only taught a small part of the lesson and because that lesson was prepared in our methods course, and I knew it was right! (Maria, journal entry 9)

Another experience that seemed to be empowering was the interaction with a scientist, as part of the methods course. Maria emphasized how the lesson helped her better understand the nature of the work of scientists.

> The scientist showed us the tools that he uses for catching the snakes and for observing them. He also showed us photographs about the field where he works and of himself observing snakes … all these, but mostly the discussion we had with him about his research helped me better understand the nature of the work of scientists. (Maria, journal entry 6)

Maria's words are important as they convey the impact that the interaction with a scientist had on her understandings about the work of scientists, a major aspect of her developing identity as a science teacher.

The case of Evelyn: emphasis on affective domains of science learning

In her self-portrait and accompanied narrative, Evelyn placed emphasis on the relationships between her and the students as well as the nature of classroom environment. For her, the affective domain of science teaching was more prevalent than the other two participants:

> I don't need use the teacher's desk … I always walk around the classroom helping out students. A group of students are using the teacher's desk and they are drawing the leaves they collected from a nature-walk … the students are excited about this investigation and the activities they are involved in. I use multiple strategies (i.e. drawing, use of technology, experimentation) in my practices in order to address all students' needs and special interests. (Evelyn, narrative accompanying self-portrait)

As evident in this narrative, Evelyn emphasized different aspects of her role as a teacher associated with affective domains of learning: to help out students, to excite students, and to address their needs and interests. Similarly, when responding to a prompt regarding the purpose of teaching science at the elementary school, Evelyn emphasized affective domains of learning:

> I believe that the main purpose of teaching science at the elementary school is to make students appreciate science, and to develop positive attitudes towards science by providing them with meaningful and positive science learning experiences. (Evelyn, journal entry 10)

Similarly to her self-portrait, in her personal philosophy statement, Evelyn placed emphasis on the relationships between teachers and students:

> I think it's important for a science teacher to develop positive relationships with her students, to make students excited about science in a safe learning environment … to make them feel that they can be successful learners of science. (Evelyn, personal philosophy)

Evelyn's words become of great interest if they are considered in light of her negative experiences as a young learner of science, and interactions with her science instructors, as will be discussed in the section that follows.

In agreement with her personal teaching philosophy and self-portrait, Evelyn paid attention to the classroom environment and affective domains of learning when designing and enacting a lesson about waste management to a group of elementary students. When reflecting on this lesson, she said:

> I was really excited to see the students' reactions and enthusiasm when I played the role of the 'waste' woman! It was an incredible feeling; to know that I was making them so excited! (Evelyn, interview 2)

As a participant-observer in this lesson, I witnessed Evelyn being very friendly and close to the students, and showing enthusiasm about the lesson as well as the students' responses to her questions.

Evelyn's life history: a range of negative early-year science experiences followed by positive experiences in university

In the first interview, Evelyn elaborated on her decision to become an elementary school teacher and pointed to a lack of memories connected to science:

> It was actually my parents' idea to become a teacher. I really did not know what to do with my life when I was 18. All I was really good at was drawing, but I did not know what to do with that. I like to work with children so I thought I'd try this. I never really have any interest in science; I don't remember anything related to science I am not even a nature-lover! (Evelyn, interview 1)

It is important to note in the above how Evelyn positions herself as someone who is not a science person, with no interest in science, and who cannot recollect any science experiences.

When talking about her younger years, Evelyn articulated a traumatic relationship with science and described negative experiences with science and her science teachers at elementary school and high school.

> My relationship with science is a traumatic one. This is because an experience I had with a really crazy science teacher at the elementary school. It was a lesson about senses and he asked us to taste different things that he brought in the classroom. So, we were trying different things like bread and lemon … and then he gave us soap to try! We thought he was joking. But, he was not. He insisted. I refused … I was really frightened. I really hated science since that day, I remember crying when I went home … he was really weird, a very strict old man. My science teachers at high school were kind of like him, all weird. (Evelyn, Interview 1)

Important in these words is how Evelyn described her relationship with science as traumatic and her science teacher as a 'weird, strict old men'. These serve as evidence of the negative interaction and continuity in terms of Evelyn's experiences in her early years of schooling.

When responding to prompts aiming at exploring the participants' life histories in relation to science, Evelyn revealed negative attitudes toward science until she went to university.

> I had negative attitudes towards science and I was not looking forward to my science courses at the university. But, now I feel more confident in teaching science, because I know more in terms of subject and more about *how* to teach science with the use of variety of instructional approaches and strategies … all four science courses (three content and methods course) helped me gain confidence in my content knowledge as well as pedagogical skills. (Evelyn, journal entry 10)

In these words, Evelyn points to how her attitudes toward science, a major aspect of her developing identity as a science teacher, changed when she went to university and gained confidence in her content and pedagogical knowledge. In the second interview she talked about her experiences as part of the science content courses:

> I enjoyed all three courses … the concepts were interesting and I learned a lot that I can apply in my life … human body, plants, global warming … we were involved in experimentation, which I enjoyed a lot. (Evelyn, interview 2)

Evelyn talked with similar enthusiasm about the two instructors of these courses as well:

> They were both young women and they were excited about science! They were very friendly and the classes were fun … I never felt bored. (Evelyn, interview 2)

These words are important, especially in view under the lens of interaction, and considering the negative interactions that Evelyn had with her science instructors in her schooling years.

In the second interview, Evelyn elaborated on this shift in the continuity of her experiences when she went to university.

> As a student, whenever I had a science lesson I felt really stressed. I just always thought that science is not for me; I was just not good at it. But, all this has changed now, because of the elementary methods course, which made me realize that a student's attitude towards a subject depends completely on the ways in which a subject is taught and also the characteristics of the instructor. (Evelyn, Interview 2)

Evelyn described how an aspect of her science identity (i.e. view of self as a science learner) had shifted because of the way in which the methods course was taught but also because of the characteristics of her instructor.

> All my science instructors were great, but the science methods course instructor especially served as a powerful role model for me. Her love for science and her enthusiasm for teaching as well as her personality contradicted the experiences I had with all the science teachers I had in my life. She was friendly, she had a sense of humor, she was passionate about science, she made me love science. (Evelyn, Interview 2)

These words provide evidence of the positive influence of Evelyn's interaction with her science instructors and especially the one who taught methods course on her orientations

toward science (i.e. *she made me love science)* and indicate a shift in the interaction dimension of her identity trajectory. Specific experiences as part of the methods course appeared to be influential on Evelyn's identity trajectory as illustrated in the following quote:

> The lesson with the visiting scientist helped me better understand the nature of science and the characteristics of the work of scientists, which made science seemed more humane. (Evelyn, journal entry 6)

It is important to note in the above how Evelyn perceived the impact of her interaction with the scientist, not only in terms of her understandings about the word of scientists, but also in terms of making science seem more humane. One could argue that this implies a shift in her orientation toward science, which is a major aspect of her developing identity.

Evelyn's views about the development of understandings of scientists' work were also expressed in a journal entry where she elaborated on the importance of providing students with opportunities to interact with scientists. A quote from her journal illustrates that:

> I learned a big lesson today: scientists can be young and attractive and with a great sense of humor. The scientist was so passionate about his work and the species that he studies … today I learned that science is not just about physics, and that scientists are not crazy loners who work in laboratories! (Evelyn, journal entry 6)

What's interesting to note in these words is how Evelyn's reconstruction of the stereotypical image of scientists conveys a shift on her own orientation towards science becoming more positive.

Other critical events as part of Evelyn's life history in relation to science are situated within the microteaching experience. A sense of becoming alongside concerns about the realities of school classrooms was identified in Evelyn's data set in various instances. An indicative example is how Evelyn described an event that made her experience a conflict between her ideas about teaching and classroom reality:

> I was a bit disappointed when we visited the elementary school. It was an old building, with no science or technology lab. Experimentation and the use of technology are two approaches that I'd like to use when I teach in the future, but if I am placed in a school like this one, I do not know what I could do. (Evelyn, interview 2)

In these words Evelyn described how the reality of the classroom with no resources, materials, or computers created a sense of disappointment. This reality was in conflict with her view of herself as a science teacher emphasizing experimentation and the use of technology. This conflict is important to note when addressing the *situation* dimension of Evelyn's identity trajectory, pointing to a clash between classroom reality and her vision of classroom reality as part of her view of self as a future science teacher.

The case of Alex: emphasis on learning outside the classroom

In developing his self-portrait and accompanied narrative, Alex described a scenario where people are disconnected from nature and identified his role as a teacher, as one of providing children with learning experiences in and about nature.

> This is my classroom in 2045. At this time, due to the population increase and the needs for houses, there are no parks left or even many trees in the cities. The students do not know

> what nature means. I believe that my role is to provide them with experiences in and about nature. I want to make them appreciate nature and realize their role and relationship with nature. My drawing shows myself teaching my students at a nature site. There are many trees and a lake with two ducks. In this whole-day lesson I teach about biodiversity and I let students free to explore the setting, the trees, the ground, the water, the ducks – all the living organisms. I ask them to develop a question that is of interest to them and collect data to respond to that question. (Alex, narrative accompanying self-portrait)

As illustrated in this narrative, Alex emphasized learning in outdoor environments as part of how he viewed his role as a teacher, which was to provide students with experiences in nature and to connect science with the students' everyday lives. When elaborating on the purpose of teaching science at the elementary school, Alex emphasized the importance of supporting students' understandings about the relevance of science to society:

> The purpose of teaching science at the elementary school is to support students in understanding the value of science to our everyday lives; to nurture their interest in science, to enhance their curiosity about scientific phenomena and to make them understand their relationship and role in the natural environment. (Alex, journal entry 10)

It is important to note a consistency in Alex's ideas about science and science teaching, and the emphasis he placed on providing students with experiences in nature. Similarly, in his personal philosophy statement, Alex emphasized student engagement in experimentation and learning science outside of the classroom:

> I believe that children learn science best through experimentation, whey they are active and they use real-world materials. Another component of my philosophy is learning outside the classroom because it's interesting and fun! It's different, the students are out in nature, and they learn more important things that what's in the science books, knowledge that is useful for their everyday lives! (Alex, personal philosophy)

Alex exhibited uniformity between his views about science teaching and his practices. As part of the methods course, he designed a lesson plan about light and shadows where students would be outside the classroom experimenting with their own bodies and their shadows at different places of the school premises. Alex, in agreement also with his self-portrait and personal philosophy, took the lead in an activity with the students outside the classroom in the context of a microteaching experience. An excerpt from my field notes in a classroom observation supports this assertion:

> Alex walks with the students and asks the students if they enjoy the fact that the activity is held outside the classroom. The students respond positively with enthusiasm. He then explains to them how important it is that they can use this space that is usually used for leisure, to learn: Isn't it great that we use this space where you usually play to have a lesson? You see, science is everywhere; it's part of our every lives. (Alex, lesson observation)

In observing this lesson, it was interesting to see how Alex articulated his views and initiated a conversation with the students about the value of learning in places outside the classroom. In doing so, he made a connection between science and everyday life, another element that featured centrally in his personal philosophy of science teaching and learning. These data illustrate an aspect of Alex's philosophy of science teaching, emphasizing learning outside the classroom, and making connections between science and society.

Alex's life history: plenty of positive experiences in nature

In articulating memories of his younger years, Alex described experiences with his family in nature:

> I had many experiences in nature when I was a kid. You know, I grew up in a village; my father is a farmer. When I was younger I used to be out in the field helping him to plant vegetables and picking olives from the trees … I was enjoying being out in the fields. (Alex, interview 1)

These words become of importance when viewed in light of Alex's ideas about science teaching, which are to provide students with experiences in nature, as will be described later on. In describing science experiences within the formal school realm, Alex recalled positive experiences with science in the elementary school. This points to the continuity in Alex's identity trajectory between his childhood and elementary school years.

> As an elementary school student I liked science because we were doing experiments, it was fun to play with batteries and bulbs and magnets. (Alex, interview 1)

This, however, was not the case with Alex's experiences in high school:

> In high school science became more theoretical, we had to memorize a lot of information, so I did not like it … lots of formulas that made no sense, I could not see the value of it for my life. (Alex, interview 1)

These words provide evidence of a shift in Alex's identity trajectory as the negative experiences in high school influenced his positioning toward science (i.e. *I could not see the value of it*).

The connection of science to everyday life featured centrally in Alex's view of himself as a future teacher of science. As evident in data from his journal entries, Alex's identity trajectory was influenced by his university coursework. In one of his journal entries, he noted that the university coursework supported him in making connections between science and everyday life.

> My science courses were fun, interesting, practical and most importantly we explored concepts that are connected to our every day lives, like climate change. (Alex, journal entry 10)

In his last journal entry, Alex described how the experiences he had as part of his science methods course impacted his views about science teaching and learning:

> I believe that students learn best when they learn in outdoor environments, in nature. I developed this view through our visit to the environmental park and the field study we conducted. It was interesting, it was fun and I learned so much at the same time. I do not think it would have been the same if we were taught this lesson in the classroom, because we would not be able to see and touch things in nature! (Alex, journal entry 11)

These words provide evidence of a field study that impacted Alex's philosophy for science teaching, which is one major aspect of his developing identity as a science teacher. In the second interview, Alex explained how the methods course supported his self-confidence as a science teacher, and also his understandings about the relevance of science to everyday life.

> I realized that I am not that bad in doing science; I feel confident to teach science. I realize that science it's not that difficult of a subject and it relates to our every day life. (Alex, interview 2)

It is important to notice in these words, Alex's development of self-confidence as a future science teacher as well as his orientation toward science – both central in his developing identity.

Another aspect of the course, which Alex commented about, was the instructor of the course, which points to the *interaction* component of his identity trajectory.

> The characteristics of my instructor helped me develop an interest towards science. She was young and cool and very passionate about science and science teaching! (Alex, interview 2)

Alex's words convey how the characteristics of the instructor of the methods course nurtured his interest toward science, a central element in his developing identity. Another experience that seemed to be influential on Alex's identity trajectory was the interaction with the scientist. As he described in a journal entry, the interaction with the scientist supported the development of understandings about scientists and the nature of their work:

> The interaction we had with the scientist helped me to realize that scientists could be young and normal people, and not weird individuals working alone in a laboratory conducting experiments … the scientist showed us pictures of himself working with others on a sandy beach collecting data about snakes … in the discussion we had with him, he emphasized how he works with other people and that he never worked in a laboratory … he was young, friendly, and he had a great sense of humor! (Alex, journal entry 6)

It is clear in the above that Alex had stereotypical ideas about scientists, which were reconstructed through his interaction with the scientist. This provides evidence of how this *interaction* influenced Alex's ideas about scientists and the nature of their work – another major aspect of his developing identity.

Discussion and implications

The stories of the three preservice elementary teachers illustrate how their identities have been in formation from their early years of their lives and how various experiences and interactions situated in various contexts impacted their identity trajectories. When elaborating on her views about how children learn science, Maria emphasized inquiry-based science. In narrating her life history in relation to science, Maria described positive experiences as a young learner, situated in her family contexts and through her elementary, high school, and university years. Unlike Maria, Evelyn had to overcome traumatic science experiences and negative orientations toward science, which were developed in her younger years. However, a shift was evident in her developing science identity because of the positive impact of her teacher preparation (i.e. relationship with instructors, fun, inquiry-based, and meaningful science experiences). Grounded within these life-history events, it is not surprising that Evelyn viewed herself as a teacher who emphasizes affective domains of learning associated with both teacher–student relationships as well as the nature of the learning environment. Alex emphasized learning in outdoor environments as part of how he viewed his role as a teacher: to provide students with experiences in nature, to provide them with opportunities for experimentation, and to connect science with the students' everyday lives. These views can be traced back to Alex's recollection of experiences in nature with his family as well as positive experiences with science in the elementary school and teacher preparation that involved experimentation, as well as

poor learning experiences in high school when he could not see the value of science to his life.

This study contributes to existing knowledge and case study research on elementary teacher education in three ways: (a) it illuminates the participants' life histories in relation to science and highlights the ways in which these life histories shaped their identities, which has theoretical implications; (b) it reveals specific experiences, events, and interactions as part of the teacher preparation program that were critical in shaping the participants' identities, which has implications for teacher preparation; and (c) it provides a methodological approach to studying beginning elementary teachers' formation of identities with the use of a case study approach through a life-history perspective.

Theory and methodology: identity and life-history intersections

This study provides evidence of how enlightening it is to adopt identity in conjunction with life history as a lens to examining teacher learning and development. Researchers have argued that life history offers a valuable tool to educational research because it can provide a high level of ethnographic, deep description, texture, and detail to data as well as information about the context (Connelly & Clandinin, 1999; Goodson, 1992). The findings of this study show that it is imperative to examine the life histories of preservice elementary teachers, to find out who they are as they come to university in order to support them in forming science identities. If a life-history perspective had not been adopted in this study there would be no information about events and experiences that would help explain the nature of the participants' identities as they entered the teacher preparation program.

A methodological contribution of this study lays at the recommendation for the use of Clandinin and Connely's three-dimensional model for examining a teacher's identity. As described earlier, the data were analyzed based on Clandinin and Connely's three-dimensional model, which served effectively in analyzing data collected about the participants' life histories, situated in three different time frames: past, present, future (i.e. vision of self as a future science teacher). Given that science identity entails a sense of an individual's past, present, and future, it is important to adopt such models when examining identity development over time. This model also served well as a framework for examining both the individual as well as the social dimension of the participants' identities. Clandinin and Connelly (2000) describe this three-dimensional space as having 'temporality, or an expression of something happening over time, along one dimension, the personal and social along a second dimension, and place along a third' (p. 50). As such, this model allowed me not only to gain a deeper understanding of the participants' experiences over time and across contexts, but it also provided me with the means for better understanding *how* these experiences shaped the participants' science identities. If teacher education is about supporting teachers in constructing science identities, then approaching science teacher education from a narrative inquiry theoretical stance becomes crucial.

Moreover, the findings of this study provide evidence, as other studies have done (Avraamidou, 2015, 2016b; Eick & Reed, 2002), that the participants filtered their learning-to-teach experiences through their existing science identities as those were developed through their schooling years. Existing literature, similarly to the findings of this study,

provides evidence that most preservice elementary teachers, especially females, enter teacher preparation with negative science learning identities and low self-confidence about science teaching due to negative science learning experiences from their schooling years (Avraamidou, 2015, 2016b; Settlage, Southerland, Smith, & Ceglie, 2009). It is hence important to first help these teachers reconstruct their negative orientations toward science and science teaching and to support them in forming science teaching identities. As Katz et al. (2011) recommended, science teacher preparation should encourage teacher candidates to be seen as modeling enthusiasm for science as they engage in science teaching and should provide opportunities for teacher candidates to be seen as knowledgeable and confident in transformative pedagogy. Such opportunities to explore questions such as 'Who I am' and 'Who I'd like to be' can be offered through the use of identity and life-history lens to teacher preparation.

Practice: the role of teacher preparation

Framed within reform recommendations in science education, the findings of this study have the potential to move the field forward by identifying how specific components and activities as part of teacher preparation could support preservice elementary teachers in developing reform-minded identities, a research area that remains largely unexplored (Luehmann, 2007). The findings of this study confirm previous research findings documenting the impact of teacher education, and especially the methods course, on the development of beginning elementary teachers' understandings about science teaching and learning (Avraamidou, 2013, 2016b; Avraamidou & Zembal-Saul, 2005, 2010; Bryan & Abell, 1999; Davis & Smithey, 2009; Zembal-Saul, 2009). As Alsup (2005) argued, although preservice teachers' professional identity formation is quite personal, teacher preparation programs can make a difference. There is clear evidence in the findings of this study about the ways in which the teacher preparation program (re)shaped the participants' identities. Certain aspects and characteristics of the preparation program appeared to be very critical: coherent framework for university science courses' (i.e. continuity) relationships with the instructors, inquiry-based science, experimentation, learning in outdoor environments, interacting with a scientist, microteaching activities, and a generally positive, fun, and engaging nature of learning environments. Some of these aspects have been examined independently by other researchers and have provided evidence of their success (Avraamidou, 2015; Katz et al., 2011; Varelas et al., 2005). The findings of this study add to this literature as they provide evidence of the effective impact that the *combination* of these approaches could have on preservice teachers' formation of science identities.

What is also important to this discussion is that, unlike most teacher education programs that offer science content courses from other departments, all science content courses and the elementary methods course were co-designed and taught by science educators. As such, all courses shared a common conceptual framework emphasizing scientific inquiry and were designed based on reform recommendations. Hence, there existed a continuity and coherence among the four courses that shared a cohesive vision of science teaching and learning. As Hammerness (2006) and Zembal-Saul (2016) argued, an approach that creates a coherent, integrated program with consistent messages and theories will result in more powerful learning for preservice elementary teachers.

Research: examining beginning elementary teachers' identity trajectories

A review of existing research on identity illustrates that much work has been done with students constructing science identities especially with young girls (Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001; Calabrese Barton et al., 2013; Tan & Calabrese Barton, 2007), homeless children (Barton, 1998), and women of color making careers in science (Carlone & Johnson, 2007; Johnson, Brown, Carlone, & Cuevas, 2011). However, preservice elementary teacher identity has been a largely unexplored area, as the majority of the studies that exist on teacher identity are either situated within the secondary education context (e.g. Enyedy, Goldberg, & Welsh, 2005; Moore, 2008) or are conducted with more experienced teachers (Goodson & Cole, 1994; Madden & Wiebe, 2015), leaving a gap of knowledge on beginning elementary teachers' identity, and especially preservice teachers, with only a few exceptions (i.e. Avraamidou, 2014a; Moore, 2012; Rivera-Maulucci, 2013). I hence recommend that research attention be directed in the area of preservice elementary teachers' science identities for the purpose of producing a set of longitudinal and ethnographic studies that illuminate the kinds of experiences and interactions that shape these identities within various contexts.

Maria, Evelyn, and Alex appeared to be developing a sense of what it meant for them to teach science, and an image of themselves as future teachers throughout their preparation program. These processes of *becoming* illustrate how the participants had been forming their identities based on how they were interpreting various science learning-to-teach experiences. These findings do not produce, of course, universal answers to questions of how preservice teachers may interpret specific learning-to-teach-science experiences. They do show, nevertheless, that the participants interpreted various events differently as they filtered those through their life histories in relation to science. It is then imperative that each teacher's identity trajectory is excavated in its own landscape. Why is it and what makes it possible for some preservice elementary teachers to re-construct their identities while others hold tenaciously to the identities constructed through their schooling years? Why are some preservice elementary teachers able to form identities that are aligned with reform recommendations? And, why is it that some events are successful in shaping some teachers' identities and thwarted in others? These questions speak to a set of recommendations for future research.

First, an examination through large-scale studies of the reasons why preservice elementary teachers enter teacher preparation with negative science identities and what experiences in their preparation help them reconstruct those identities might be a fruitful form of research. Second, further research that examines the opportunities for reconstructing teachers' views of scientists that are offered in the context of teacher preparation (as in this study) would be valuable as we explore ways to support beginning teachers develop contemporary understandings about the nature of science and the work of scientists. Third, the ways in which environments outside the university could be integrated in teacher preparation programs to support beginning elementary teachers' formation of science identities is a largely unexplored research area that holds interest and potential (Avraamidou, 2014b). Lastly, some data (i.e. lesson plans, classroom observations) in this study provided evidence of how the participants' identities were translated into practice. However, a more thorough understanding of the processes by which these identities are enacted is warranted. This is, in fact, a limitation of this study that has only looked at

the nature of the processes of formation of the participants' identities, and not at their practices as well. As Madden and Wiebe (2015) argued, the value of connecting identity with practice is critical for understanding the implications of identity on student outcomes. More research into the ways in which beginning elementary teachers enact their science teaching identities for the purpose of identifying challenges and difficulties in this process is essential as we aim to support them in embracing reform recommendations.

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No potential conflict of interest was reported by the author.

Notes on Contributor

Lucy Avraamidou is Associate professor of science education. Her interests include teacher learning and development and her research is associated with theoretical and empirical explorations of what it means to understand and teach science, with the use of qualitative approaches and through the lens of identity.

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