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# Preservice Elementary Teachers and Science Instruction: Barriers and Supports

**Katherine P. Dabney\***

*Virginia Commonwealth University*

**Kimberly B. Good**

*Virginia Commonwealth University*

**Michael R. Scott**

*University of Texas at Austin*

**Teri N. Johnson**

*Virginia Commonwealth University*

**Devasmita Chakraverty**

*Indian Institute of Management Ahmedabad*

**Brittany Milteer**

*Henrico County Public Schools*

**Alicia Gray**

*Chesterfield County Public Schools*

## Abstract

*Research suggests that elementary school is a crucial period for sparking students' long-term interest in science and consideration of a STEM career. Teachers influence students' dispositions towards science; therefore, it is important to consider elementary teachers' identity development, a preservice teacher's own voice and self-image, with science as a factor in science education. This longitudinal, qualitative study examines the experiences that served as barriers or supports to elementary Master of Teaching preservice teachers' science teacher identity development. Six preservice teachers were interviewed at the beginning of their graduate teacher education programs and again during their first year of teaching. Our findings indicate that identity development of future elementary teachers begins during their own elementary school experiences as a student and spans through their teaching practicums. Barriers to science identity development included prior elementary science experiences/lack of interest, science content and coursework requirements, practicum experiences, and socioeconomic status. Supports that bolster elementary teacher identity for instructing science included hands-on/inquiry-based science coursework, prior experience in schools and working with children, positive practicum experiences, and support from family and friends. This research indicates that in order to develop more rigorous elementary science teacher preparation programs, in regard to instruction and self-efficacy, educators and public policymakers will need to provide a series of supports for future science teachers ranging from their initial elementary school experiences through their practicum placements.*

## Preservice Elementary Teachers and Science Instruction: Barriers and Supports

Concerns about the size of the United States' Science, Technology, Engineering, and Mathematics (STEM) workforce have influenced the rise of science

education and engagement with science as high educational policy priorities (National Academy of Sciences, 2007). Earlier research examining students' interest in science and STEM-related careers emphasizes high school or college factors as important for supporting persistence into

the workforce (Davis, 1999; Ivie, Czujko, & Stowe, 2002; Maltese & Tai, 2011; Sax, 1994); however, recent studies demonstrate that STEM career interest tends to begin in elementary or middle school (Dabney et al., 2012; Maltese & Tai, 2010; Tai, Liu, Maltese, & Fan, 2006).

Keywords: Elementary education, science, preservice teachers, identity, supports, barriers, self-efficacy

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\* To whom correspondence should be addressed at Department of Teaching and Learning, Virginia Commonwealth University, 1015 West Main, P.O. Box 842020, Richmond, VA 23284-2012, phone: 804-828-9930, fax: 804-828-5639, e-mail: kdabney@vcu.edu

Therefore, additional studies are needed to examine role of students' experiences in elementary science classrooms where formal science education begins (Maltese & Tai, 2011). Tosun (2000) found that elementary preservice teachers tend to have adverse feelings towards science content and instruction that negatively impact their self-efficacy for teaching science. In many cases, these negative feelings eclipsed preservice teachers' prior achievement in science courses. An elementary teachers' aversion to science can lead to the avoidance of teaching science or to the use of instructional methods (e.g., reading the text and answering questions) that fail to engage students meaningfully within the content (Avery & Meyer, 2012).

Current supports in elementary teacher preparation programs have seemingly been insufficient in helping teachers overcome these obstacles (Davis, Petish, & Smithey, 2006). This study extends the line of inquiry into elementary teachers' orientation to teaching science by examining preservice teachers' experiences with and perceptions of science and science teaching. Longitudinal interviews were conducted with Masters of Teaching candidates, at both the beginning of their degree program and in their first year of teaching, to consider internal and external factors during their graduate education that served as barriers or supports for the development of science instruction skills and science self-efficacy. This knowledge could provide insight into improving elementary science teacher preparation which could, in turn, enhance science instruction in elementary classrooms. The research question guiding this study is: *What do preservice elementary teachers report about supports and barriers for science teacher identity development?*

### **Identity Development in Preservice Teachers**

In order to understand the barriers and supports that preservice elementary teachers face when becoming teachers of science, it is pertinent to explore theories of identity development, specifically as they relate to preservice teachers. These theories include the dialogical self and social identity development.

#### **Dialogical Self**

An exploration of identity is two-pronged: both self and culture must be explored (Hermans, 2001). This is necessary because the study of an individual can easily be siloed, and culture made abstract, in spite of each unit's dependence on the other (Hermans, 2001). Culture helps to make the person, and the person helps to shape the culture. Dialogical Self Theory posits that people engage in a self-dialogue to negotiate their identities, which are both personal and social (Hermans, 2001). Emotions and experiences help develop voices that define their identity, which can be both stagnant and dynamic (Hermans, 2001; Ligorio, 2010). Akkerman and Meijer (2011) called for more empirical work exploring the processes that teachers endure in order to construct their own identities. Preservice teacher programs and practical experiences are integral components of the development of teachers' identities. Thus, these programs should be sensitive to the importance of the identity development process in order to foster a more supportive environment (Lee & Schallert, 2016).

Understanding identity is complicated, partially due to the complexities of creating a concrete definition (Beauchamp & Thomas, 2009). Furthermore, each person carries a variety of identities based on their biological and social selves that are manifested in sundry situations (Gee, 2000). While a teacher preparation program can support preservice teachers, the development of a teacher's identity is complex and requires support from various outside actors, including current practicing teachers. However, it is also largely constructed through the preservice teacher's own voice and self-image (Sutherland, Howard, & Markauskaite, 2010). Nevertheless, teacher identity is not contained to personal experience; examining the teacher's identity within a social context is also relevant (Friesen & Besley, 2013).

#### **Social Identity Development**

Another way to examine the identity development of teachers is through the social and philosophical underpinnings that guide such construction. Identity development manifests in various forms

(Gee, 2000). While one's identity as a teacher is usually categorized within an institution or as a professional identity (Sutherland, Howard, & Markauskaite, 2010), there is more to teaching than just the job itself (Sanger & Osguthorpe, 2011). The moral work of teaching and the support of student teachers through moral work is critical for their development as teachers; teachers' beliefs are built upon their own experiences and identities (Sanger & Osguthorpe, 2011). Capitalizing on these experiences, therefore, is critical. Furthermore, teacher identity is important in the personal construction of barriers and supports. Since emotion is tied to the social construct of teaching (Zembylas, 2005), it is essential to understand its role in teacher development (Timoštšuk & Ugaste, 2010). Woolhouse and Cochrane (2015) argue that while policies and practices may impose on identity development and self-efficacy, teaching preservice teachers to be reflexive in their practice can help these individuals better negotiate their identity, and thereby also increase self-efficacy.

#### **Identity Development of Teachers of Science**

Despite the various perspectives on teaching and learning science, most can agree that the purpose of science education is to provide students with critical tools to engage in dialogues to discover and understand the nature of science (Anderson, 2007). However, science education in the neoliberal era requires the cramming of facts in order for students to be able to regurgitate them on standardized tests (Hayes, 2016). This duality of fear based on past experiences and the necessity to teach science prevents preservice teachers from knowing how the nature of science should actually be taught. Due to this, Siry and Lara (2012) have indicated the importance of the exploration of emotion and self-efficacy of elementary science preservice teachers.

**Emotion and Self-Efficacy.** Self-perceptions of efficacy can greatly impact one's performance, even when holding skillset and knowledge constant (Bandura, 1997). In order to prepare preservice

teachers to be effective once they enter the classroom, they must be mentored and nurtured to feel prepared. As such, the development of an elementary science teacher should be about the process, rather than the end goal. This notion is further articulated in that the process of becoming a science teacher should be developed through a variety of experiences in one's teacher education program including mentoring and nurturing (Gunning & Mensah, 2011). One particular experience showed how student excitement for learning increased preservice teachers' confidence in teaching science, thereby increasing self-efficacy (Carrier, 2009). Furthermore, Kane and Varelas (2016) maintain that implementing instructional designs that support student engagement through inquiry improves teacher self-efficacy due to students' enjoyment of learning.

**Purposes of Teaching Science.** Another aspect of improving preservice teachers' self-efficacy is fostering their curricular role identity (Forbes & Davis, 2008). This requires learning innovative strategies that better support their beliefs about the purpose of teaching science, which includes critically responsive teaching and inquiry-based learning (Moore, 2008; Schwarz, 2009). Specifically, teaching science content to students living in poverty proves challenging due to limited time, resources, and support (Moore, 2008). Teaching and learning science provides an opportunity for teachers to be culturally responsive by incorporating diverse styles of learning for diverse learners (Settlage, Southerland, Smith, & Ceglie, 2009). Training preservice teachers to use current best practices improves their self-efficacy and cultivates better student learning.

Preservice teachers' self-efficacy in teaching science can be impacted by the ability of teacher education programs to cultivate the development of preservice teachers' science identities with consideration to both dialogical self-theory and social identity. Teacher education programs can help students cultivate a positive dialogical self-identity through positive experiences and emotions of instructing science throughout their

development as a teacher. Additionally, Siry and Lara (2012) report that maintaining a reflexive dialogue with both themselves and others in order to improve preservice teachers' self-efficacy is key. Thus teacher education programs can provide the tools needed to overcome perceived barriers for becoming successful teachers of science.

### **Support Programs for Preservice Teachers**

A number of support programs focused on inquiry-based science teaching and learning have been provided to preservice elementary teachers with at least moderate success. Riegle-Crumb and colleagues (2015) and Bergam and Morphew (2015) learned that preservice teachers enrolled in inquiry-based science content courses reported increased enjoyment and perception of relevance of science content, decreased anxiety, and increased efficacy and outcome expectations for teaching science. Avery and Meyer (2012) found that the majority of preservice teachers in an inquiry-based course experienced gains in conceptual understanding of science, the scientific process and scientific research.

Science support programs for preservice elementary teachers are not limited to inquiry-based content and methods coursework. Having opportunities to practice inquiry-based science teaching in an informal learning environment led to preservice teachers transferring those experiences to their teaching (Cartwright, 2012). Specific practices included a focus on creating a safe learning environment for students, encouraging students to discuss their thinking about science, and incorporating students' ideas into science lessons. Furthermore, Katz et al. (2011) demonstrate that participation in a science internship in an informal learning environment positively influenced preservice teachers' identity development as science teachers. Following the internship, participants exhibited positive attitudes toward science, sensitivity to diversity and increased confidence in facilitating hands-on science participation, inquiry, and collaborative work (Katz et al., 2011).

## **Data and Sample**

### **Data**

The data analyzed in this paper were collected as a part of Project Early Science Education, funded by an internal institutional award and led by the first author. Project Early Science Education is a longitudinal qualitative study designed to examine the transition from graduate student to classroom teacher in elementary science education. The study took place in a public, urban university in the Eastern United States. The first phase of the study consisted of interviews of preservice elementary teachers currently progressing from graduate students to classroom teachers. The second phase, occurred a year later and followed up with former students in their first year of teaching.

Data sources included individual semi-structured interviews and participants' academic transcripts. Original participants were selected through purposive sampling techniques; future participants were selected through snowball sampling (Maxwell, 2012). Interviews were digitally recorded, ranging in length from 30 to 90 minutes. Participants were elementary Master of Teaching students in different stages of their teacher preparation program at the time of recruitment. An initial round of eleven interviews took place Spring 2015 with both preservice teachers that were enrolled in full-time coursework and full-time student teachers. During Spring 2016, six follow-up participants were interviewed at the end of their first year of teaching. The primary focus of the interviews was to allow themes to emerge linking prior education and graduate school experiences with science content knowledge, pedagogical content knowledge (PCK), career development, self-efficacy, and identity development of elementary school teachers (Miles & Huberman, 1994). All interview recordings were de-identified and transcribed with an alphanumeric code prior to analysis. Incentives were not provided to the participants in this study besides the chance to discuss their science experiences as pre-service and practicing elementary teachers.

## Sample

This research consisted of six semi-structured and open-ended interviews of pre-service elementary teachers/practicing first year teachers. The set of data used here is homogenous as all participants were in the course of receiving, or already had received Master of Teaching in Elementary Education degrees. Specifically, this sample included interviews of the six initial participants, that were pre-service teachers in 2015, who then participated a year later, in 2016, as full-time first year teachers. Pseudonyms will be used in respect to all references of university, school placements, and participant names in order to maintain participant confidentiality. Table I shows participants' pseudonyms along with their science coursework GPA (methods coursework was excluded), science self-efficacy upon entry to the Master of Teaching program, science self-efficacy when exiting the Master's program, and whether the participants taught science as a full-time elementary school teacher in 2016.

## Methodological Overview

Interviews were analyzed in order to understand how participants described barriers and supports to their teaching of science within the elementary classroom. A postpositivist paradigm is used to support this research in the analysis of participants' personal experiences, beliefs, and knowledge within elementary teacher preparation programs (Lent, 2000).

## Data Coding and Analysis

The interview data were examined through a critical realism lens, in that

there are truths that can be found through methods of cause and effect (Miles & Huberman, 1994). This approach focuses on generalizability and aggregating the data in order to find themes within the material regarding our research question (Miles & Huberman, 1994). Epistemological understandings indicate that these themes can be examined based on both the interviewee's responses and existing literature. We developed a code list prior to the analysis as a means to deductively aggregate and decipher themes present in the data (Saldaña, 2012). A brief literature review indicated that preliminary codes of interest should include some of the following: experiences, attitudes, direct instruction, elementary science education, science knowledge, science methods inquiry, self-efficacy, etc. (Tai et al., 2006; Maltese & Tai, 2011; Carrier, 2009; Mulholland & Wallace, 2000; Avery & Meyer, 2012; Tosun, 2000; Hayes, 2016; Riegler-Crumb et al., 2015; Bergman & Morphew, 2015). The lists of all preliminary and final codes are available in Appendix A.

Interview sets for each participant were reviewed multiple times and coded across the first and second years for consistency or divergence in responses. Additional codes emerged throughout the analysis leading to a blended coding approach (Saldaña, 2012). Coding and data aggregation was created and completed with the use of NVivo11 to examine how pre-service elementary teachers' professional and personal experiences with science interact while earning a Master of Teaching degree. These were

considered in light of their science teaching practices and identity development in the elementary classroom. In order to maintain the integrity of the critical realist perspective and blended coding approach, we will present our findings by themes based on our research question, rather than individual groups or interviews.

## Results

### Barriers

Throughout the pre- and post-interview process, participants described negative experiences that impacted their science teaching identity. Barriers to teaching science were categorized according to the following themes: prior elementary science experiences and lack of interest, science content and coursework requirements, practicum experiences, and socio-economic status of both the pre-service teacher and the school.

**Prior elementary science experiences and lack of interest.** Children with early positive science efficacy are more likely to be successful and interested in science later in life (Maltese & Tai, 2010; Tai et al., 2006; Simpkins, Davis-Kean, & Eccles, 2006). In our findings, five out of six participants indicated that a lack of science interest and adverse experiences as an elementary student later influenced their views of science. The majority of participants stated they did not remember science instruction from their time in elementary school. Those that did, recalled science negatively. For example, Jessica said,

I don't remember science being part of [elementary] instruction in school in general. It's weird because you know, as you're in this, and you're in the elementary school and you're teaching these kids, you have a lot of these memories come back like, 'Oh, my gosh! I so remember doing this... And science just isn't one of those things.

The ages of our participants places them as members of the curriculum standardization and high-stakes testing generation. This testing focus, beginning in early education, was often defined by our

Table I. Sample Demographics including pseudonym, entry science coursework GPA, Master degree entry science teaching self-efficacy, Master degree exit science teaching self-efficacy, and status of teaching science in 2016

Pseudonym	Entry Science GPA	Program Entry Science Teaching Self-Efficacy	Program Exit Science Teaching Self-Efficacy	Teaching Science in 2016
Lisa	3.6	Negative	Negative <sup>1</sup>	No
Olivia	3.2	Positive	Positive	Yes
Donna	3.7	Negative	Positive	No
Audrey	2.7	Negative	Positive	Yes
Jessica	2.8	Negative	Positive	Yes
Nancy	3.1	Negative	Positive	Yes

1. Attributed to a lack of background knowledge/negative prior experiences.

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sample as a precursor to a science interest deficit. Nancy described her early science education as,

I don't remember a whole lot of science instruction as a kid... I never wanted to be a scientist because a lot of it was notes. I was in the first year of [standardized] testing so we did a lot of that, preparing for [standardized testing] more than inquiry and learning through doing.

Many of the participants indicated their own early elementary science experiences, or lack thereof, hampered their instruction as future teachers. Furthermore, upon entry into their elementary teaching degree program, our participants' low interest in science and for teaching science was, in part, attributed to their early experiences. These findings are partially supported by research (Avery & Meyer, 2012; Carrier, 2009; Mulholland & Wallace, 2001) that prior science teaching experiences, as preservice elementary teachers, can lead to avoidance of teaching science or using certain science practices. Our study further delineates that early elementary experiences, as a student, have an influence on students' dialogical and social self-identity development and persist as well as influence later elementary science teacher self-efficacy.

**Science coursework requirements and teaching degree content.** Beyond early science education, half of our participants indicated that university science content and coursework requirements were concerns in their elementary teacher preparation program. Science pre-requisites for the teaching program were described as being predominantly lecture-based and thus mirroring the type of instruction they received in preparation for high-stakes testing instruction. For example, Donna explained a barrier to science teaching as,

a lot of the undergrad pre-[requisites] [for the elementary education program] are very lecture based and they are very... "Here is a power-point, show up if you want to, don't show up, and then come and take a test." All of your grades are based on two or three tests.

Finally, participants cited concerns with there being only one science methods course in their Master's of Teaching program. They felt as though science was, "a forgotten subject," as the program predominantly focused on reading, writing, and mathematics. Specifically, Lisa said,

I do wish that in our [early elementary Master's degree coursework] and really prior to even entering the teaching prep stage, that we would have had more classes that incorporated [science], like I feel like they set us up so well for math and language arts, but science and history were kind of the forgotten subjects.

Prior research showed that elementary teachers often have inadequate backgrounds in science and with science content overall (Tosun, 2000). Yet the graduate teacher preparation program in this study required 15 credits of science coursework prior to admission. However, the reliance on direct instruction and rote memorization in prerequisite courses leads to a lack of reflexive dialogue needed for positive science identity development and was a significant concern for these pre-service teachers during both of their initial and follow up interviews. When reviewing the participants' prior coursework, the average science grade point average (GPA) was a 3.2. Interestingly, GPA did not appear to differ based on prior science interest, experiences, coursework, or past or current teaching self-efficacy (See Table I). This supports Tosun's (2000) argument that adverse attitudes toward science can eclipse prior science achievement. Finally, as there was only one science methods course required upon entry into the preservice teaching program, our respondents felt preparation for science PCK instruction was lacking once in the teaching program.

**Practicum experiences.** Five out of six participants stated that their practicum experiences were potential barriers to their future as an elementary school teacher. Challenges included direct instruction being used at the primary form of instruction in the classroom as well as a lack of science instruction. Donna stated,

I didn't see a whole lot of science included. It was winter, we had a lot of snow days and things like that so both teachers really focused heavily on math and English. Science and social studies just kind of got pushed to the side.

Audrey indicated this lack of science instruction was dictated by administration. "My [cooperating] teacher told me that the principal had said, 'All that's important is that we get to reading and writing.'" When science instruction occurred, Jessica described it as,

Lots of worksheets that drove me crazy... They just did [inquiry] in magnets and they got to go through a basket of items and see what was magnetic and what wasn't and then discuss how and why it was magnetic. I think that it's the only science lesson that I have seen taught other than teaching myself... But it was a little 20 to 30-minute activity that they got to do and then moved right along from there.

When the preservice teachers reached their practicum placements, many felt that science was a subject of less importance. Being expected to teach science induced anxiety for the preservice teachers, because what they observed—direct instruction methods, or not being taught at all—contradicted what they were learning in their programs about best practices for teaching science. Woolhouse and Cochrane (2015) discuss the disconnection between educational policy and teacher practice in the schools. Our research reinforces that policy influences preservice teachers as well in regard to science teaching experiences in the local schools.

**Socioeconomic status.** Finally, four out of six respondents discussed financial concerns that served as a barrier to their success and persistence in their teaching program, both with students' opportunities at home and related to the schools in which they serve. For example, Olivia described,

The problem is not all kids are getting those experiences at home and

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not all kids are getting that literature at home. The key in the primary grades is incorporating science and social studies into language arts.

Nancy further noted the differences in science instruction when comparing placements in a lower socioeconomic status (SES) elementary school and more affluent school,

In [one] practicum experience, I was at a very affluent school in the western part of my county... they have a STEM lab. It was filled with all the latest technology. Being in my [other] practicum class, which was at one of the lowest (SES) schools in [the] City, they didn't have any of that. Science wasn't even taught at all.

It has been shown that access to science is often associated with a student's socioeconomic status and parental education (Maltese & Tai, 2011; Dabney, Tai, & Scott, 2016). Past research has found that pre-service teachers find teaching science more challenging and have lower self-efficacy based on factors related to students' SES during their student teaching placements (Moore, 2008; Cone, 2009). Our study further delineates that at-home and school based socioeconomic status and subsequent opportunities may influence pre-service elementary teachers' overall science identity development/opportunities and subsequently their feeling of self-efficacy in their science program.

### Supports

While barriers could be overwhelming for our participants, they described supports that bolstered their science teaching identity as they entered the field of elementary science teaching. These supports included hands-on/inquiry-based science coursework, prior experience in schools and working with children, positive practicum experiences, and support from family and friends.

**Hands-on/inquiry based science coursework.** Every participant reported that hands-on/inquiry based approaches to elementary instruction in their undergraduate science coursework, as well as within their Master's degree program,

supported their identity as a future elementary science teacher. A general theme, well summed up by Lisa, was the recommendation that prerequisite science coursework focus on, "how you can present the material and subject matter that the child will understand, and really, that's appropriate for them. I would have liked something like that for science on all levels." Participants frequently recommended developing an inquiry-based method of prerequisite university science coursework, specifically with a focus on instruction for elementary school children. This ethos is well supported by research (Cone, 2009; Riegel-Crumb et al., 2015) findings that show inquiry learning experiences often boost elementary pre-service teacher self-efficacy.

A hands-on/inquiry approach as well as a variety of PCK instructional techniques were provided within the required science course for participants' Master of Elementary Teaching degree. As Lisa described this course had, "the largest emphasis [on] science through inquiry, because that's really what sparked my curiosity in science to begin with and it gave me hope like "Oh thank god these kids won't have to go through what I did." This study shows that inquiry instruction should be provided not only in preservice elementary teacher programs but also prerequisite science coursework. This type of instruction could lead to a change in teachers' science identities developed from prior negative experiences, and improve self-efficacy in teaching science.

**Prior teaching experience in schools and work with children.** Another support reported, by five out of six participants, was prior experience in schools and working with children. Olivia felt that experience in an informal education environment was helpful, stating, "Even just working at a daycare and having after-school kindergartners and doing their [science] homework with them." Audrey further shared, "I was volunteering after school, it was an after school program in [the] county. I'm going back here to teach, I'm home currently now... I just wanted to make sure I could try and make a change and help the kids

out." Having the opportunity to interact with children prior to entering a teaching program and having hands-on/inquiry-based science within and outside the classroom prior to degree entry made science more enjoyable for them and their students, thus boosting positive science identity and self-efficacy. Furthermore, lacking this experience was perceived as a barrier among our participants.

Cartwright (2012) and Katz et al. (2011) found that preservice teachers benefit from placement and practice in informal science programs. Our study further delineates that prior experience with children and science was beneficial to our candidates. Future research could examine whether prior teaching experience, both formal and informal, if used as a prerequisite prior to entrance to the teacher preparation program, may increase degree attainment, teacher retention, and self-efficacy in science.

**Positive practicum experiences.** Five out of six preservice teachers described positive practicum experiences that helped their preparation as a future teacher. These placements included hands-on and inquiry based methods of instruction similar to those explored and discussed in their elementary science methods course. Jessica offered the following, "In the practicum's first grade they were doing plants. That was cool... I brought in a plant for them to dissect; that was fun". She further discussed an influential lesson from a practicum placement as,

Some hands-on instruction... they did do a [lesson on] mixtures and solutions. They dealt with the oil, and she let them do it themselves, she was awesome. They had an experiment chart and they had to document their experiment and they got to do mixtures with different things and solutions with different things and figure out what was and what wasn't and why...They got the biggest kick out of it, and they loved it.

Another participant, Lisa, shared the following,

I worked with six year olds and nine year olds. I saw a lot of science

through inquiry in the first grade classroom which was very effective. I think it was almost hidden in the way the students were learning. They thought they were just having fun, and that they were getting to do experiments and try stuff.

As such, placement with cooperating teachers that use a hands-on/inquiry approach to science was important to preservice teachers being able to observe and implement lessons in a manner that bolstered their identity and self-efficacy toward teaching science. Carrier (2009) found that positive preservice teacher experiences with science inquiry in the classroom led to an increase in self-efficacy. Our research reinforces these findings and indicated that these science experiences should be sought in elementary teacher practicum placements.

#### **Support from family and friends.**

Finally, four out of six participants emphasized the importance of support from family and friends. Specifically, with regard to science instruction, participants mentioned parent support, practice with younger siblings, discussions at home, support from friends who were already teachers, and practicing science discrepant events. Donna stated, “I practice at home getting ready to do butterfly life cycle and so I had movement[s] of what the kids could do. They were like: be an egg and then a caterpillar. I practiced and I made my 18-year-old sister do it.” Olivia indicated the following about her support system understanding what she does as an elementary science teacher, “My mom’s a teacher, so she’s absolutely 100 percent supportive. My brother is a professor, so he is 100 percent supportive.”

Additional supports were also mentioned such as collaborating with other schools, sharing materials, and fundraising to provide science opportunities for students in at-risk schools. This builds upon previous research demonstrating that professional networking with colleagues and mentors as well as personal support from family helps the development of new teachers (Baker-Doyle, 2011). Our findings provide additional

evidence that building personal and professional support networks for preservice teachers has a similar positive influence on science teaching practice. Moreover, our results support the notion that social interaction and dialogue about teaching science can further bolster confidence and affect science identity (Lara, 2012).

### **Contribution to the Teaching and Learning of Science**

Early science education has a renewed focus in education policy (National Academy of Sciences, 2007). While we know that elementary students may be positively or negatively influenced by their teachers’ self-efficacy toward science and science teaching (Carrier, 2009; Mulholland & Wallace, 2001), questions still remain regarding how to best support and prepare preservice elementary school teachers for elementary science instruction. Prior research examining preservice teachers’ efficacy for teaching science has led to suggestions for improving elementary science teacher preparation such as focusing on inquiry-based instructional methods (Avery & Meyer, 2012; Bergam & Morphew, 2015; Riegler-Crumb et al., 2015).

This study offers a unique perspective as our participants were followed from the beginning of their teacher education program through their first year of teaching. Our participants indicate that science self-efficacy and instructional practices are continuous, as opposed to singular points in time, and developed throughout a variety of experiences such as learning science as an elementary student, prior science work with children in informal environments, prerequisite science courses, science methods coursework, and practicum experiences during their Masters’ degree program. Thus, the identity development of future elementary teachers begins during their own elementary school experiences as a student and ranges all the way through their teaching practicums.

The data from this research also suggests that certain barriers can decrease science teaching identity of future elementary school teachers. Considering past experiences as students in a high-stakes

testing environment (Kane & Varelas, 2016), preservice teachers had few opportunities for inquiry-based learning in elementary school prior to their teaching degree program. Many reported a lack of rich science experiences, or disengaging teaching practices such as lecture and worksheets during their own elementary school years. Participants also identified barriers related to their prerequisite science coursework. Once in college, similar teaching practices involving lecture and rote memorization continued for our students. Since policy now calls for teaching elementary-aged children through a variety of instructional techniques with a focus on inquiry, it is understandable that self-efficacy is low (National Academy of Sciences, 2007; Sax, 1994; Maltese & Tai, 2011; Maltese & Tai, 2010).

Both self and culture contribute to science identity development (Hermans, 2001). By better understanding supports and barriers that preservice and practicing teachers face in teaching science, teacher education programs can better develop a culture that cultivates positive science identities in students. Working to influence the dynamic aspects of science identities in preservice teachers can then influence how they work to influence their students’ science identities within their own classrooms. Additionally, implementing these practices can encourage both teachers and students to engage in reflexive dialogues about science knowledge and science teaching that can heighten self-efficacy to teach inquiry-based science in the future.

In order to improve science experiences for students of all ages, providing students, preservice teacher candidates, and teachers with instructional support, affordable materials, and ample experiences to teach and learn science through inquiry and hands-on methods of instruction will provide a better teaching and learning environment for all. Beyond being strong methodologically, preservice teachers also delineated specific personal and professional supports to develop self-efficacy as future elementary science teachers (Bursal, 2012; Mansfield & Woods-McConney, 2012; Mulholland & Wallace, 2001). Through

an increased focus on preservice teachers' perceived supports such as providing teaching experiences in informal learning environments, incorporating inquiry coursework within teacher preparation programs, selecting practicum placements that emphasize science instruction, and building professional and personal support systems, preservice teachers' efficacy and science teaching identity may increase. Most of our participants indicated they did not think specifically about teaching science when they considered teaching as a career. Rather, they just knew it would be part of the job. If we want to spark interest and engagement with science among our youth, we must ensure that interest is ignited in their teachers. To develop more rigorous elementary teacher preparation in regard to science instruction and self-efficacy, public policymakers and educators will need to provide a series of supports for future science teachers ranging from their elementary school experiences through their practicum placements.

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**Appendix A: Coding Lists**

**TABLE II.** Preliminary codes developed from pre-existing literature

Barrier	B
B: Negative Experiences	B-NEGEXP
B: Attitudes	B-ATTITUD
B: Lack of Materials	B-LACKMAT
B: Elementary Teacher Negative Attitude	B-ETEACHNA
B: School Poverty	B-SCHOPOV
B: Direct Instruction	B-DIRECTINS
Support	S
S: Elementary Science Education	S-ELESCIED
S: Middle School Experiences	S-MIDSCHEXP
S: Science Knowledge	S-SCIKNOW
S: Science Grades	S-SCIGRADE
S: Science Methods Inquiry	S-SCMETHINQ
S: Informal Science Experience	S-INFSCIEXP
S: Nature of Science	S-NATUREOSCI
S: Prior Teaching Experience	S-PRIORTEAEX
Other	O
O: Teacher Identity	O-TEACHIDEN
O: Teacher Voice	O-TEACHVOIC
O: Elementary Teacher Self-efficacy	O-ELETEASFE
O: Teacher Policy	O-TEACHPOL

**TABLE III.** Final codes created from a blended coding approach of preliminary and emergent codes

Barrier	B
B: Prior elementary science experiences/interest	B-PRIOELSCEX
B: Science content and coursework requirements	B-SCIENCONT
B: Practicum experiences	B-PRACEXP
B: Socioeconomic status	B-SOCECONS
Support	S
S: Hands-on/inquiry-based science coursework	S-HANDINQCOU
S: Prior experience in schools and work with children	S-PRIOREXP
S: Positive practicum experiences	S-POSPRACEXP
S: Support from family and friends	S-FAMFRSUPP
Other	O
O: Elementary Teacher Self-efficacy	O- ELETEASFE