ELECTRONIC JOURNAL FOR RESEARCH
IN SCIENCE & MATHEMATICS EDUCATION
VOL. 25, NO. 1, 20-45

Influence of Science Experiences on Preservice Elementary Teachers' Beliefs

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ABSTRACT

The purpose of this mixed-methods research was to investigate changes in preservice elementary teachers' science teaching beliefs and explain how these beliefs influence the way these teachers interpret their science teaching and learning experiences. Supported by the theoretical underpinnings of teacher beliefs and drawings as a tool to investigate teacher beliefs, this research utilized qualitative (written science autobiographies and reflections) and quantitative (Draw-a-Science-Teacher-Test-Checklist as a pre and post measure) data collection techniques. A total of 55 preservice elementary teachers participated from two public universities located in the United States and Canada. Quantitative analysis revealed positive shifts in science teaching beliefs of preservice elementary teachers largely in two ways: A small shift representing small positive difference or a large shift representing large positive difference between the pre- to post-course DASTT-C scores. Qualitative data analysis for the two sub-groups of participants (small shift and large shift) provided evidence that preservice teachers' beliefs were linked to their personal histories and were influenced by their prior science experiences. Preservice teachers' beliefs and their self-images changed as they participated in the field teaching experiences in elementary classrooms and engaged with elementary learners, during the science methods course. Implications for preservice teacher education programs, science teacher education, and research are included.

Keywords: Draw-A-Science Teacher Test-Checklist (DASTT-C), preservice teacher education, science methods courses, science teacher beliefs

Introduction

Science education reforms across the globe strive to achieve high-quality elementary science teaching (Australian Curriculum, 2015; National Curriculum in England, 2015; Newfoundland & Labrador, Department of Education, 2016; NGSS Lead States, 2013). And, teachers play a critical role (Battista, 1994) as "the decisive component" in implementing any science education reform (Bybee, 2014, p. 144). Despite the calls and systemic reform initiatives to improve science teaching in elementary classrooms (AAAS, 1993; NRC, 2012; No Child Left Behind, 2000; van Driel, Beijaard & Verloop, 2001), anecdotal evidence from the recent surveys in the United States and Canada suggest that fewer elementary teachers felt prepared to teach science (Banilower et al., 2013; Rowell & Ebbers, 2004; Trygstad, Smith, Banilower, & Nelson, 2013), and sometimes tend to avoid teaching science altogether (Appleton & Kindt, 2002). Past research highlights several factors related to elementary teachers' preparedness to teach science such as limited science content knowledge, confidence to teach science, and less positive attitudes and beliefs about science teaching (Bianchini & Colburn, 2000;

Gunning & Mensah, 2011; Howes, 2002; Murphy, Neil & Beggs, 2007; Rice, 2005; Taylor & Corrigan, 2005).

Science teaching beliefs have a strong impact on teachers' practices (Pajares, 1992; Richardson, 1996), and have become an important area of research within the last few decades. Research has shown that teachers' science teaching beliefs influence (a) their instructional decisions and learning (Rubie-Davies, Flint, & McDonald, 2012), (b) implementation of content and/or curricula in a classroom (Luft, 1999; Roehrig, Kruse, & Kern, 2007), and (c) reasons to engage in certain type of science teaching practices, such as inquiry (Lotter et al., 2007; Roehrig et al., 2007). Science teaching beliefs center at teachers' views about disciplinary knowledge on how children learn, specifically, how they "make sense of science concepts," guiding their goals "to promote students' deep thinking, rather than students memorizing factual and discrete information" (Crawford, 2007, p. 17). However, there is an evidence that beliefs and practices are not essentially consistent because teacher negotiates their beliefs differently in changing contexts, which makes this interaction complex and context-dependent. (Kang & Wallace, 2005; Savasci & Berlin, 2012). Science teaching beliefs are "personal construction" of ideas, and therefore, the goal of teacher preparation programs is to promote positive changes in teachers' beliefs about science teaching (Jones & Leagon, 2013). Therefore, science teacher educators "need to find new and different ways to challenge preservice teachers to move towards the formation of reform-based beliefs" (Fletcher & Luft, 2011, p. 1144).

Preservice teachers enter teacher education programs with a set of beliefs regarding science teaching that impact their views of self as a science teacher and science teacher self-image (Menon, 2016; Richardson, 2003). Researchers argue that teacher beliefs and self-images are re-shaped within the teacher preparation programs that are carried to future classrooms (Menon, 2016; Bautista, 2011; Gunning & Mensah, 2011; Hancock & Gallard, 2004). There is enough evidence that teachers restructure their science teaching beliefs during science methods courses (Ambusaidi & Al-Balushi, 2012; Hancock & Gallard, 2004; Minogue, 2010; Pilitsis & Duncan, 2012). However, some evidence shows regression to these changed beliefs by shifting back to beliefs that teachers brought to the course (Fletcher & Luft, 2011). This evidence has emphasized the need to study this *change* to explore how teachers' initial beliefs, shaped by their K-12 science experiences, called "insider effect" (Pajares, 1992), further influence their beliefs in science education programs. Understanding how newer experiences within the science methods courses influence one's 'belief-system' can help teacher educators provide more meaningful and appropriate support during the science methods course to enhance the stability of this change.

The present study not only examines the change in science teaching beliefs by identifying the science teaching beliefs that preservice elementary teachers (PETs) brought to their science methods course but the science teaching beliefs they left the course. This research also quantifies this change by determining the amount of shift in PETs' science teaching beliefs during the science methods course and investigates two distinct groups of PETs with a small and a large shift in their science teaching belief to examine how these two groups interpret their science teaching and learning experiences. Specifically, the following research questions are part of this investigation: (1) How do preservice elementary teachers' prior science experiences influence their initial science teaching beliefs? (2) How do preservice elementary teachers' experiences within the science methods course influence their science teaching beliefs?

Theoretical Underpinnings and Background Literature

This study draws on two theoretical underpinnings (a) teacher beliefs about teaching and learning, and (b) drawing in science education. Below is the description of these theoretical perspectives and their interpretation for the purposes of this study.

Teacher Beliefs about Science Teaching and Learning

Teacher beliefs that relate to teachers' motivation and performance have been defined and conceptualized in many different ways by researchers in the field. Pajares (1992) defined teacher beliefs as "individual's judgment of the truth or falsity of a proposition, a judgment that can only be inferred from a collective understanding of what human beings say, intend, and do" (p. 316). According to Nespor (1987), beliefs are highly influenced by prior experiences and these "episodic memory of prior events" influence teacher practices (p. 17). With regard to the teaching profession, several researchers relate beliefs systems to teacher behavior and instructional decisions (Nespor, 1987; Pajares, 1992). Others also assert that beliefs held by teachers determine decisions regarding the adoption of curriculum reforms and new research-based strategies (van Driel, Bulte, & Verloop, 2007). There is a consensus in the literature that understanding teacher beliefs is crucial to improving classroom practices because these beliefs act as filters through which teachers process relevant information and interpret new knowledge related to teaching (Kagan, 1992; Putnam & Burko, 1997).

Teachers' beliefs have been the topic of great interest in the science education research community as they are highly influential in teachers' classroom practices. Some researchers argue that beliefs that preservice teachers hold at the time they begin their teacher preparation coursework are difficult to amend (Kagan, 1992; Pajaras, 1992). However, others argue that experiences within the teacher preparation programs may help shape beliefs regarding their ability to teach science (Gencer & Cakiroglu, 2007; Mulholland & Wallace, 2001). Past research shows that the belief system is adaptive in nature, and experiences have the potential to refine beliefs that preservice teachers hold at the time of entering teacher preparation program (Bursal, 2010; Yilmaz-Tuzun, 2008). Empirical studies have documented that hands-on learning experiences, along with instructor modeling of appropriate teaching practices positively impact preservice teachers' self-efficacy beliefs (Menon, 2016; Menon, 2018; Bautista, 2011; Palmer, 2006). Other studies document that science methods courses provide a variety of experiences to enhance preservice teachers' self-efficacy beliefs such as hands-on investigations, designing science lesson plans, watching videos of exemplary science teaching, and holding discussions of different aspects of teaching (Bautista, 2011; Gunning & Mensah, 2011; Mulholland & Wallace, 2001).

Changes in Teachers' Beliefs

Research has established that preservice teachers' science teaching beliefs change during teacher education program (Menon, 2016; Bautista, 2011; Gunning & Mensah, 2011; Hancock & Gallard, 2004), particularly during science methods course (Ambusaidi & Al-Balushi, 2012; Hancock & Gallard, 2004; Minogue, 2010; Pilitsis & Duncan, 2012). And, teachers' previous experiences related to science learning and teaching are considered to influence this change process (Gunstone et al. 1993; McDiarmid et al. 1989; Olson & Appleton, 2006), which is referred to as an "insider effect" by Pajares (1992). However, the role of this insider effect has not been an explicit focus of research on science teachers' beliefs. In this current research, we conjecture that PETs' previous belief systems about teaching science could be shaped through the science methods coursework; however, this change may not be consistent. We investigate the group of PETs with varied shifts in their science teaching beliefs and study how they interpret their prior science learning experiences. We further investigate whether and how PETs' negotiate their science teaching beliefs in the context of new experiences gained in the science methods course.

Studying Teachers' Beliefs

To uncover preservice teachers' complex set of beliefs about science teaching, researchers have utilized a variety of tools and methods including interviews (Brown & McNamara, 2011; Furlong, 2013; Luft & Roehrig, 2007), questionnaires (Avalos & De Los Rios, 2013; Hong, 2010), focus groups (Avalos & De Los Rios, 2013), and drawings as preservice teachers' images of self as science teachers (Markic & Eilks, 2012; 2015; Markic et al. 2016; Thomas, Pedersen, & Finson, 2001). Drawings have been considered as an important tool for preservice teachers to reflect on their views on how they represent themselves as a teacher of science, within a classroom, and their students as science learners. One of the commonly used drawing tools is the Draw-A Science-Teacher-Test-Checklist (DASTT-C) developed by Thomas, Pedersen, and Finson (2001). Past studies utilized pre and post-test design implementing the DASTT-C tool to preservice teachers at the beginning and end of an intervention or a semester-long course (Markic et al. 2016; Markic & Eilks, 2012; 2013; 2015). It has been established that science methods courses support the changes in preservice teachers' beliefs, as evident from their drawings (Markic et al. 2016; Markic & Eilks, 2012; 2013; 2015).

Drawings in Science Teacher Education

Studies suggest that preservice teachers' beliefs regarding science teaching shape their perceptions of self as science teachers (Menon, 2016, 2020). Literature posits that preservice teachers' drawings of themselves as science teachers are a valuable tool to reveal their perceptions of science teaching as well as their self-image as science teachers (Akkus, 2013; Finson, 2001; Minogue, 2010). To illustrate, researchers suggest that drawings of self as science teachers provide information about mental models capturing the ways preservice teachers may identify themselves as teachers of science and their students as learners of science. One of the drawing tools widely used to provide insights on preservice teachers' views of teaching is the Draw-A-Science Teacher Test Checklist (DASTT-C), developed by Thomas, Pederson, and Finson (2001). This tool is an extension of the previous work where Finson, Beaver, and Crammond (1995) developed the Draw-A-Scientist-Test Checklist (DAST-C) based on the Draw-A-Scientist-Test (DAST) developed by Chambers (1983). The tool allows preservice teachers' to think about themselves as science teachers and how do they want to represent themselves in a classroom. It also permits preservice teachers to think about their students and how they perceive overall science instruction for their classrooms. According to Thomas et al. (2001), DASTT-C allows preservice teachers to "(a) picture themselves as elementary science teachers, (b) place themselves along a teaching theory continuum, and (c) consider the ways in which they developed their own science teaching beliefs" (p. 298).

Several studies use DASTT-C as a tool to understand preservice teachers' science teaching beliefs on a continuum ranging from traditional views of teaching (teacher-centered) to student-centered views that are aligned with inquiry-based teaching (student-centered instruction). In general, this tool has been used as a pre and post-test to understand the self-image before and after the intervention. A majority of studies document that preservice teachers' initial science teaching beliefs are teacher-centered at the time they enter the teacher preparation program, and there is a lack of focus on how teacher actions impact positive student learning (Markic & Eilks, 2013; Thomas & Pederson, 2003). Buldur (2017) found that preservice teachers' beliefs about science teaching changed from the traditional to student-centered beliefs after their exposure in a science methods course. Other studies suggest that preservice teachers held traditional views of teaching as depicted by their drawings at the beginning of the science methods course (Ambusaidi & Al-Balushi, 2012; Finson, 2001; Minogue, 2010). In a study conducted by Ambusaidi and Al-balushi (2011), there were significant shifts in preservice teachers' beliefs from teacher-centered to the student-centered view of instruction after the first science methods course; however, the second methods course and teaching practicum did not bring any further change in their beliefs. For the purposes of this study, we adopted the DASTT-C tool to investigate the change in PETs' science teaching beliefs during a science methods course and examine the role of prior experiences in this process.

Methodology

Research Design

This mixed methods research integrates quantitative [quan] and qualitative [QUAL] data by utilizing a triangulation convergent design [quan +QUAL → comparison of quan and QUAL results] (Creswell & Plano Clark, 2011). Mixed methods research "focuses on collecting, analyzing, and mixing both quantitative and qualitative data" and uses them in combination to provide a better understanding of the research problem (Creswell & Plano Clark, 2011, p. 5). In this design, we collected, analyzed, and mixed both quantitative (DASTT-C scores) and qualitative (experiences described in science autobiographies and reflections) data in the context of a science methods course, however, qualitative data weigh more than the quantitative data . This mixed-methods approach provided a better understanding of the research problem that is understanding a connection between PETs' science teaching beliefs and their science learning and teaching experiences before and after the course. The quantitative data were collected using DASTT-C as a pre and post measure. The qualitative data were collected through written science autobiographies and reflections, classroom observations, and artifacts. While the quantitative tool was useful to provide information regarding preservice teachers' beliefs through their drawings, qualitative data provided a deeper understanding of how preservice teachers' drawings were related to their science learning and teaching experiences before and after their participation in the course. Triangulation of results across multiple data sources is a foundational concept that provides a justification for using mixed method research through enhanced validity (Green, 2007). It emphasizes rigor through the conjunction of results from the qualitative and quantitative methods. Therefore, both quantitative and qualitative data were compared and contrasted to explain the research problem that is a connection between PETs' science teaching beliefs and their experiences with science and science teaching before and during the course.

Research Context

The study is part of a research project conducted at two public universities in the Atlantic Region, in the context of two science education courses, one in the United States and the other in Canada. At the mid-Atlantic public university in the United States (U.S.), the science education course was offered in the Spring and Fall semester 2017, and the average enrollment in the course ranges from 15-18 PETs. At the Canadian university, the science education course was offered in Spring 2017 and a typical enrollment in the course ranges from 20-25 PETs. Both the courses were 3 credit hours. However, the course span for two courses varied regarding the time for weekly class meetings and the number of weeks. Table 1 describes the common course components.

Table 1
Science Methods Course Experiences and Activities

Course Activities	Learning Experiences
Hands-on science (science and engineering practices)	Preservice teachers participate in several hands-on inquiry activities designed to model reform-based science and engineering practices. The intent of hands-on science activities was to provide opportunities for preservice teachers to engage in science and engineering practices such as 'planning and carrying out investigations, 'asking relevant questions and defining problems.'
Planning science lessons	Preservice teachers plan and design science lesson plans for teaching in an elementary classroom. They receive feedback from peers and the course instructor. Through the experience, preservice teachers develop the skills of planning effective science lessons based on science practices. This is an iterative process, which requires them to make improvements to their lesson based on the feedback from the course instructor.
Field-based teaching	Preservice teachers teach their science lessons in elementary classrooms. Teaching science in elementary classrooms provide preservice teachers first-hand teaching experiences for them to practice what they learned in the course. The intent is that through teaching lessons in real classrooms, they will develop confidence in science teaching.
Reflective Practices	Reflective practices were incorporated throughout the course to help preservice elementary teachers to confront, challenge, and shape their science teaching beliefs. At the beginning of the course, PETs reflected on their K-12 and college science experiences that might have shaped their attitudes and beliefs about science and science teaching. Sharing these experiences with peers, help PETs to judge the science teaching experiences that help learning science. During the course, PETs were provided opportunities to reflect on the course experiences to help them gain a new understanding of science teaching, using these experiences to help science learning of their future students and rethink and reshape their science teaching beliefs. As a part of field-based teaching experiences, PET reflect on their teaching of science lessons and their students' learning to understand what works in a real classroom to strengthen research-based and reformed base science teaching beliefs

Participants

A total of 55 PETs participated in this research. At the public university in the United States, 42 PETs enrolled in the two sections of the course offerings in the Spring and Fall semester, out of which 36 volunteered to participate in the study. A majority of the participants were females (one male and 35 females). The participants were between the age group of 20- 23 years with a few exceptions (three participants of age 25, and one participant was of age 33 years). A majority of them were Caucasian, with a few exceptions (four Asian, seven Hispanic, one Ethiopian and one of Native American origin). At the Canadian University, 27 PETs enrolled in the course, out of which 19 volunteered to participate in the study. A majority of them were females (18 females and one male).

The participants were between the age group of 20-25 years with one exception, who was 30 years old. All participants were of white Canadian ethnicity. They all had completed an undergraduate degree, including nine credit hour courses in three science areas or two specially designed science courses for elementary teachers, before entering their after-degree Bachelor of Education program.

Data Sources

Data collection procedures included both qualitative and quantitative sources of data. The qualitative sources of data included participants' written science autobiographies, individual reflection papers, researchers' field-notes on student-teaching sessions, and artifacts. Each data collection source is described in detail below. The quantitative sources of data included pre and post-drawings, collected through the Draw-A-Science-Teacher Test Checklist (DASTT-C) instrument, developed by Thomas et al. (2001) and modified by Markic & Eilks (2012), at the beginning of the semester and towards the end of the semester.

1. **Science autobiography.** Science autobiographies have been considered as a useful tool to reflect and narrate their past experiences (positive and negative) with science and to reveal their teacher self (Ellsworth & Buss, 2000). This research used written science autobiographies of participants as a source of qualitative data to access PETs' prior experiences with science learning and teaching. Participants' written science autobiographies ranged between 1200 - 1500 words and contained a description of events and incidents related to prior science learning and teaching.

2. **Reflections.** Engaging PETs in the process of reflecting on their teaching experiences allow them to discover the strategies that work in the classroom and help them identify their areas for improvement (Davis, 2006; Lee, 2005). This research used written reflection papers by the participants as a source of qualitative data to analyze their experiences with planning and teaching a science lesson in an elementary classroom. Participants' written reflections consisted of 1500-1800 words and contained their reflections about what went well, what did not go well in their science lesson, and what changes they would like to make if teaching the same lesson in the future. Participants' written reflections helped us in interpreting their beliefs about science learning and teaching, which have the potential to influence their future science teaching.

3. **Draw-A-Science-Teacher-Test Checklist (DASTT-C)**. A drawing tool, Draw-A-Science-Teacher-Test Checklist (DASTT-C) developed by Thomas, Pedersen, and Finson (2001) and modified by Markic, Eilks, and Valanides (2008) was used in this research study to make explicit participants' mental representations of science teaching before and after the course. The central idea of DASTT-C was to prompt participants to draw themselves and their students engaged in a science teaching act/situation (see Appendix A). In addition to drawings, we further asked them to describe their illustration of the teaching act/situation as it relates to teacher's and students' activities. Analysis of participants' pre and post-drawings helped us interpret their science teaching beliefs before and after the course.

Data Analysis

Below, we describe the quantitative and qualitative data analysis techniques. The qualitative data were analyzed first, followed by the analysis of the quantitative data.

Qualitative Data Analysis

The qualitative data were analyzed in three stages. In the first stage, open coding techniques were used that involved reading the written science autobiographies and reflection papers multiple times to identify common events or ideas described by the participants. To begin with, both researchers independently coded one autobiography and one reflection paper. The researchers discussed and compared initial codes, and any discrepancies were resolved through discussion. Then, both researchers coded all of the autobiographies and reflection papers based on their initial agreement on codes. At the second stage, axial coding was employed to assemble initial codes into categories and subcategories. A coding scheme was generated where categories and subcategories were rearranged in three broader themes, namely: Teacher, Student, and Environment.

The peer-debriefing and triangulation across multiple sources contributed towards the trustworthiness. We purposefully aimed for evidence that supports or refutes themes that emerged from the various data sources, and this process enabled the triangulation of the findings. Thus, triangulation provided a thorough and comprehensive understanding of the complex phenomena under investigation, particularly regarding the connections between self-images and their science learning and teaching experiences.

Table 2
Sample Coding Scheme for Science Autobiographies and Reflections

Categories		Description	Codes	Sample Quote
Autobiographies	Teacher	Prior experiences with science teachers	Struggle with science, discontentment with the science teacher	I felt she didn't really understand me. Maybe she expected too much, or I didn't grasp the material very well. I struggled to try to remember detail by detail the definitions of the part of the eye and how light traveled. I thought I had to get it exact by the book to prove I knew the content
	Student	Prior experiences as a science learner	Lack of confidence in science	I lost my confidence in my own ability to master the concepts being taught, and it became a challenge to get good marks. I began to always second guess myself, thus spending more time trying to learn than actual learning.
	Environment	The learning environment in a previous science course	Memorization, note-taking	It seemed that science in my senior year was more about memorization than about really knowing how something works or how it relates to our understanding of the world. I recall a lot of nights trying to memorize definitions and long answer questions, trying not to leave out a word.
Reflections	Teacher	Experiences of teaching a science lesson	Lesson Planning (effective science lesson)	The skill of effective lesson planning was necessary to ensure that the children were engaged in the lesson during our time at the school.
	Student	Experiences of science learners while teaching	Student Engagement	One of the reasons that I believe the lesson was successful is because the students were engaged throughout the entire lesson, which shows that they found the lesson and activities interesting.

	Environment	The learning environment created while teaching science	Collaborative learning	To allow students to explore the topic, we put them into groups asked them to identify as many animals as they could in each of the four habitats. We then followed up with a group discussion on the different animals identified as well as why the students classified them under each category.

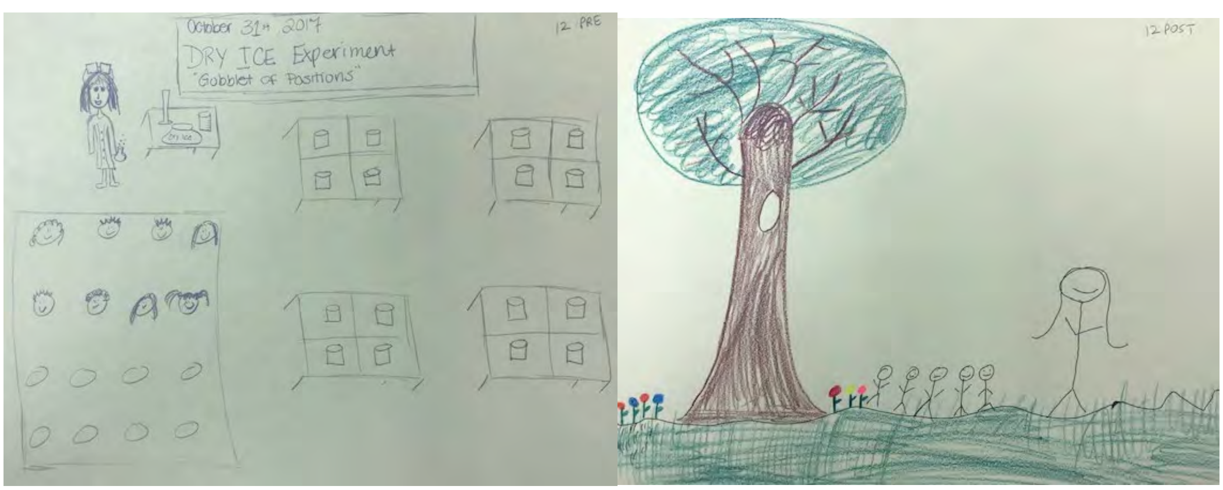
Quantitative Analysis

The analysis of the drawings from the DASTT-C tool was based on the checklist suggested by Thomas et al. (2001); the score for each drawing was calculated based on the presence or absence of these 13 elements (see Appendix B).

Below, we present an example of our analysis of the pre and post-drawing of a participant (Participant 12). The participant received a score of 11 points for the pre-drawing (see Figure 1a). This score represents teacher-centered beliefs held by the participant. A closer examination of the drawing shows a teacher demonstrating a science experiment/activity and using a whiteboard with a written caption of the experiment (teacher activity). The teacher is positioned at the center of the class with a somewhat erect posture (teacher position). The students are seated in rows in front of the teacher (student position), and they are listening to or watching the teacher (student activity). The student desks are arranged in a traditional pattern, while the teacher's desk is located in front of the class. Further, the symbols of science (equipment) can be seen on the teacher's desk, and symbols of teaching (whiteboard) can be seen in front of the classroom (Environment). The post-drawing received a score of 1 representing student-centered beliefs regarding science teaching (see Figure 1b). A closer look at the post-drawing shows that the class is being held outside, where students are able to explore the natural environment. Here, the students' group is taking the lead looking into the plants and trees while the teacher is at a distance behind the students (teacher position). Students are sitting on the ground as a group exploring and appear to have fun with the activity. The learning environment is non-traditional with no classroom seating pattern, and no symbols of science and teaching can be seen.

Figure 1

Participant 12 (a) Pre-Drawing (DASTT-C Score 11) and (b) Post-Drawing (DASTT-C Score 1)



Inter-Rater Reliability

Each researcher independently coded four drawings of the same participants that were randomly selected from the sample. The inter-rater reliability was calculated using Cohen's Kappa for a total of 52 entries for the 4 participants (13 elements per participant data). There was less than 50% agreement between the two coders. One of the problems was how each coder interpreted each element within the three dimensions. For instance, the teacher's posture or student activities were at times unclear in drawings. After a thorough discussion of the three elements, eight drawings (15% of the data) were randomly picked and independently coded by each researcher. The value of Cohen's Kappa was found to be 0.923 with $p<0.001$, indicating a strong agreement between the two coders (Hallgren, 2012).

DASTT-C Scoring Issues

In addition to the scoring issues due to subjectivity, as described above, other issues were identified. According to Thomas et al. (2001), the score ranging between 7 and 13 represents teacher-centered beliefs, whereas the score between 0 and 4 represents student-centered beliefs. What it means is that the two participants with a score of 13 and 7 in their drawings respectively, are both in the category of teacher-centered beliefs. Similarly, a score of 0 and 4 for any two distinct participants' drawings are in the category of student-centered beliefs. Our challenge was to distinguish between the participants falling into similar categories, considering the scoring scheme is a spectrum. Therefore, we decided that instead of distinguishing PETs based on teacher-centered and student-centered beliefs only (as per the challenge described above), we created categories 'small' and 'large' shifts in science teaching beliefs. The small shift represents small positive differences from pre to post-DASTT-C score, where PETs entered the science methods course with somewhat student-centered beliefs and improved on these during the course. The large shift represents large differences from pre to post-DASTT-C score, where PETs entered the science methods course with teacher-centered beliefs and the beliefs changed to somewhat student-centered beliefs.

In addition, Thomas et al. (2001) considered a score of 5 or 6 as indecisive, which we found in a few cases. However, in most cases, invalid score of 5 or 6 was for both pre- and post-drawings. We decided to not focus on these cases in this study, due to a relatively small number of invalid cases.

Findings

We present the quantitative analysis of the DASTT-C scores followed by the qualitative trends from science autobiographies and reflection. First, we present the shift in PETs' science teaching beliefs from the beginning to the end of the science methods course based on their DASTT-C scores at the beginning and the end of the course. Then, we present examples from the large shift and small shift groups to reveal how PETs from these two groups interpret their science teaching and learning experiences.

The Shift in PETs' Science Teaching Beliefs

We found positive shifts in PETs' drawings with more student-centered beliefs from pre to post-test; however, the amount of the shift varied on the scale of 0-13. Table 3 presents a shift in PETs' science teaching beliefs based on their pre and post overall DASTT-C score.

Table 3

Change in Science Teaching Beliefs Based on Pre to Post DASTT-C Scores

Change in Science Teaching Belief		DASTT-C Score Range
Large-shift	32	9-13 pre score & 0-4 post score
Small-shift	17	6-4 pre score & 0-3 in post score
No-shift	1	7 pre score & 7 post score
Invalid cases	5	Pre and post scores ranged between 5 to 6, considered as indecisive (Thomas et al. 2001)
Total	55	

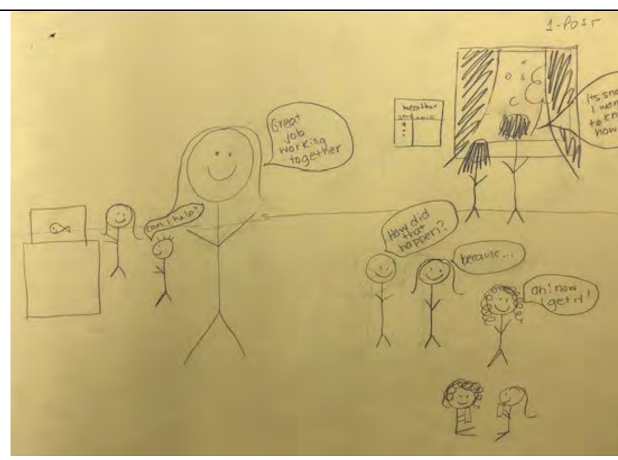
Examples of a Small and a Large Shift in Science Teaching Beliefs

In this section, we present two examples that highlight a large shift (Amanda and Sarah), one from the USA and one from Canada, and two examples of a small shift (Lucy and Karen), one from the USA and one from Canada, in these PETs' beliefs regarding science teaching and learning using the pre and post-DASTT-C scores. Then, we present the themes from analysis of these participants' written science autobiographies and reflections representing similarities and differences in their interpretations of prior science experiences and the science methods course experiences influencing their science teaching beliefs.

Figure 2a displays the pre and post-DASTT-C scores of Amanda and Sarah (large shift) and Figure 2b displays the pre and post-DASTT-C scores of Lucy and Karen (small shift), along with the qualitative interpretation of their drawings showing a small and large shift in their science teaching beliefs.

Figure 2a

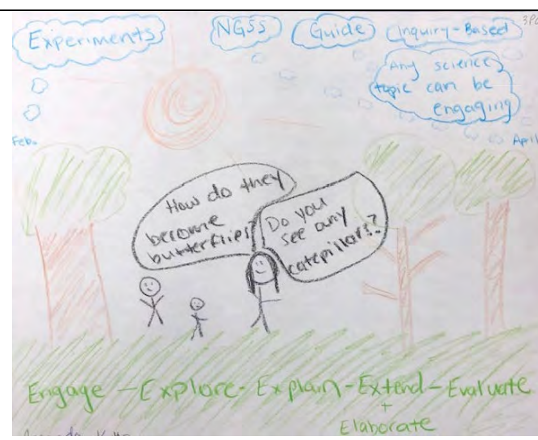
Large Shift Participants' Pre- and Post-Drawings

<table>
<tr><th>Amanda pre-drawing</th><th>Amanda post-drawing</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>DASTT-C score = 10. The teacher appears to be leading/giving instructions using a whiteboard. The teacher appears to be standing and as a head of the class, and has an erect posture. Students are sitting/standing in front of the teacher and appear to listening/responding to the teacher.</td><td>DASTT-C score = 4. The teacher appears to be more of a guide and is positioned in the center of the classroom with students. Student are working in groups and the classroom appears less structured and more inquiry-oriented. The learning environment appears to be less traditional in the post-course drawing.</td></tr>
</table>

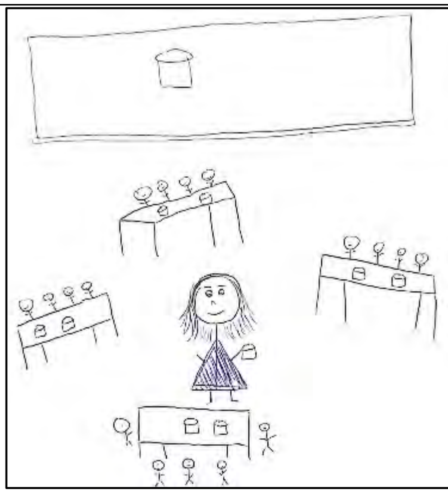
<table>
<tr><th>Sarah pre-drawing</th><th>Sarah post-drawing</th></tr>
<tr><td>
DASTT-C score = 12. The teacher is leading/giving instructions using a whiteboard, standing as a head of the class, and appear to have an erect posture. Students are sitting/standing in front of the teacher and appear to be listening to the teacher as she is holding an object and a worksheet in her hand.</td><td>
DASTT-C score = 4. The teacher appears to be asking thought provoking questions to students (“I wonder” questions). The teacher posture is not erect but rather welcoming. Students appear to be involved in a thinking process and sharing ideas. The learning environment appears to be less traditional.</td></tr>
</table>

Figure 2b
Small Shift Participants’ Pre- and Post-Drawings

<table>
<tr><th>Lucy pre-drawing</th><th>Lucy post-drawing</th></tr>
<tr><td>

DASTT-C score = 4. The teacher is guiding students to making observations outside the classroom, positioned at a distance from the students and does not appear to have an erect posture. Students appear to be standing on the ground and listening to their teacher. The learning environment is non-traditional with no classroom seating.</td><td>

DASTT-C score = 2. This drawing also shows learning taking place outside the classroom. A major difference is that the teacher is with students as a guide as opposed to be standing at a distance and giving instructions (as in the previous picture). Students are exploring the natural environment. This is not a traditional classroom with no classroom seating pattern.</td></tr>
</table>

Karen pre-drawing	Karen post-drawing
 **DASTT-C score = 4** The teacher appears to be guiding students to complete an activity, positioned in the center from the students' desks. Students appear to be performing the experiment as their desks as a group, while desks are not arranged in rows. The teacher does not have an erect posture.	 **DASTT-C score = 3.** While the teacher is holding the equipment in her hand; however, it appears that all students are getting equal opportunity to perform the task. The teacher appears to be with the student-group in a circle where students are not seated in a traditional manner. The learning environment is less-traditional and more inclusive (we see a student with special needs sitting on a wheelchair but performing as other students).

Influences on Science Teaching Beliefs

In this section, we describe findings from the qualitative analysis to reveal how prior science experiences and the science methods course experiences influenced PETs' science teaching beliefs. We particularly focused on how participant with small and large shifts in their science teaching beliefs, from the beginning to the end of the semester, interpret their science learning and teaching experiences. First, we present themes from analysis of science autobiographies followed by the analysis of their reflections to represent similarities and differences in their interpretations of prior science experiences and the science methods course experiences influencing their science teaching beliefs.

Prior Science Experiences Influencing Science Teaching Beliefs. Findings in this section are organized under three themes: (a) experiences with science teachers, (b) experiences as science learners, and (c) experiences with the learning environment in prior science courses.

Experiences with Science Teachers. In this section, we present participants' description of their experiences with their prior science teachers and how specific teacher attributes impacted their interest in science. There were noticeable differences between the prior science experiences of participants' who had large shifts in their DASTT-C scores versus those who had small shifts in their DASTT-C pre to post scores. Participants with large shifts often mentioned their distress towards science. In general, two participants, Sarah, and Amanda (large shift) often reported negative experiences with their science teachers. For instance, Sarah reported her teachers from high school science courses as those who "didn't really bring enthusiasm to the class" to help them get excited about the science topic. These experiences seemed to affect participants' confidence in the subject. As Amanda reported, "Those negative experiences affected me by making me not like the topic covered and also decreased my confidence levels in those areas." Conversely, participants, Karen, and Lucy (small shift), who had small shifts in their scores often reported their science teachers as 'great teachers' and used adjectives such as 'enthusiastic' and 'passionate' for their science teachers. These participants reported that their interest in science developed because of their teachers, as Karen mentioned, "having excellent science teachers is a reason why I love science. Throughout my school years, I was fortunate enough to have a number of great teachers, especially in science."

Interestingly, there were differences in the teaching strategies employed by the science teachers in the prior science courses for large versus small shift participants, which impacted their present beliefs about science teaching. For instance, participants who had large shifts in DASTT-C scores reported using worksheets more often. As Sarah mentioned, "I can recall a lot of worksheets and coloring material, I am unable to remember much about the science content." Conversely, Karen, who had a small shift in DASTT-C scores mentioned learning via a variety of strategies employed by her teachers, which sparked her interest in science. She mentioned, "Not only is my science teacher responsible for creating that spark within me, but I also think that my love for science is largely due to the wide variety of activities he made us performed within our class."

E*xperiences as Science Learners.* In this section, participants from the above two groups describe their prior science experiences and how they felt about learning science in their schools and colleges. In general, the prior science learning experiences were mostly positive for participants who had small shifts in their DASTT-C pre to post scores as compared to participants with large shifts in pre to post scores. For the small shift participants, science was relatable for their daily life and part of their daily school routine since elementary grade-level. As Lucy (small shift) wrote, "The science classes that I took in high school increased my interest in understanding how things occur. Science was a part of my daily learning and no matter how long I spent focusing on science I never got tired of it." In contrast, participants who had a large shift in pre and post score mentioned anxiety and pressure when learning science. As Amanda (large shift) mentioned, "I felt so much pressure during lab to not make a mistake." Sarah wrote similar thoughts as she mentioned, "When having to do experiments and record our answers, I had a lot of anxiety over getting the same result as everyone else." Both participants' responses about their experiences as a science learner suggested disappointment with lack of success in learning science content.

Experiences Within the Learning Environment. The learning environment refers to how participants described their science class atmosphere and whether they found the atmosphere conducive towards their learning. The participants with a large shift in their pre to post-DASTT-C scores reported more memorization and learning facts rather than learning through strategies that led to deeper connections with the material. For instance, Sarah (large shift) described the learning environment as "unpleasant because his teaching approach was not very effective and hurtful at times toward the class. It did not create a pleasant atmosphere for learning." Similarly, Amanda (large shift) described prior science learning as "disorganized and straight from the book" or "test-oriented and brutal as unless you had the information memorized like the back of your hand there was no way to succeed." On the contrary, Karen and Lucy (small shift) described their learning environment as having "freedom and independence." Karen elaborated on the positive environment, "I was able to explore through experimentation. I enjoyed doing experiments the most because they were hands-on and it allowed me to apply what I learned in class to the experiment."

Science Methods Course Experiences Influencing Science Teaching Beliefs. The findings have been organized under three themes: (1) experiences as science teachers, (2) experiences with young learners, and (3) experiences in the learning environment participants created for their learners.

Experiences as Science Teachers. In this section, we describe participants' science methods course experiences and how these experiences impacted their confidence in science teaching. Participants from both groups (large and small shift) described their experiences regarding planning and implementing their science lessons in elementary classrooms. Despite having varied prior science experiences, both participant groups described their experiences of using the 5E learning cycle and probing questions to engage students. For example, Sarah (large shift) wrote, "We asked them if they knew how animals protect themselves in their environment and then guided them through an activity using their imagination to pretend they were an animal trying to avoid a predator. We then asked them questions on how they kept themselves hidden, what animal they were, and if they could catch their prey." Similarly, Karen (small shift) said, "We asked questions that encouraged higher level thinking such as, "What do you think would happen if all the trees in a forest were cut down to make room for new buildings?" The participants' views on thought-provoking questioning is interesting as not all participants learned science this way but were willing to include more questioning rather than 'teacher telling' traditional approach.

Both participant groups (small and large shift) felt that the learning cycle approach offered more clarity towards building students' understanding of the science concepts and saw value in teaching this way. While describing their experiences using 5Es in their reflections, we noticed that while the 5E model was an obvious approach to teaching for the participants with small shifts in their DASTT-C scores, it was a reflective approach for participants with large shifts to make that strategy as their choice for their teaching. For example, Sarah (large shift) "thought about reading the book to the students," however, reflecting on the lesson objectives, she changed the lesson plan and decided to use "a more hands-on approach" to engage her science learners. She further described that "the key strategies that guided their group's lessons were constructivism and 5E approach."

The participants' thoughts are interesting considering that participants' with a large shift in their DASTT-C scores did not experience inquiry-based science teaching in their previous science courses. On the other hand, participants with a small shift in their DASTT-C scores integrated hands-on approach seamlessly in their lesson planning and were more confident in doing so for their science lesson. As Lucy (small shift) said, "My group member and I vigorously prepared our lesson plan until we were comfortable and confident with the material we were planning to teach to the children. We followed the 5E model when developing our lesson plan." It is worth noting that the participants with small shift were more exposed to hands-on inquiry-based learning in their previous science courses, as evident from their descriptions in their science autobiographies.

Experiences with Science Learners. In this section, we describe participants' experiences with young learners while reflecting on their science teaching experiences, which revealed that both participant groups (with a large and small shift in their pre-post DASTT-C scores) were able to engage their learners successfully. Witnessing their students' interest in their science lessons enhanced participants' confidence in science teaching. For example, Amanda (large shift) described, "I feel that the students responded well to the lesson and to us. They were comfortable in asking us questions and interested in learning what we were teaching." Similarly, Karen (small shift) mentioned, "They were much more engaged than we had anticipated and it filled me with encouragement and pride when teaching the lesson." Lucy's (small shift) response echoed this tendency: "The students had a positive response to the lesson, and they were very interested and engaged throughout the entire thing."

Both participant groups shared their success with student engagement, however, there were few differences in terms of the challenges they faced. In general, the participants with small shifts in their pre to post-DASTT-C scores were more confident in their ability to engage young learners and described their positive experiences with their students' learning as a result of their field teaching. Conversely, the participants who had a large shift in their pre to post-DASTT-C scores, who earlier had negative science experiences as science learners, shared challenges that they faced helping their students. For example, Sarah (large shift) wrote, "I think that the most commonplace that our students got stuck on was the data chart. I think that even though we explained how to record the answers and where it would all go on the sheet, they still had difficulty looking up and down the column and across the row depending on where we were." And, Karen (small shift) described that "the students were able to follow along with the initial activity in which they used their imagination to pretend they were an animal, and they did well in answering questions, but in the second activity there seems to have some confusion." These ideas were interesting as participants with a large shift in their DASST-C scores included more descriptions of the challenges they faced with the implementation of science lessons in the field as compared to the small shift group participants.

Experiences Within the Learning Environment. The learning environment referred to how participants designed the activities that created an atmosphere conducive for student learning. Participants from both groups (large and small shift in DASTT-C score) described their experiences within the learning environment they designed for their learner and the impact of this environment on their students' learning. Both the groups (1) experienced success with their lessons, and (2) created a hands-on student-centered learning environment for their elementary learners. For example, Sarah (large shift) described, "We wanted to create a hands-on learning experience for our students, but we also wanted to find out how much knowledge they had already acquired about the concept of camouflage. The intention was to provide an opportunity to expand their knowledge base of how animals protect themselves in the environment, as well as to modify any misconceptions they may have." However, the participants who had small shifts in their pre to post-DASTT-C scores, who had positive prior science experiences relatively, were more confident in their ability to include hands-on learning experiences. For example, Karen (small shift) described, "I allowed the students to explore the materials. This lesson was really hands-on and we made sure that each student had a turn for each trial of rolling the ball." Furthermore, the small shift group participants were more flexible to adapt their lessons according to the learning needs of their students as well as to let students test their ideas. For example, Lucy (small shift) described a situation where two of her students wanted to explore newer ways to see how the ramp height is related to how far the ball would go.

The other two boys were experimenting with the materials by lifting the ramp higher and higher to make the ball roll further. The one boy thought that if the ramp was straight up down, it would go the furthest, but when he tested it, he saw that it dropped straight down and did not roll anywhere. He learned from playing with the materials that a ramp has to have a slight tilt to allow the ball to roll. This was a great example of what students can learn if you let them explore.

On the contrary, the large shift group participants, who were designing and implementing the hands-on learning for the first time, struggled with classroom management with this new learning environment. For instance, Amanda (large shift) mentioned, "One thing that did not go well was our materials. Hands-on learning is important but attempting to control my group, hold the materials in a place where they could not get them, and facilitate the lesson was difficult." The participant struggled to keep students on the task given that the lesson involved balls, which according to her distracted one of her student from the topic. As she said, "The students kept finding a way to get a ball or a block and hiding or playing with it. The students would take the ball and rub it on their hands. It was hard not to get frustrated, and I feel as if I did a good job keeping my calm. It was frustrating because every time I had to stop to receive the material, it would take away time from the lesson."

Discussion and Implications

The study investigates preservice elementary teachers' beliefs about science learning and teaching and how a shift in these beliefs is influenced by their experiences with science learning teaching before and during a science methods course. PETs' pre and post drawings were used because they have shown to be a powerful tool to document teacher beliefs of self as science teachers, about science teaching styles, personal theories, and pedagogical attitudes regarding science teaching (Ambusaidi & Al-Balushi, 2012; Markic & Eilks, 2015; Yilmaz, Turkmen, Pederson, & Cavas, 2007). The DASTT-C tool has been utilized by prior researchers with preservice teachers at various levels of their teacher training programs to study the change in their science teaching beliefs. In this study, using DASTT-C tool allowed us to compare PETs' science teaching beliefs, however, this study also added to the literature by explaining the issue of subjective scoring and suggested a way to compare shifts in science teaching beliefs before and after a science methods course. To reveal this process of belief change this research quantified the change in PETs' science teaching beliefs by determining the amount of shift in PETs' science teaching beliefs. A large shift shows a shift from teacher-centred beliefs to student-centred beliefs, and a small shift shows a shift from less student-centered beliefs to more student-centred beliefs. This research, then investigating how PETs with a small and large shift interpret their experiences of science teaching and learning in context of a science methods course.

Past research suggests that prior K-12 science learning experiences may impact preservice teachers' beliefs at the time they enter the teacher education program (Knaggs & Sondergeld, 2015; Yoon et al., 2006). However, recent recommendations suggest a need for a rigorous investigation to develop a deeper understanding of how specific experiences (memories and episodes of science learning and teaching) impact science teachers' images (Bulder, 2017).

Regarding our findings, we observed that at the beginning of the course PETs' science teaching beliefs were more teacher-centered and authoritative in nature. More drawings showed teacher as an authority, at the center of the classroom with control over the class, materials, and students listening to them. Other studies have also found similar images held by preservice teachers at the time they enter science methods courses (Ambusaidi & Al-Balushi, 2012; Bulder, 2017; Markic & Eilks, 2015; Thomas & Pederson, 2003). Upon further investigation of PETs' science autobiographies, we found that their pre-drawings were reflections of their prior science learning experiences. For instance, reflections of how they felt as learners of science, ways they were taught by their science teachers, and the overall learning environment they were exposed to within their previous science courses. Other researchers have also claimed that these critical episodes have the power to influence PETs' existing beliefs about science teaching and learning (Goodman, 1988; Nespor, 1987; Thomas & Pederson, 2003). For those participants who had positive learning experiences (small shift) held more student-centered beliefs regarding science teaching as represented in their drawings. Conversely, participants who learned science in a traditional way (large shift) held traditional views of science teaching as depicted in their drawings. Evidently, these views as represented in their drawings were reflections of their prior experiences with science.

Changes in Beliefs Regarding Science Teaching

Previous research have noted a change in PETs' beliefs after the exposure in science methods course (Buldur, 2017; Markic & Eilks, 2015; Minogue, 2010). In this study, we further investigated the change in terms of small and large shifts in context of the science methods course. Evidently, learning reform-based pedagogies as well as planning and implementing the science lesson using those pedagogies proved crucial towards causing such a change. Interestingly, the participants (large shift) who held negative beliefs about science teaching, owing to their prior experiences, experienced a positive shift in their science teaching beliefs because of the successful teaching experiences in the field. This tendency was found in the reflections on their science teaching where participants found appreciation and value in science teaching using student-centered styles of teaching. Other factors that may have impacted participants' positive beliefs about science teaching (as depicted through their drawings) include understanding the context that includes what to expect when teaching science with younger students, more familiarity with the classroom environment, the improved vision of how pedagogical strategies impact student learning.

Regardless of the nature of their prior experiences, PETs (both small shift and large shift) in this study had greater success in engaging their learners and were able to witness that the student-centered environment could help students learn, as evident from the qualitative analysis of participants' reflection papers. These episodes of success solidified their confidence in themselves as science teachers. More drawings showed the teacher acting as a *guide* and as a *facilitator* as opposed to the head of the class. Also, the drawings depicted students taking active roles in hands-on scientific investigations and figuring things out on their own. Interestingly, many drawings showed science learning in informal learning environments such as students outside the classroom with hand lenses or observing trees in the garden. These findings are in accord with other studies which had found a shift in PETs' beliefs from traditional to more student-centered instruction after their participation in the science methods coursework (Buldur, 2017; Minogue, 2010; Thomas & Pederson, 2003). Our study adds to the literature by providing evidence on how teachers' beliefs are linked to personal histories and critical incidents regarding their prior science experiences. Based on our results, we conclude that successful teaching experiences have a potential to influence PETs' self-images as science teachers.

Implications for Practice and Future Research

There are important implications for PET education given the results showing positive shifts in PETs' beliefs owing to personal success with science teaching. Often times, students confront student-centered learning approaches and reform-based pedagogies during science methods course that they may not have experienced as science learners. Science teacher educators must provide continuous support and mentoring to PETs as they confront and revisit their beliefs regarding science teaching. It is well known that new and positive experiences gained during science methods courses help support self-efficacy beliefs and positive science teacher self-image (Menon, 2018) thus, more opportunities are needed for PETs to plan, design, practice, and implement science lessons with new pedagogies they learn in methods courses. We may hope that successful personal experiences in the field may create new images that PETs may rely on for their science instruction. Given this conjecture, more longitudinal studies are needed to explore how and whether images formed during the teacher training program inform future practices.

In this study, we found that PETs' personal experiences as science teachers, their engagement with learners, and the learning environments impacted their science teaching beliefs. What added value to their student-centered beliefs is reflecting on their own practices as they were able to analyze elements of effective science teaching. Written science autobiographies also helped participants to recollect their memories from prior science experiences and challenge their beliefs about science teaching as they experience new strategies for teaching science. Therefore, opportunities for reflective practice are required for PETs in science methods courses. Additionally, a closer look at how views and perceptions are emerging with each additional teaching practice must be explored longitudinally. Studies should continue to explore elements of science methods courses and field-experiences that impact teachers' science teaching beliefs in the long-term. Such exploration must consider including multiple data sources to provide rich descriptions of changes in PETs' beliefs regarding science teaching.

This research was supported by research grants from Faculty of Education, Memorial University of Newfoundland, Canada, and Newfoundland, Canada, and Fisher Endowment research funds, Jeff and Mildred Fisher College of Science & Mathematics, Towson University, USA (grant number 20171759-ED).

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Appendix A

Draw & Explain Yourself as a Science Teacher

1. **What is the teacher doing? What are the students doing?** ______________________________

2. **Where are they? What is happening?** ______________________________

Appendix B

DASTT-C Scoring Scheme (Thomas, Pedersen, & Finson, 2001)

	Category	Sub-Category	Description	Present/Absent 1/0
I	Teacher	**Activity**	Demonstrating Experiment/Activity	
			Lecturing/Giving direction (Teacher talking)	
			Using visual aids (chalkboard, overhead, and charts)	
		Position	Centrally located (head of class)	
			Erect posture (Not sitting or bending down)	
II	Students	**Activity**	Watching and listening (or so suggested by teacher behavior)	
			Responding to teacher/text/questions	
		Position	Seated (or so suggested by classroom furniture)	
III	Environment	**Inside**	Desks are arranged in rows (more than one row)	
			Teacher desk/table is located at the front of the room	
			Laboratory organization (equipment on teacher desk or table)	
			Symbols of teaching (ABC's, chalkboard, bulletin boards, etc.)	
			Symbols of science knowledge (science equipment, lab instruments, wall charts, etc.)	
			Total Score	**___ /13**