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Abstract

This article describes the intervention strategies implemented in an effort to affect a group of Hispanic pre-service elementary teachers' images of scientists during a science methods course in a teacher preparation program in the U.S.-Mexico border region. Although there is an extensive volume of research reporting on the use of the DAST-C instrument to study K-16 students' images of scientists, the number of studies on exploring and influencing preservice teachers' views of science and scientists is rather scarce. Findings in this study indicate that a semester-long intervention strategy focused on (a) pre-service teachers' generated inquiry project, (b) written reflections on inquiry learning, and (c) a pre and post-drawing tests, allowed participants to reflect on their views about scientists and science, and experience a gradual shift from views conforming to stereotypical views of scientists to portrayals of science practitioners as individuals, just like other people in our society pursuing real interests.

Introduction

The study described in this article was proposed in an attempt to explore and influence positive changes in pre-service elementary teachers' (PSETs) images of scientists during a science methods course. Shifts in the participating pre-service teachers' images of scientists were examined using the Draw a Scientist Test Checklist (DAST-C), and the participants' reactions to course assignments focused on the role they played as researchers in a semester-long inquiry project. The study described in this article adds to the existing literature in relation to PSETs' images of scientists not only by exploring and describing the perceptions they hold about this field and its practitioners, but also by exploring ways for PSETs to reflect on their individual views about science and scientists.

The origin of this study is in a General Information Questionnaire (GIQ) (see Appendix) typically administered to pre-service teachers on the first class meeting in an elementary science methods course. In this questionnaire, one item prompts pre-service teachers to share their views about their previous learning experiences with science. In their accounts, over half of the PSETs (59.8%) identified science as a subject they do not feel attracted to or one that is not part of their favorite school disciplines. This finding corresponds with other reports in the literature addressing this issue (Watters & Ginns, 2000; Palmer, 2001; Howitt, 2007). Likewise, a

relationship between low self-efficacy and the avoidance to teach science has also appeared in science education publications (Cooper, Kenny, & Fraser, 2012; Harlow, 2012). There is consensus in the science education community that this relationship resides in the lack of content knowledge in many in- and pre-service teachers in elementary schools (Akerson, El-Khalick, & Lederman, 2000). Teachers' dispositions are known to play an important role in the quality of learning that takes place in school classrooms. This is an important premise because 'teachers who hold more accurate concepts of scientists are likely to send more encompassing messages about who can be a scientist and who can do science' (Milford & Tippett, 2013, 746). We believe that "providing accessibility to science is important "if students are to become interested and motivated about science; to begin to see the social impacts of science; accept opportunities to develop scientific literacies; and experience authentic science" (Medina-Jerez, Melville & Walker, 2015, p. 3).

The study of PSETs' views about scientists is of paramount interest for the following reasons: first, there is a trickling effect of views and attitudes about science and scientists that takes place in science classrooms and throughout elementary and secondary grade levels. Teachers who have not been trained to decrease stereotypical science teaching may establish and promote ways of teaching and learning in their classrooms that emphasize stereotypical views of scientists. It has been argued that teachers who hold negative conceptions about science tend to promote those views (Czerniak & Chiarellor, 1990; Rosenthal, 1993; Ucar & Aytakin-Sanalan, 2011). Second, a sound goal in education reform documents encourages science teachers to present this subject to their students as a discipline that is exciting and worthwhile, especially to female students and to students from under-served populations. This is the case in the Next Generation Science Standards (NGSS) (Achieve, 2013) in relation to the role of inquiry as a learning methodology. In the science and engineering practices, the definition of inquiry is focused on two aspects, what scientists do and the work students do in the classroom. Likewise, the National Research Council's *Framework for K-12 Science Education* (Achieve, 2013) calls for 'opportunities for science learning and personal identifications with science as long-term developmental processes that need sustained cultivation' (p. 282). Third, since students form their images of scientists by the end of elementary school (Schibeci & Sorenson, 1983; Wyer, Schneider, Nassar-McMillan & Oliver-Hoyo, 2010)—others suggest that this image-formation takes place as early as in second grade, particularly in girls (Knight & Cunningham, 2004), intervening in the early years of schooling might contribute to having students "view scientists as real people who like them belong to real communities and pursue real interests," and science as a profession that is doable and worthwhile (Medina-Jerez, Melville & Walker, 2015, p. 46). Reports in the literature indicate that appropriate interventions can contribute to changing stereotypical views at young ages (Finson, 2009). Finally, conducting studies of this sort find relevance in teachers as agents of change. Encouraging PSETs to examine their own perceptions about scientists and the practice of science, is of great interest because of the unique position they hold in schools to mediate the formation of positive views and images of science and scientists in their students (Steinberg, Wyner, Borman, & Salame, 2015). Furthermore, an important function of teacher preparation programs is to encourage pre-service teachers to reflect on their pedagogical practices and professional conceptions regarding science, science teaching, and scientists (Bryan & Abell, 1999; Bryan & Tippins, 2005; Chionas, & Emvalotis, 2021; El Takach, & Yacoubian, 2020.; El Takach, & Al Tobi, 2021; Lotter, 2004; Milford & Tippett, 2013; Medina-Jerez, Middleton & Orihuela-Rabaza, 2011; Ucar, 2012).

Review of the Literature

The Draw-a-Scientist Test (DAST)

The Draw-a-Scientist Test (DAST) is an instrument that falls into the category of tools used to elicit students' ideas about the members of different disciplines. Some related tests include the Draw of a Mathematician test (Picker & Berry, 2000), the Draw of an Archaeologist test (Renoe, 2003), and the Draw of an Engineer test (Knight & Cunningham, 2004).

The origin of the DAST goes back to the late 1950s. Although not through a drawing test, it was Mead and Metraux (1957) who made the first attempt to explore students' perceptions about scientists. Their approach consisted of having students share their views about scientists through written reports. In 1983, Chambers proposed the Draw-a-Scientist Test (DAST). This was the first time a pictorial test was used to investigate students' conceptions about scientists. Although this research tool has maintained its currency for over 30 years, some modifications have been proposed in order to improve its use as a research tool. For instance, in 1995 Finson, Beaver, and Cramond introduced the use of a checklist (DAST-C) which was suggested as a companion tool to the DAST to keep track of the stereotypical features identified in the scoring procedure. The checklist contains 15 features divided into two sections: seven stereotypical (lab coat, facial hair, goggles, research instruments, symbols of knowledge, use of technology, and captions) and eight alternative features (male gender, Caucasian, indications of danger, presence of lightbulbs, mythic figures, indications of secrecy, scientist working indoors, and middle age or elderly scientist). Each item in the checklist is rated either 1 or 0 depending on whether the evaluator(s) determine(s) the presence (or not) of the feature. The proposed changes have been made in terms of presentation, administration, and scoring procedures. Modifications have been suggested on the grounds of potential issues with reliability when students are asked to produce only one drawing (McComas & Farland, 2007). Similarly, it has been argued that even the wording and presentation of the drawing task to participants may have an effect on the content of the depictions produced (Symington & Spurling, 1990). A new iteration of the test, an enhanced iteration (E-DAST) was proposed by McComas and Farland (2007).

As a valuable research tool, the DAST has been used in different school communities across the globe to explore the views that students in K-12 classrooms and in post-secondary education hold about scientists (Medina-Jerez, Middleton & Orihuela-Rabaza, 2011; Raty & Snellman 1997; Song & Kim 1999). Its use with elementary and high school students has been focused on the relationship between stereotypical views and gender (Carlton-Parsons 1997), grade level (Barman, 1997; Turkmen, 2008), ethnicity (Monhardt, 2003; Medina-Jerez, Middleton & Orihuela Rabaza, 2011), and teaching style (Finson, Pedersen, & Thomas, 2006). At college level, the use of this instrument has been centered on investigating how students, in non-education (Quita, 2003) and education programs (Rosenthal, 1993; Rubin & Cohen, 2003) perceive scientists. Others (Thomas, Henley, & Snell, 1996) have used it to compare both of these groups to each other.

Preservice Elementary Teachers' Images of Scientists

In the science education literature, a number of research studies, particularly those including PSETs as

participants, have been designed to explore (1) pre-service teachers' images of scientists (Moseley & Norris, 1999; Subramaniam, Sprivalo Harrell, & Wojnowski, 2012) and of themselves (Thomas & Pedersen, 1998), (2) PSETs' understanding of scientific ideas and the nature of science (El-Khalick & Akerson, 2004; Bilen & Cose, 2012); (3) self-images and role as science teachers (Thomas & Pedersen, 1998; Seung, Park, & Narayan, 2011); (4) images of science, science teaching, and the science teacher (Moore-Mensah, 2011), comparisons of perceptions about scientists held by science and science education majors (Rosenthal, 1993) and by undergraduate and graduate students in education programs (Miele, 2014), and (5) self-efficacy beliefs and anxiety as a function of their content knowledge (Yürük, 2011). Despite the rather extensive use of the DAST-C, the number of publications documenting changes in views of scientists held by PSETs in science methods courses is very limited (Ucar, 2012; Miele, 2014).

The basis for this study was the prior learning experiences of PSETs as science learners. In the first class meeting of the semester, and in their autobiography essay as science learners, the participating PSETs narrated experiences with science that for the most part included negative tones. In their accounts of their previous learning experiences with the subject, the PSETs described the role of their science teachers as the main influence on their likeness (or not) of science. They also alluded to the classroom context which was described as teacher-centered, rigid, and dull with little attention to the students' needs and interests, and even to the difficulties they faced as English learners; the majority of the participants in this study were of Hispanic descent. In addition to identifying PSETs' images of science, this study examined the effectiveness of a semester-long inquiry project as an opportunity for them to play the role of scientists, and in turn look at science through the lenses of these practitioners. This study attempted to answer the following research questions:

1. What are the main features in the way PSETs from a U.S.-Mexico border region depict scientists?
2. What is the effect of a semester-long inquiry investigation on the perceptions of scientists held by PSETs?

Method

This study used a mixed methods approach to the examination of pre-service elementary teachers' images of scientists and the effectiveness of a semester-long inquiry investigation in an attempt to alter possible stereotypical views about scientists. Data were gathered using the DAST-C in a pre and post fashion during a two-year period, a General Information Questionnaire (GIQ), My Views about Science Teaching concept map from the first class meeting, two essays (autobiography as a science learner, science teaching philosophy), and a written reflection on their role as investigators in a semester-long inquiry activity. The data collection began with the GIQ because of the persistent reports in previous semesters in which PSETs highlighted their negative experiences with the learning of science in their K-12 education. The DAST-C was administered on the first and last class meetings of the semester to gauge the effect of the semester-long inquiry investigation in promoting positive shifts in PSETs' perceptions about scientists. The written reflections allowed participating pre-service teachers to share, from their role as scientists during their inquiry investigation, their perceptions about the work scientists do.

Research Context

This study involved the participation of 134 undergraduate PSETs from four cohorts during the years 2012 and 2013; PSETs were in their senior year and enrolled in an elementary science methods course in a university located in a U.S.-Mexico border region. At the time of the study, the participating pre-service teachers were completing their elementary education training programs in Bilingual and Early Childhood Education. The majority of the pre-service teachers in this study were female (95.5%), which is a typical gender trend in elementary education programs.

The science content knowledge of the participating PSETs consists of two or three courses including biology, geology, and physical science. All of the PSETs in the science methods courses were in their senior year and concurrently enrolled in other methods courses. This science methods course is usually taken before the student teaching semester, which is a 16-week assignment in a local elementary school. Although this science methods course does not include a practicum component, it does provide opportunities for the enrolled PSETs to practice their skills in the context of informal or formal contexts during a science circus day either in the university museum or in the College of Education building where they interact with a group of elementary school students from the local community.

According to the course's guiding principles, pre-service teachers (1) participate in a community of practice and learn to design 5E lesson plans that build on funds of knowledge practiced by members of the local community; and (2) understand and are able to implement in their lesson plans the basic tenets of the Socio Transformative Constructivist view of teaching and learning (Rodriguez & Kitchen, 2005). A major challenge that must be overcome in this science methods course is the negative view the majority of the PSETs hold about science based on their previous experiences with this subject. Additionally, the language barrier appears often in their recollections of learning science in a second language. Therefore, part of the mission for the course instructor is to assist PSETs as they identify and confront their personal theories about science teaching and learning. This science methods course attempts to accomplish this goal through group and classroom discussions of (1) scientific inquiry as practiced in exemplary learning environments (video lessons and publications) and by scientists in their respective fields; (2) review of case studies and vignettes depicting scientific misconceptions and ways in which students learn science; (3) designing and peer-reviewing teaching approaches that attend to cross-curricular connections (e.g., art and science) and everyday practices (e.g., food pedagogy) students bring to the science classroom; and (4) by reflecting on their beliefs about teaching and learning after the design and delivery of the 5E lesson.

Data Collection

Data were collected throughout four consecutive semesters in a science methods course. On the first class meeting students responded to a General Information Questionnaire (GIQ) (see Appendix), produced a concept map on their views about science teaching, and completed a pre-drawing of a scientist using the DAST-C. Unlike Miele's (2014) study in which participants (undergraduate and graduate students) assessed their own

drawings and created graphs of common stereotypical trends at the pre-drawing phase, PSETs in this study were told that their drawings would be revised on the last class meeting and that for that purpose no further information would be given at the moment. PSETs were also informed that they did not have to have artistic skills and that their renditions were not related in any way to their partial or final grades in the course. Following the presentation of the task, PSETs were given a DAST-C template (8 ½ X 11 paper) containing the date and the instructions that read: *In the space below, complete the drawing of a scientist or scientists by using the knowledge you have about these people or about the work they do. Please do not use any information source. Feel free to add notes and/or labels.* Finally, students (PSETs) were told to choose and use a nickname to match their pre and post drawings. The autobiography as a science learner consisted of a 1-page statement in which PSETs described a single science learning episode they considered relevant in their K-16 education career. The science teaching philosophy essay was drafted and peer-reviewed. In this essay, PSETs addressed their vision and mission as science teachers; they also integrated their autobiography into this essay by describing the ways in which their prior science learning experiences were informing their current views about science teaching and learning. The first essay (autobiography) was submitted in the third week of the semester and the drafts of the science teaching philosophy were produced in the second half of the semester. A 1-page reflection was also submitted at the end of the semester; in this piece PSETs discussed whether their views about scientists and scientific inquiry changed as compared to their views at the beginning of the semester.

The semester long inquiry project was designed as a group assignment. Each team consisted of four or five members. The open inquiry project started with a project proposal that was peer reviewed and approved by members of other groups and the course instructor. Each team was provided with all the materials necessary for the proposed investigation including the plant seeds of a species that is known for having a short life cycle. Once the project started, each group documented the progress made in their investigation using a science journal and submitted three written reports throughout the semester on the status of the investigations. In each of these reports, students were encouraged to revise their prior assumptions as reflected in the research question and hypothesis formulated at the beginning of the project. On the last two class meetings, each team collaborated in the execution of an artwork using the silk batik technique that was used as a vehicle to communicate the main findings in their investigations. Each team presented its art and inquiry projects during the last class meeting.

Data Analysis

The scoring of the drawings was conducted by a co-author of this article and his graduate student. In order to secure consistency in the scoring procedure, both raters used the DAST-C (Finson et al., 1995) to rate a set of five randomly chosen drawing samples. After the scoring of these samples, each drawing was examined based on the partial and total score differences. Throughout this exercise, some discrepancies were found in the rating of features that included the presence (or not) of lab coat and glasses, light bulb, and age of the scientist. In order to standardize the scoring procedure both raters agreed that for instance the lab coat feature would be considered as present only if the scientist was wearing a lab coat-like garment falling below the waist and secured with buttons on the front. In terms of the light bulbs feature, it was determined present if either a light bulb or a question mark was observed over the head of the scientist, and the elderly scientist feature was based

on the presence of facial wrinkles and/or declining stature. High overall scores are associated with highly stereotypical views about scientists and conversely, low scores indicate less stereotypical images.

A second data set was collected by conducting a frequency analysis of inquiry terminology used in the written assignments (concept map, essays, and reflection). A co-author of this article and his graduate student conducted the analysis. For this task, the assignments were divided into three groups: beginning of the semester assignments (concept map and autobiography), middle of the semester assignment (first draft of the science teaching philosophy) and end of the semester assignments (final version of the science teaching philosophy and written reflection). The purpose was to search for an increase in inquiry terminology usage PSETs could have incorporated in their understanding of inquiry as an instructional approach. In each assignment set, the raters tallied the frequency of 14 inquiry terms which were taken from the National Research Council' (NRC, 1996) Essential Features of Science Inquiry.

Results

According to the data gathered in the GIQ, the following trend was found: 41% of the participating PSETs stated enjoying science in their elementary school, 35.6% identified science as their favorite subject in high school, and 29.1% liked science in college. As for the question about identifying themselves as science teachers, less than half of the participating PSETs (40.2%) reported that they considered themselves as such (hereafter called *Teachers*). It is important to note that the participating PSETs were in their senior year and about to start their student teaching assignment in public elementary schools. Of this group (those who identified themselves as *Teachers*), 75.9% reported liking science in their schooling career versus 24.1% who did not like this subject but still considered themselves as science teachers. Over half of the participating PSETs (59.8%) did not identify themselves as science teachers (hereafter called *Non-Teachers*). Of this group, 48.0% indicated liking science in their K-12 education. The PSETs' self-nomination as members of either the *Teachers* or *Non-Teachers* group seems to be related to (1) their prior learning experiences with science, especially in their elementary and secondary education years, and (2) their confidence (or lack of it) with science as a subject in which, in their views, *one needs lots of experience and knowledge*. A major trend found in the answers to the questions in the GIQ was the narrow science content knowledge as determined by the science courses required in their degree plans. The participating PSETs in this study, like PSETs in similar studies (Milford & Tippett, 2013), complete their teacher education programs with a rather limited science experience due to the small number of science courses required in their degree plans.

As shown in Table 1, and according to the DAST-C frequency features, the views of the participating PSETs at the beginning of the semester portrayed scientists as white (94.4%), male (77.9%), middle age (52.2%) individuals, wearing eyeglasses (56.8%), and working indoors (79.8%); they are also depicted manipulating scientific research instruments (80.7%). Although the same features continue to receive high scores at post-drawing, they all showed a reduction in different proportions. Of the 15 stereotypical features in the DAST checklist, notable reductions were observed in the age of the scientist, use of research instruments, presence of eyeglasses and lab coat. Similarly, the depiction of more scientists conducting their investigations outdoors was

observed in the post-drawing submissions. A small reduction was noticed in the gender and ethnicity of the drawn scientist. In general, the depictions of scientists produced at the end of the semester describe science as an endeavor that can be undertaken by a group of, not necessarily old people, in outdoor settings, or even in the classroom where both the teacher and her/his students were portrayed as scientists.

Table 1. DAST Frequencies at Pre and Post-drawing

DAST Features	Pre-Drawing		Post-Drawing	
	<i>n</i>	% of Students	<i>n</i>	% of Students
1. Lab Coat	45	41.2	9	8.25
2. Eyeglasses	62	56.8	32	29.3
3. Facial hair	8	7.33	3	2.75
4. Symbols of research	88	80.7	56	51.3
5. Symbols of knowledge	48	44.0	34	31.1
6. Technology	34	31.1	22	20.1
7. Relevant captions	42	38.5	40	36.6
8. Male	85	77.9	78	71.5
9. Caucasian	103	94.4	96	88.0
10. Indications of danger	5	4.58	0	0
11. Presence of light bulbs	13	11.9	13	11.9
12. Mythic stereotypes	12	11.0	1	0.91
13. Indications of secrecy	2	1.83	0	0
14. Scientist doing work indoors	87	79.8	65	59.6
15./ Middle age or elderly	57	52.2	11	10.0

A mixed ANOVA was done to examine whether there was a difference in the number of stereotypical images drawn using the DAST-C at the beginning and at the end of the science methods course and whether there was a difference in stereotypical images drawn depending on teacher type. The results showed that there was a statistically significant difference in the number of stereotypical images in the pre- and post-drawings, $F(1,109) = 44.63, p < .001$. The PSETs drew more stereotypical images on the first class meeting ($M = 6.20, SD = 2.33$) than they did on the last one ($M = 4.09, SD = 2.05$). There was not a significant difference between teacher type (*Teacher* versus *Non-Teacher*), $F(1, 109) = .255, p = .615$. There was a significant interaction between pre- and post- drawing and whether the student (PSET) consider herself/himself as a science teacher, $F(1, 109) = 5.22, p = .02$.

According to Figure 1, PSETs who did not identify themselves as science teachers (*Non-Teachers*) initially drew more stereotypical images of scientists than their counterparts (*Teachers*). At post-drawing there was a smaller decrease in the number of stereotypical images drawn by the PSETs in the *Teachers* group than there was by those who did not admit assuming the role of science teachers at the time of the study (*Non-teachers*). As a result, *Non-teachers* drew less stereotypical images at the end of the semester.

The frequency analysis of course assignments was focused on the inquiry terminology usage at the beginning, in the middle, and at the end of the semester. Of the 14 concepts, six of them: *Science on my own*, *Inquiry*, *Questions*, *Test*, *Hands-on*, *Knowledge/knowledgeable*, and *Scientists* showed an increase in frequency usage from the beginning toward the end of the semester. Likewise, five other terms: *Observation*, *Curiosity*, *Exploration*, *Answers*, and *Higher-order thinking*, showed frequencies that grew by at least twice from the start to the end of the course. Only one term, *Excitement* showed minimal growth, and one last term, *Real Life Connections* did not show increments in its usage (see Table 2).

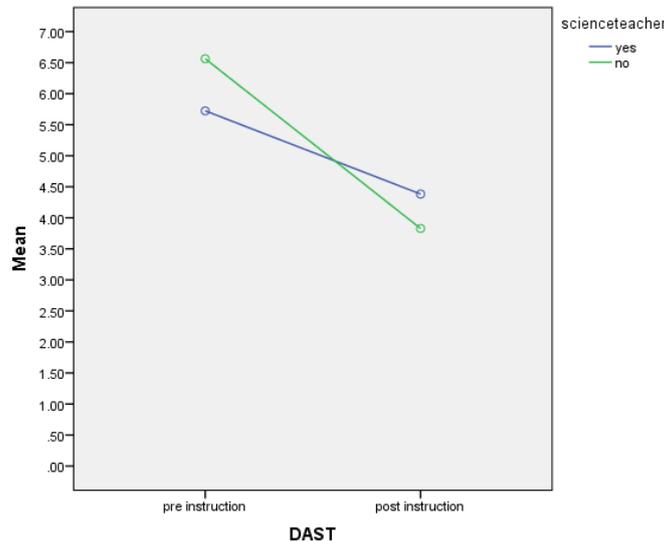


Figure 1. Mean Differences between PSETs Teachers and Non-teachers

Discussion

This article examined the shifts in the images of scientists and science held by a group of minority PSETs during a science methods course. This study also incorporated a series of hands- and minds-on tasks that revolved around the semester-long inquiry project intended to mediate PSETs’ assumptions about who is a scientist and the work they do. There is an extensive body of research focused on the use of the Draw-a-Scientist Test (DAST) describing the images that students possess about scientists. Nevertheless, the volume of research focused on influencing stereotypical views of PSETs about scientists is scarce and even less frequent with minority PSETs.

Additionally, and taking into consideration the negative views about science and the stereotypical images of scientists constantly reported by PSETs in this science methods course, the study described in this study was undertaken as a professional responsibility on the part of the instructor/researcher by presenting PSETs in the science methods course with opportunities to re-imagine and re-shape their conceptions of science and scientists. Feedback provided at the end of the semester in the student evaluations attest to this intention: *I liked this activity (DAST) because it offered an opportunity to reflect on my own growth; I can benefit from it as a form of self-reflection; it proves that I have a better understanding of science.*

Table 2. Inquiry-related Terminology Usage at Three Times during the Semester

Inquiry Codes	Code Frequency & Chronological Order	Usage Examples
1. Science on my own	15b, 51m, 113e	<i>Students can feel more comfortable around any subject because they can take control of what they are going to investigate.</i>
2. Inquiry	42b, 38m, 322e	<i>My science classes were never conducted as an open-inquiry environment. I would then have the student's come up with questions and observations</i>
3. Observation	30b, 24m, 73e	<i>so I could engage the students and see for myself what they were learning and acknowledging.</i>
4. Questions	85b, 68m, 176e	<i>Instead of providing direct instruction to students, we help students generate their own content-related questions and guide the investigation that follows.</i>
5. Curiosity	24b, 22m, 45e	<i>It is very important to give enough time to expose different hypothesis and inferences towards their curiosity of the world.</i>
6. Test	130b, 107m, 141e	<i>I would have students collect their own liquids along with a hypothesis of their own and then have them proceed with the test.</i>
7. Exploration	35b, 46m, 87e	<i>I believe that science teaches them to think for themselves, observe, predict, explore, work on teams, and work individually.</i>
8. Excitement	89b, 69m, 93e	<i>Prior to high school my previous science experiences weren't memorable, or exciting.</i>
9. Scientists	21b, 24, 78e	<i>I want each child to leave my classroom knowing that, with work, effort, and imagination, they can become successful scientists.</i>
10. Hands-on	67b, 77m, 101e	<i>The way I thought I was learning science was by working on hands on activities, utilization of new terminology and small group work.</i>
11. Knowledge	39b, 88m, 128e	<i>Understanding that science is a way of expanding our knowledge of the world around us. I realized that students have the ability to inquire about how our world</i>
12. Answer	29b, 23m, 67e	<i>functions and the ability to answer their own questions through inquiry and research.</i>
13. Real live connections	64b, 32m, 58e	<i>Using the students' interest to connect to the lesson truly has a huge impact in relating how they can apply their knowledge to real life.</i>
14. Higher order thinking	19b, 23m, 49e	<i>I must provide the students with various critical-thinking strategies to promote learning.</i>

Chronological identifiers: b= beginning of the course; m= middle of the course; e= end of the course

Because of the unique geographical location and socio-economic features in the community where this study took place, it is difficult to establish a comparison with pre-service teacher groups in similar studies. Perhaps a

comparable PSETs group is the one in the study published by Subramanian et al. (2013). Although that study also included preservice teachers of Hispanic descent, participants resided in a metropolitan area of the Southwest of the U.S., and not necessarily in a borderland community like the one described in this article. In Subramanian et al.'s (2013) study researchers examined the images of scientists held by a group of PSETs. In comparing the stereotypical views reported by participants in this investigation and in the Subramanian et al.'s study, four indicators of the 15 in the DAST-C, were rated with high scores by members of both groups: the two groups of minority PSETs described scientists as Caucasian males, working indoors, manipulating research instruments, and wearing eyeglasses. The ratings in the other features did not show comparable scores. Another similarity between the two groups is in the DAST indicators that received low scores. Both group of PSETs do not perceive science as a secretive and dangerous occupation; they also do not seem to associate scientists with mythical stereotypes always coming out with brilliant ideas, as depicted with a light bulb on the scientist's head. Another important finding indicates that minority pre-service teachers do not see individuals like themselves engaged in scientific activities. This is an important finding because as pointed out before, those teachers who perceive science as an activity accessible to everyone may not present this idea to their own students.

Unlike findings in other studies (Rahm & Downay, 2002) in which participants portrayed scientists as unstable and evil individuals working in isolation, PSETs in this study did not identify scientists with such features; the evil and secretive elements were not observed in the submitted drawings. When comparing the findings in this study with the images of scientists held by elementary pre-service teachers from a different generation (15 years ago), one finds that again, the same four DAST features are rated with high scores: male Caucasian individuals, working indoors, and manipulating research instruments. Likewise, in the 1990s pre-service teachers, although not from minority groups, did not identify science as a dangerous discipline nor scientists as mythical figures. In an attempt to explain this finding, it could be submitted that science education reform initiatives that took place at the end of the last century made the teaching and learning of science more focused on giving students in K-16 classrooms opportunities to engage in authentic science activities relevant to their lives outside schools, and in which they were to act like scientists.

The interaction between whether the PSET considers herself/himself as a science teacher (*Teachers* or *Non-Teachers*), and the frequency of stereotypical images at pre- and post-drawing further explains the purpose of this study which was intended to help reduce stereotypical thinking about scientists among those who did not consider themselves as science teachers. In sum, there was a positive shift observed in the post-drawings and in the content of the second half of the semester assignments. A point worth highlighting is the origin of the participating PSETs' images of scientists which seems to be demarcated within the context of the science learning settings in their K-12 education; this is a finding previously reported in the literature (Carlton-Parsons 1997).

One PSTE summarized her end-of-the-course views as follows:

Every year in elementary, middle, and high school, I had the idea that scientists were only those people who wore lab coats, goggles, and worked with liquids in a lab. Before taking this course and even when drawing the picture of how I thought scientists look, that is how I pictured it. Toward the end of the

course, I noticed that the picture I had in mind had changed. The Nature of Science principles impacted the way I see scientists.

Their views about who can do science expanded by the end of the course by referring not only to stereotypical “scientists” as qualified individuals to pursue this endeavor; they also included themselves as practitioners of science:

At first I thought it was just a lab where you do experiments with a scientist. After taking this course I realized that it is much more than that; I drew a picture of my three teammates and I observing outside about what is happening and being curious about our surroundings.

This view resonated with other PSETs who defined scientific inquiry as the practice of inquiry skills not only by scientists but also by their students who they depicted as *true scientists formulating questions leading to the discovery of new concepts*. Additionally, they pointed out that *we can all be scientists and use science in our daily lives*, and that scientific investigations help *people and scientists understand the natural world*. Yet another participant acknowledged gender differences as an obstacle to perceive science as a more inclusive profession: *We are so accustomed to think or to assume that men should be the only ones to experiment. Maybe this is a stereotype that empowers men and leaves women behind as just assistants.*

Initially, the mean of stereotypical images drawn was higher for the *Non- Teachers* group, but by the end of the course, members of this group drew less stereotypical images than their counterparts in the *Teachers* group. Perhaps, and since the PSETs in the *Non-teachers* group were holding more stereotypical views about scientists at pre-drawing, they had more ‘room’ for change and therefore were able to reconsider their perceptions at a higher rate as compared to their counterparts in the *Teachers* group. This is promising because these PSETs should be more likely to encourage their students to approach the learning of science as an exciting and doable activity than they would have been prior to taking the science methods course. It is important to emphasize that both groups (*Teachers and Non-teachers*) produced depictions of scientists with less stereotypical features at post-drawing. This finding differs from the outcomes reported in other studies in which the participating preservice teachers did not change their stereotypical views about scientists from pre to post drawing (Ucar, 2012). It should be made clear that Ucar’s study included not only the study of perceptions about scientists but also the views about science and science teaching during the entire teacher preparation program.

The second research question addressed the effectiveness of the inquiry investigation in the PSETs’ professional conceptions and views of scientists. The semester-long inquiry investigation was the focus of the intervention strategy, especially in the second part of semester when PSETs engaged in the design, execution of the project, and analysis of findings in an open inquiry investigation while playing the role of scientists and also positioning themselves in the role of elementary school students practicing science process skills. In their periodic reports they admitted wrestling with anomalies in their observations. In the ensuing classroom discussions they relied on the basic tenets of the Nature of Science already addressed in previous class meetings to confront and resolve the discrepancies they encountered while making sense of their observations. For instance, they realized that science is an inviting and accessible field, available to anyone; they also perceived it as an activity that can be

practiced not only in a science lab but also in the outdoors.

One PSET shared her thoughts in this way:

I now view science inquiry as a needed component of true teaching because it has shown me how it naturally activates student activity and involvement...I have learned that it is inquiry that provides students with the ability and chance to take on the role of true scientists as they formulate questions and ponder the great extents of learning that can be accomplished and reached as a result of implemented opportunities for inquiry.

Another major observation was the realization that scientific work does not follow a cut and dry path, always guaranteeing a right answer. Tackling discordant observations and pondering alternative interpretations from different angles allowed PSETs to confront their views of science as practiced in a linear and simplistic fashion. By the end of the semester, and as determined by the inquiry terminology usage in the written projects, their assumptions about how scientists approach their work highlighted multiple ways of doing science. This perspective was evident in statements like this: *Scientific work involves the different approaches students take to do research and understand the findings.* Likewise, unexpected results obtained in the inquiry projects emphasized the idea that scientific work does not conform to the wishes and well-intended work of each practitioner. As one PSET put it, *in science we cannot move forward if we do not stop looking at things how we want to see them.*

Conclusions

The purpose of this 4-semester study was to examine and attempt to influence the stereotypical images of scientists that prospective teachers possess while completing a science methods course. Overall, the data show significant variation at pre- and post-test, indicating that students reported less stereotypical views of science and scientists at the end of the semester. There was also an interaction between teacher type and time of drawing which indicated those who did not view themselves as science teachers initially drew more stereotypical images of scientists than those who viewed themselves as science teachers, but by the end of the course, these individuals drew images that were less stereotypical than individuals who actually viewed themselves as science teachers.

In their emerging reflections and philosophy statements which centered on the scientific investigation, as well as in the post-DAST-C survey, participating pre-service teachers exhibited a more balanced knowledge of the nature of science. In other words, their view of science inquiry and their practitioners, the scientists, are perceived in less stereotypical ways. Based on the results, the scientific investigation carried out throughout the semester, and the shared reactions during class discussions and the end of the course reflections indicate that PSETs in these cohorts experienced a positive change in their views about science and scientists. A practical implication of these results could be in the preparation of elementary teachers, particularly in promoting instructional practices that present science as an exciting human endeavor and potential career choice for students of both genders and all races.

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