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Changes in American preservice elementary teachers' efficacy beliefs and anxieties during a science methods course

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Abstract

Fifty-five American preservice elementary teachers' personal science teaching efficacy (PSTE) beliefs, science anxiety (SANX) levels, and common science misconceptions were investigated during a science methods course. A significant increase in the PSTE scores and a slight -but statistically insignificant- decrease in the SANX scores were detected during the course. Consistent with Bandura's social cognitive theory, the inclusion of inquiry activities and micro-teaching experiences into science methods course contributed to positive changes in preservice teachers' beliefs regarding science teaching. On the other hand, a majority of the participants possessed several misconceptions about basic science topics. It was concluded that, similar to mastery experiences as a source of efficacy beliefs, participants' unawareness of their science misconceptions contributed to enhancement of their personal science teaching efficacy beliefs.

Keywords: Mastery experiences, personal science teaching efficacy, pre-service elementary teacher, science anxiety, science misconceptions

Introduction

Global competition for technological innovation in the twentieth century forced many nations to examine the quality of science taught to their citizens. Preparing scientifically literate citizens has become a primary educational goal of both educators and politicians. It is perhaps not surprising that the United States, as a major international superpower, aims to be the leader in the world science education league. The statement "By the year 2000 U.S. students will be first in the world of science and mathematics achievement" was adopted by the former President George W. Bush from *America 2000: An Education Strategy* (1991) and published as part of the nation's education goals. However, according to the 2003 Trends in International Mathematics and Science Study (TIMSS) data, the U.S. 4th graders could outperform similar students in only 16 of 24 countries (Gonzales et al., 2004). Likewise, the U.S. 4th graders are outperformed by 4 Asian countries (Singapore, Chinese Taipei, Hong Kong SAR, and Japan) and stand in the 8th seat among the 36 participating countries in the 2007 TIMSS. The U.S. participants are reported to show no significant increase in their science scores from 1995 to 2007, but a decline in the mean scores from 542 to 539 (Gonzales et al., 2008).

Lower-than expected scores in the TIMSS and similar studies urge to reconsider the quality of science education at elementary schools (Jang, 2004). More than often, these reconsiderations end up with criticizing the elementary teacher preparation programs. Failings within teacher education programs with respect to science preparation had already been identified in the field (Bhattacharyya, Volk, & Lumpe, 2009; Gunning & Mensah, 2011; Levitt, 2001; Plourde, 2002a; Wenner, 1993). As an earlier critic of American science teacher education, Shrigley (1974) started his report with a general statement as, "That many elementary teachers have less than a positive attitude toward science is one of the truisms of American education" (p. 243). Later studies supported this view, since less than 30% of elementary school teachers have been found to feel competent to teach science (Cox & Carpenter, 1989; Jarrett, 1999). As Wenner noted, one indicator of a teacher's attitude toward science may be the amount of time devoted to science instruction at schools. Results from several studies indicate that very little time has been devoted to teaching science at elementary schools (Brand & Wilkins, 2007; Levitt; Palmer, 2001; Rice, 2005).

Previous research has reported that various factors affect teachers' effectiveness to teach elementary science. Among these factors, teachers' science content knowledge was usually considered to be the main criteria to predict their future success in classroom teaching for many years (Feistritzer & Boyer, 1983; Ramey-Gossert & Schroyer, 1992). However, in later studies, it has been repeatedly reported that teacher efficacy beliefs and attitudes toward science also have significant effects on the quality of classroom science instruction (Cantrell, Young, & Moore, 2003; Downing & Filer, 1999; Newton & Newton, 2011; Ramey-Gossert & Schroyer; Riggs, 1991). The similar conclusion of these studies is that a significantly large percentage of preservice and inservice elementary teachers experience low self-efficacy levels to teach science (Bhattacharyya et al., 2009; Gunning & Mensah, 2011; Stevens & Wenner, 1996; Tosun, 2000; Wenner, 1993).

Science Teaching Self-Efficacy

Bandura (1977) introduced the term *self-efficacy* to educational literature with his social cognitive theory. Bandura's main assertion was that the interplay between the behavior, personal factors, and environmental factors. Bandura used the concept of *reciprocal determinism* to explain that each of the three factors influences and is also influenced by the others. Therefore, the personal factors in the cognitive, affective, and biological forms should not be ignored when investigating the human behavior. Self-efficacy represents the belief that an individual possesses and is defined as "the beliefs in one's capability to organize and execute the courses of action required to produce given attainments" (Bandura 1997, p.3).

According to Bandura (1977), self-efficacy beliefs are formed by the interpretation of four sources. First, and the most influential source, is the interpreted result of one's previous performance or the *mastery experiences* because these experiences provide the authentic evidence that one can succeed in a desired task. A second source of perceived efficacy is the *vicarious experiences* generated by observing another individual while performing a task that is relevant to the observer's perceived goals. *Social persuasion* is the third source of efficacy beliefs which is received from others such as the verbal judgments. The fourth and final source of efficacy is the *physiological and emotional states* such as anxiety, stress, and mood states. Bandura hypothesized that "Efficacy expectation is a major determinant of people's choice of activities, how much effort they will expend, and how long they will sustain effort in dealing with stressful situations" (p. 194).

Bandura's new theory was welcomed in research in teaching and Ashton and Webb (1986) defined two types of teaching efficacy [personal teaching efficacy and outcome teaching efficacy] along with the definitions of Bandura. Since the efficacy beliefs are accepted to be context and subject matter dependent, definitions have been extended to specific subject areas. In the area of science teaching, two forms of efficacy beliefs are defined: personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). PSTE – or science teaching self-efficacy – is a person's belief in his or her ability to teach science effectively and STOE is the belief that effective teaching will have a positive effect on student learning. PSTE and STOE operate independently; therefore it is possible to see teachers with high PSTE but low STOE or vice versa (Cantrell et al., 2003; Moore & Watson, 1999).

Since the introduction of the concept of self-efficacy to the literature, there has been a growing interest to discover the impact of self-efficacy beliefs in science education. The case is of utmost importance in elementary education because elementary teachers are expected to teach all subjects in their classrooms, but it is highly unlikely that they are equally well prepared to teach all of those subjects.

Science Anxiety

Science anxiety has been defined as a fear of or aversion toward science concepts, scientists, and science related activities (Mallow, 1981). The causes of science anxiety are linked with past negative experiences in science classrooms, stereotyping of scientists in the popular media, and exposure to science anxious science teachers (Mallow et al., 2010; Udo, Ramsey, & Mallow, 2004). Science anxiety is viewed as a composition of different forms of anxieties, such as classroom anxiety, test anxiety, performance anxiety, and anxieties toward other content areas, like reading anxiety and math anxiety (Brownlow, Jacobi, & Rogers, 2000; Wynstra & Cummings, 1990).

Compared to the growing body of research on anxiety, it is interesting to note that there is little research on science anxiety. In one of the pioneer studies, Westerback and Long (1990) stated that they could not locate any published study in which science anxiety was considered a separate phenomenon and measured. Recently, more researchers have become interested in investigating this phenomenon. For example, after their study with 500 college students, Udo et al. (2004) concluded that education majors were among the most science anxious students in colleges. Based on this finding, science anxiety states of elementary teachers can be shown as a major reason for the limited time spent for science instruction at schools.

Research on Self-Efficacy Beliefs and Science Anxiety in Teaching

It has been repeatedly cited that elementary teachers' negative beliefs about science had resulted in a science anxiety, poor attitudes toward science, avoid spending time to teach science and lack confidence to help students involve in scientific activities (Bhattacharyya et al., 2009; Carrier, 2009; Gunning & Mensah, 2011; Plourde, 2002b). Similarly, many elementary teachers are reported to dislike and fail to understand science (Davis & Smithey, 2009; Ramey-Gassert & Schroyer, 1992; Rice, 2005; Tosun, 2000). These findings lead to the conclusion that elementary teachers' negative attitudes toward science negatively affect their science teaching self-efficacy beliefs, which eventually leads to ineffective science instruction. Low self-efficacious teachers are cited to rely on the overly use of teacher-directed instruction, such as text-based instruction or lecturing, and characterized by authoritative teacher-centered roles (Palmer, 2001; Smolleck, Zembal-Saul, & Yoder, 2006). Due to their low levels of confidence in their effectiveness, these teachers may avoid science experiments and other inquiry experiences to prevent any challenging outcomes (Downing & Filer, 1999; Palmer, 2006).

On the other hand, there is ample evidence stating that high self-efficacious teachers use more inquiry and student-centered teaching strategies. These teachers feel confident that they have adequate training or experience to implement teaching strategies for overcoming the barriers to student learning. High self-efficacious teachers were found to be more effective and more likely to spend the time needed to develop science concepts and also their students had more positive attitudes toward science and achieved higher on achievement tests (Cantrell et al., 2003; Marshall, Horton, Igo, & Switzer, 2009; Palmer, 2006; Riggs, 1991).

Science methods courses in teacher preparation programs are maybe the last opportunity for future elementary teachers to develop teaching strategies and potentially gain positive attitudes toward science and teaching before starting their teaching careers. Therefore, the main task of teacher educators should be designing science methods courses that will be beneficial to prospective teachers in various aspects. By the end of these courses, all prospective teachers' self-efficacy levels should be high enough to deliver high-quality instruction in schools and they should be able to overcome any anxiety toward science.

As self-efficacy became a popular topic in most educational areas, a similar trend was also seen in research on science teacher preparation. Numerous studies have been conducted to measure preservice teachers' self-efficacy levels before, during, or after the science content and/or science methods courses. Most researchers have concluded that the completion of science content courses did not necessarily improve teacher candidates' self-confidence to teach science, but practice-based science methods courses seemed to make the desired impact (Bleicher, 2009; Bleicher & Lindgren, 2005; Huinker & Madison, 1997; Morrell & Carroll, 2003; Palmer, 2001, 2006; Stevens & Wenner, 1996). However, it is not investigated in detail what aspects of these courses promote high teaching self-efficacy levels and why all students' self-efficacy levels do not change in the same direction during the methods courses. Since the topic is relatively new in science education research, few studies have been conducted to investigate the factors that influence students' self-efficacy levels during a science methods course. Most studies focused on the changes in groups' mean self-efficacy scores (Bleicher & Lindgren, 2005; Jarrett, 1999; Stevens & Wenner, 1996). Some researchers identified several factors that contribute to self-efficacy beliefs (Bhattacharyya et al., 2009; Carrier, 2009; Ginns & Watters, 1999; Gunning & Mensah, 2011; Nugent, Kunz, Levy, Harwood, & Carlson, 2008; Palmer, 2006), but due to use of small sample sizes, generalizations to larger populations still needs extra research data. Although their effects were not investigated in detail, many researchers agree on that the use of hands-on science inquiry activities (Bleicher, 2006; Cox & Carpenter, 1989; Ramey-Gassert & Shroyer, 1992), group studies (Bleicher; Moore & Watson, 1999; Ramey-Gassert & Shroyer), class discussions (Cox & Carpenter; Ginns & Watters, 1999), and authentic teaching experiences (Cantrell et al., 2003; Huinker & Madison, 1997; Kenny, 2010; Palmer, 2006) are more likely to improve students' attitudes toward science and science teaching. Among all factors, consistent with Bandura's emphasis on the mastery experiences, field experiences or micro-teaching experiences (authentic teaching experiences) are agreed to be the major factor shaping preservice teachers efficacy beliefs (Carrier, 2009; Huinker & Madison; Kenny; Morrell & Carroll, 2003; Nugent et al., 2008; Palmer).

Science Misconceptions

Science misconception term is used to describe the situations in which people's ideas differ from the ones accepted by scientists (Schoon & Boone, 1998; Stein, Larrabee, & Barman, 2008). Misconceptions mostly arise from faulty reasoning. People develop misconceptions as they attempt to make sense of the outside world. The sources of the misconceptions can be categorized as: (i) *Nonscientific beliefs*, include commitments to authoritative sources other than scientific education, such as mythical teachings, (ii) *Informal ideas that* are formed in everyday life, especially from the improper use of the language (e.g. the use of terms sun rise, sun set), and (iii) *Incomplete or erroneous views* that students develop during the classroom instruction.

Most people would agree that teachers would help students correct their misconceptions, but as noted above, some of the science misconceptions are formed in classrooms. This means that the teachers may be spreading misconceptions to their students (Burgoon, Heddle & Duran, 2010; Stein et al., 2008). Therefore, special interest should be given to the situations where teachers themselves have science misconceptions or alternative conceptions. This problem is extremely important because many researchers argue that misconceptions are deeply rooted and strongly resistant to change; thus persons holding misconceptions probably would have difficulty learning new materials (Burgoon et al., 2010; Cakiroglu & Boone, 2002; Gomez-Zwiep, 2008). Science can be seen as confusing to these people because of the discomfort caused by the results from scientific phenomena that do not support the alternative conceptions they hold (Schoon & Boone, 1998).

Having science teachers with an accurate understanding of science concepts is a must-have requirement for a better science education; however, studies about inservice (Lawrenz, 1986) and preservice teachers (Schoon & Boone, 1998) show that elementary teachers are not immune to holding science misconceptions. For example, Schoon and Boone surveyed 110 preservice elementary teachers and reported that a large percentage of their sample held the same alternative conceptions of the Earth and space sciences as their prospective students have. Preservice elementary teachers also have been found to possess several misconceptions about photosynthesis and inheritance (Brown & Schwartz, 2009; Cakiroglu & Boone, 2002). Moreover, many researchers concluded that most teacher candidates do not have a clear understanding of the common topics taught in elementary schools (Davis, Petish, & Smithey, 2006; Nilsson & van Driel, 2011; Stein et al., 2008). For example, Trundle, Atwood and Christopher (2002) noted that less than the 10% of the 78 participants in their study held a scientific understanding of moon phases. Similarly, 18% of the 122 elementary preservice teachers surveyed by Schoon (1995) were reported to have a scientifically acceptable understanding of moon phases. Although it is among the most common topics taught in elementary schools, preservice elementary science teachers were found to demonstrate inaccurate scientific understandings of the water cycle (Davis et al.). Same conclusion has been drawn by several researchers for different topics, such as astronomical subjects, gravity, magnetism, gases and photosynthesis (Burgoon et al., 2010; Cakiroglu & Boone; Kücükozer, 2007; Nilsson & van Driel; Rice, 2005).

In light of these findings, it is not likely that teacher candidates will be able to deliver scientific information, as well as they should. Based on the responses from 305 preservice teachers, Stein et al. (2008) stated that “This study helps to confirm that, in the elementary grades, students are likely to have teachers who have an abundance of misconceptions ... More importantly, nothing can be changed if the teachers have misconceptions and are not aware of them.” (p.8). These findings raise the concern for the need to investigate the relationship between holding science misconceptions and preservice teachers’ personal science teaching efficacy beliefs, because, “If teachers are unaware of the misconceptions held by their students and/or have misconceptions themselves, teachers may unknowingly reinforce or propagate new misconceptions to their students during science instruction” (Burgoon et al., 2010, p. 861).

The research questions investigated in this study are:

- How do personal science teaching efficacy beliefs of preservice elementary teachers change during a science methods course?
- How do science anxiety levels of preservice elementary teachers change during a science methods course?
- How do micro-teaching and classroom activities impact preservice teachers' science teaching self-efficacy beliefs and science anxieties during a science methods course?
- Does holding science misconceptions impact the changes in preservice elementary teachers' science teaching self-efficacy beliefs and science anxieties?

Methodology

Participants

The sample consisted of 55 preservice elementary teachers (50 females and 5 males) from a mid-western American university. The age range was between 22 and 31, where 96% of the participants were between 22 and 24. The participants were enrolled in a master of education licensure program and were taking a science methods course during the study. All participants had taken college-level science courses required by their program (a minimum of 9 semester credits) prior to the methods course semester. Courses could only be selected from the following areas and at least two of the three courses were required to include experimental sessions in a laboratory: Physical science (chemistry or physics), Earth science (geology, astronomy, or meteorology), and biological science (biology, biochemistry, botany, or ecology).

Science Methods Course

The two-credit science methods course in which the participants were enrolled was a part of an inquiry block where students were also enrolled in mathematics and social studies teaching methods courses. The inquiry block was designed to focus on the inquiry process in science, social studies, and mathematics. The science methods course was taught in three hour-long class periods, and nine class sessions were held during the 10 week course period. During the inquiry-block methods course, the students also attended elementary schools two half days per week, and completed three 3-day inquiry micro-teaching sequences in science/health, social studies, and mathematics.

The purpose of the science methods course was helping elementary licensure students to practice inquiry-based, constructivist teaching methods for teaching science and health at the elementary school level. The in-class science experiments consisted of exploratory science inquiry activities that were appropriate for elementary school level. Inquiry activities were designed to help students develop positive attitudes toward science and science teaching. Micro-teaching activities at elementary schools allowed students to increase their teaching skills and practice the course information about current science teaching methods. Therefore, the inquiry activities and micro-teaching experiences can be considered as the mastery experiences impacting the efficacy beliefs of participants during the course. The group studies in the college classroom, discussions about the micro-teaching experiences, and feedback from the course instructor were the examples for social persuasion source of participants' self-efficacy beliefs. Observing the course instructor in college during the inquiry activities, as well as the classroom teachers teaching science at elementary schools can be considered as the vicarious experiences of participants during the course. This study focused on the impact of the mastery experiences on efficacy beliefs, since these experiences were defined by Bandura (1977, 1997) as the most influential source of the self-efficacy beliefs.

To fulfill the course requirements, all students were required to prepare portfolios, which included reflection papers explaining what they learned in the course, micro-teaching papers explaining what they observed and learned in elementary classrooms, science lesson plans, and an analysis of a science curriculum that is being used in elementary schools.

Research Design

For answering the research questions, both quantitative and qualitative data collection methods in a mixed method research paradigm was used (Johnson & Onwuegbuzie, 2004). During this research, surveys and interviews were used to gather data. Quantitative data analysis was predominantly used in this study because the main purpose was to detect changes in preservice teachers' attitudes. Qualitative analysis results were used to support and further explain the quantitative results.

Surveys

The Science Teaching Efficacy Belief Instrument (STEBI-B) (Enochs & Riggs, 1990) and the Science Anxiety (SANX) survey (Bursal, 2008) were administered at the beginning and end of the science methods course as traditional pretest and posttest. To analyze the changes in preservice teachers' efficacy beliefs and anxiety levels during the science methods course period, paired-samples t tests were used to compare the pretest and posttest data. Before the STEBI and SANX posttests, the Science Misconceptions Test (SMT) was administered to the participants as one-shot survey.

The Science Teaching Efficacy Belief Instrument (STEBI-B) was developed by Enochs and Riggs in 1990, and is a widely used instrument to assess self-efficacy beliefs of preservice teachers regarding science instruction in schools. The instrument consists of two subsets: personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE). PSTE beliefs refer to the extent that teachers believe they have the capacity to positively affect students' achievement and STOE beliefs refer to the fact that student learning can be influenced by effective teaching. Since the goal in this study is to investigate the changes in the personal efficacy beliefs, only the PSTE scale of the STEBI-B instrument was used. PSTE consists of 13 items (5 positive-worded and 8 negative-worded), each to be rated by the respondent on a one (strongly disagree) to five (strongly agree) rating scale. The internal reliability alpha coefficient of the PSTE scale of the STEBI-B was calculated to be 0.90 (Enochs & Riggs). When participants' survey scores were calculated, the item scores were reversed for the negative-worded items. The score range for the PSTE subset was 13-65, and the higher the score, the higher the level of PSTE. The Cronbach's alpha reliability coefficients for the PSTE scale were found to be 0.86 and 0.80 for the pretest and posttest data in this study.

The Science Anxiety (SANX) (Bursal, 2008) survey was designed to measure students' science anxiety levels and contained 20 statements, each to be rated by the respondent on a one (no anxiety) to five (high anxiety) rating scale. The statements described everyday life and academic situations requiring scientific thought or tasks, and were rated as to the degree of anxiety that the respondent perceived he/she would experience in the given situations. Possible scores ranged from 20 to 100 and the higher the score, the higher the level of science anxiety. Most of the test items were adapted from popular anxiety surveys that were used to measure students' math anxiety levels, such as Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972) and Revised-MARS (Plake & Parker, 1982). In a pilot study with 154 preservice elementary teachers, the Cronbach's alpha for the SANX was calculated as 0.91. The factor analysis of SANX survey showed that all items contributed to the "science anxiety" factor with higher contributions than 0.428 (Bursal). Likewise, reliability coefficients of 0.92 and 0.94 were calculated for the pretest and posttest data in this study.

The Science Misconceptions Test (SMT) is an 11-item instrument, which has been developed from the misconception tests of Lawrenz (1986) and Schoon and Boone (1998). Questions in the original survey of Lawrenz were selected from the website of the National Assessment of Educational Progress (NAEP) from among the questions that were administered to 12th grade students. All questions had multiple-choice responses and assessed various misconceptions about science concepts, like conservation of matter, laws of dynamics, moon phases, and photosynthesis. The questions contained one correct or scientifically-acceptable answer, one common alternative conception, and two other distracters. Lawrenz has reported a Kuder-Richardson (KR_{20}) reliability of 0.80 for the misconception test.

Interviews

The researcher conducted semi-formal interviews with 23 volunteers at the end of the semester. Nineteen of these volunteers were female and the remaining four volunteers were male. All interviews were digitally recorded. Participants were basically asked to evaluate the changes in their beliefs about science teaching and science topics. The terms, "science teaching self-efficacy" and "science anxiety" were not used in the interview questions in order to prevent any leading responses. The interview questions were as below:

- *Please compare yourself at the beginning of the semester and now, in terms of your feelings toward science and science teaching:*
    - *Did your confidence about science teaching change during the methods course?*
    - *If yes, why do you think this change has happened?*
    - *What helped you most during the science methods course?*
    - *What helped you least or did not help at all?*

The interviews lasted 25 minutes to 45 minutes. Participant responses to the semi-structured interview questions were transcribed and triangulated with the quantitative data to explore the impact of course activities on participants' beliefs about science teaching during the science methods course.

Quantitative Data Analysis

A summary of the participants' pretest and posttest mean scores for the PSTE subset of the STEBI-B and SANX survey are given in Table 1. The paired-samples test results indicate that the mean PSTE score of the participants significantly increase (ΔPSTE = +3.57; $p < .001$) during the science methods course. Also, a noticeable but statistically insignificant decline (ΔSANX = -2.37: $p = .123$) in the mean SANX scores is observed from pretest to posttest.

Table 1. Participants' pretest and posttest PSTE and SANX scores

	PSTE		**SANX**	
	Mean	**S. D.**	**Mean**	**S. D.**
Pretest	46.78	6.35	44.43	12.16
Posttest	50.35	5.92	42.06	13.57

To investigate the changes in students' beliefs about each STEBI item, the percentages of participants who agreed/strongly agreed with the STEBI items are reported in Table 2. When reporting the percentages in Table 2, the negative STEBI items are reworded as positive items and the percentages for the disagree/strongly disagree options are given for these items.

Table 2 indicates that more than half of the participants did not agree that they knew necessary steps to teach science effectively (Item 3), would be able to explain why science experiments work (Item 7) and would have the necessary skills to teach science (Item 9) prior to the course. Also, half of the participants had doubts about their conceptual science knowledge (Item 6). This data was consistent with the percentage of students who doubted on their efficiency to answer students questions (Item 8) and help students turn on to science (Item 13).

After taking the methods course, more than half of the students expressed confidence related to all statements in the posttest. An increase in agreement percentages from pretest to posttest were observed for all but three items (Items 4, 5, and 12). The largest percentage increase was seen in item 3 (62 %), item 6 (37 %), item 2 (23 %), and item 9 (22 %) respectively. On the other hand, it was worrisome that more than one-third of the participants did not express sufficiently high enough self-efficacy for situations described by posttest items 7, 8, 9, and 10. It was also equally disturbing that, compared to 76% agreement in item 4 of the pretest, a smaller percentage of the participants (71%) agreed that they would be effective in monitoring science experiments as indicated by the posttest.

Table 2. *Percentages of participants who agreed (A)/strongly agreed (SA) with STEBI items*

STEBI Items	Pretest (A/SA)	Posttest (A/SA)
1. Will find better ways to teach science.	90%	96%
2. Will teach science as well as other subjects. *	61%	84%
3. Knows the steps necessary to teach science effectively.	20%	82%
4. Will be effective in monitoring science experiments. *	76%	71%
5. Will teach science effectively. *	94%	94%
6. Understands science concepts well enough to be effective.	49%	86%
7. Will be able to explain why science experiments work. *	45%	63%
8. Will be able to answer student questions.	51%	57%
9. Will have necessary skills to teach science. *	35%	57%
10. Willing to be observed by supervisor. *	63%	65%
11. Will be able to help students understand science concepts. *	74%	86%
12. Will welcome student questions.	94%	90%
13. Knows what to do to turn students on to science. *	55%	74%

*:Negative item rewritten in positive form

When the individual pretest and posttest scores were compared, it was observed that the PSTE score of 19 students had increased greater than the pooled standard deviation (s_p= 5,7) of the pre- and posttest scores, whereas only 2 students had experienced a decline in PSTE scores greater than the s_p during the study.

Qualitative Data Analysis

All interviewees, without any exception, agreed that the format of the methods course was helpful to develop positive attitudes toward science and science teaching. The main reasons for this positive impact were shown as; (a) science inquiry activities carried out in college classrooms and (b) micro-teaching experiences at elementary schools.

Science Inquiry Activities

The science methods course investigated in this study included hands-on science inquiry activities in all class meetings. Activities were usually open-ended or guided inquiry types and all interviewees were in favor of doing science experiments in the science methods course.

> *I learned a lot more from doing the actual experiments. Looking at the lesson plan, how it is set out, and then doing the activity, how it is presented in the lesson. So, seeing how you can actually do that, I think that really helped.*
> *At the beginning of the semester, I did not understand what inquiry was, and I thought it was mostly just the teacher telling you how to do things, but now, I have seen that it is more student directed… I am beginning to feel more comfortable. I have a good idea in my mind now what it should look like. It is just a matter of practicing.*

The common theme in the interview data was that the inquiry activities undertaken in college classrooms could be directly used in elementary schools; thus completing those activities helped the participants enhance their confidence in their science teaching skills.

> *I actually really enjoyed… [Science inquiry activities] were all interesting for me. It is fun to see that you can actually do hands-on activities with younger students, rather than you always think of them like high school or junior high activities. You can do these things in elementary school and get them thinking about that kind of stuff.*
> *I have learned that you can make it inquiry and you can make it fun for students. I feel like I am [confident]. I am excited to do student teaching.*

Micro-Teaching Experience

All interviewees agreed that having opportunities to implement the methods they learned in the science methods course were very encouraging for them, and therefore enhanced their PSTE beliefs. In addition to micro-teaching experiences completed during the science methods course, a majority of the participants stated that their previous teaching experiences with children contributed to their confidence in teaching, as well as their willingness to work with children. All participants agreed that micro-teaching activities affirmed their enjoyment of working with elementary students.

> *I learned a lot from this class, but I think that teaching a micro-teaching lesson was a huge mean [pause]…, if anything confidence booster that I can teach. Because, it [science] is kind of intimidating subject to teach, at least for me.*
> *I had a lot of fun teaching it [micro-teaching lesson]. Kids were engaged. We needed a little bit more time. It was the only thing... I think teaching is something I really enjoy. These classes I have taken this year, kind of affirmed that. Being able to work more in classrooms and actually getting to teach in the micro teaching just affirmed that this is what I want to do).*

The Ugly Part: Science Misconceptions

To explore the presence of common science misconceptions among the participants, the percentages of the students who agreed with the misconceptions included in the SMT are reported in Table 3.

As seen in Table 3, compared to their strong PSTE beliefs at the end of the science methods course, at least 40% of the participants shared 7 of the 11 common science misconceptions.

The participants were found to hold common misconceptions about various topics, especially about astronomy and the conservation of matter. For example, some students wrote that adding hydrogen to a vacuumed container lessens the mass since the gases are light and make balloons float. Compared to an increase in the agreement percentage from 49% (pretest) to 86% (posttest) with the STEBI item 6 (understands science concepts well enough to be effective), it is important to note that the participants did not correctly respond to any of the SMT questions at this percentage rate.

Table 3. Common science misconceptions of the participants

Misconceptions	Agreement
The sun is directly overhead at noon in the northern hemisphere.	94 %
Earth is nearer the sun in summer.	81 %
Moon phases are caused by the shadow of the earth falling on the moon.	67 %
Rusted iron weighs less or the same as the iron it came from.	58 %
When a balloon is taken from the Earth to the Moon, its mass changes.	46 %
Adding hydrogen to a vacuumed container does not increase the mass.	42 %
Venous blood is blue.	42 %
Heavy balls fall faster than lighter balls.	39 %
Plants get their food from the soil.	24 %
When an uncharged metal plate gains electrons, the plate is positively charged.	19 %
To be able to see a ball, the necessary path of light is from the eyes to the ball.	16 %

Discussions and Conclusions

The first two research problems investigated in this study were about the personal science teaching efficacy (PSTE) and science anxiety (SANX) changes of the elementary teachers during a science methods course. The participants started the science methods course with moderate PSTE scores, but generating self-efficacy via the course activities helped them gain considerably higher PSTE scores by the end of the semester. In agreement with the results from the similar studies of Cantrell et al. (2003), Morrell and Carroll (2003), and Palmer (2001), the participants in this study enhanced their PSTE at a statistically significant level from pretest to posttest (ΔPSTE = +3.57; p= < .001). Consistent with this finding, participants had experienced a slightly lower, but statistically insignificant, level of science anxiety at the end of the methods course (ΔSANX = -2.37: p = 0.123). The significant increase in the PSTE and the slight decrease in the SANX scores indicate that completing a practice-based science methods course resulted in improving the participants' beliefs about science and science teaching.

The third research problem was about the sources of the changes in preservice teachers' beliefs about teaching science. According to Bandura (1997) and numerous other researchers (Cantrell et al., 2003; Carrier, 2009; Huinker & Madison, 1997; Kenny, 2010; Palmer, 2006), mastery experiences were expected to be the main factor affecting the preservice teachers' beliefs. The findings were consistent with this argument because the science inquiry activities and micro-teaching activities were reported by the participants to be the most effective experiences to increase preservice teachers' self-efficacy beliefs and lower their anxieties toward science. Getting first-hand teaching experiences and interacting with children seemed to help participants improve their views on their efficiency to teach science. For these reasons, a main contribution of this study to the teacher education literature is strengthening the emphasis on the mastery experiences. If teacher candidates are allowed to complete various mastery experiences in teaching during the college years, it is highly likely that they will develop strong self-efficacy beliefs to teach science and also overcome their science anxieties.

The high percentages in the STEBI-B posttest indicate strong self-efficacy beliefs of the elementary teacher candidates to teach science but these high percentages, along with the low SMT success, raises the concern that some teacher candidates are developing strong self-efficacy beliefs during teacher education programs despite holding misconceptions about science. Therefore, in response of the fourth research question, one might conclude that holding science misconceptions did not have an impact on the increment of participants' self-efficacy beliefs during the course. This finding agrees with the conclusions of Cakiroglu and Boone (2002) where the authors stated that "Most people are comfortable with their own alternative conceptions because they believe that what they know is true." (p.11). Thus, participants' unawareness of their self-deficits seems to be a source of their self-efficacy beliefs as well.

The discrepancies between some of the STEBI item percentages can also be explained as a result of students' overrated views of their elementary science content knowledge. As was reported in Table 2, more than 85% of the teacher candidates expressed confidence in their understanding of the science concepts (item 6) in the posttest. Also, 90% of the participants agreed that they will welcome student questions (item 12). However, only 57% of the sample expressed confidence for item 8 (will be able to answer students' science questions). This discrepancy between the STEBI items percentages agrees with the results of Stevens and Wenner (1996):

> While the students are generally confident in their teaching competencies and believe that they possess adequate content area knowledge, they harbor doubts concerning their ability to teach at a conceptual level or to conduct process-oriented, hands-on experiences in classroom settings (p. 6).

The percentages in Tables 2 and 3 are alarming, because more than half of the participants held strong PSTE beliefs and at the same shared several common science misconceptions. Research shows that many science misconceptions are formed in elementary classrooms (Burgoon et al., 2010; Cakiroglu & Boone, 2002; Rice, 2005; Stein et al., 2008). Self-confident but science-incompetent teachers seem to be the best candidates to spread misconceptions. For this reason, a significant contribution of this study to the literature is showing that limiting our attention to the increase of the PSTE scores in educational research would cloud some facts that would cause serious troubles in the long term.

As was described by Bandura (1997), the PSTE beliefs are mainly generated from actual mastery experiences, which comprehend self-perceptions about the science content competency. However, the findings of this study suggest that a similar impact would be due to unawareness of the presence of an individual's own science misconceptions. Being satisfied with the unawareness of own misconceptions can be called *unrealistic optimism* (Brookhart & Freeman, 1992; Weinstein, 1989), which was used to describe high – but unrealistic – level of confidence among entry-level preservice teachers. Therefore, one of the major contributions of this study to the literature is underlining the fact that, the ultimate goal of teacher education programs should not be preparing merely highly self-efficacious teachers, but preparing highly self-efficacious teachers who have solid science content knowledge, especially in the areas that many teachers and students possess misconceptions.

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