Elementary Preservice Science Teaching Efficacy and Attitude Toward Science: Can A College Science Course Make A Difference?

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Abstract

University laboratory science courses are typically designed to prepare science majors or those who are pursuing health related careers. These courses often do not provide the experiences necessary to improve elementary preservice teacher science teaching efficacy or attitudes and beliefs toward science. This research utilized a university science content course that was designed for preservice elementary teachers. The course was designed to specifically teach science content consistent with national and state standards for K-5 science. The course was also designed to encourage elementary preservice teachers to share uncertainties concerning science and science education, while allowing them to experience the mastery of science content through discovery, inquiry, and collaborative laboratory experiences. The purpose of this design and implementation was to promote science content understanding, but also improve science teaching efficacy and attitudes toward science. Data was collected utilizing the Science Teacher Efficacy and Beliefs Instrument for preservice teachers (STEBI-B) and an end of course survey designed to encourage reflection on science teaching and attitudes toward science. The findings from this research suggest that a course specific to the science content needs of elementary preservice teachers' can also improve confidence in teaching science and attitudes toward science as a body of knowledge.

Key words: science education, elementary teacher education, science teacher self-efficacy, attitudes toward science

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Teacher preparation programs may struggle in advising for college science courses that promote science teaching efficacy and positive attitudes toward science for elementary preservice teachers. While it is important that elementary preservice teachers master science content, it is also essential that they hold positive attitudes concerning science and feel confident that they will become effective science teachers (Fidler, 2012; van Aalderen-Smeets & van der Molen, 2015). Cobern and Loving (2002) suggest that there are three times more elementary teachers who feel confident teaching Reading/Language Arts than those who feel confident teaching science. Addressing specific science concept mastery, as well as promoting positive attitudes toward science and confidence in science teaching, should be priorities for college science course advisement of elementary preservice teachers.This research provides quantitative evidence that college science courses can provide preservice elementary teachers with not only the necessary content knowledge, but can be taught in such a way that preservice teachers overcome past prejudices against science and gain science teaching self-efficacy.

Theoretical Framework

It is imperative that elementary preservice teachers know that the college science courses they take will directly impact their ability, attitude, and efficacy to teach science. The number of college science courses and the type of experiences in those courses can be major factors in improving science teaching efficacy (Hechter, 2011). Colleges and universities should have definitive protocols to guide elementary education majors in choosing science courses that will be most beneficial to their teacher preparation. Typically, elementary preservice teachers take two 4-hour laboratory science courses. These courses are often grouped into “majors” and “non-majors” courses with the indication that those seeking science majors will be tracked into the more rigorous science courses. Those who are non-majors may be tracked into less rigorous science courses. While serving the purpose of preparing students in one specific area, i.e. biology, astronomy, environmental science, etc., these college science courses do not cover the broad range of science topics required to effectively teach science in grades K-5. A perusal of the topics listed in most state standards, including the Texas Essential Knowledge and Skills (TEKS) (Texas Education Agency, 2009), and the Next Generation Science Standards (NGSS Lead States, 2013) reveals the breadth of science content required to be taught at those grade levels. Topics include chemistry, physics, earth and space science, life science, and technology and engineering practices. It is problematic to expect elementary education majors to have the breadth of science knowledge necessary to teach K-5 science based on completion of two non-majors college science courses.
Research shows that elementary preservice teachers thrive when they learn content that is relevant to the science standards they will ultimately teach (Steinberg, Wyner, Borman, & Salame, 2015). Unfortunately, many college science courses are specific to one area of science, resulting in specific and often limited science knowledge. While this approach may contribute to a deep understanding in one content area, it cannot address the breadth of elementary science required for elementary teachers. According to Palmer (2011) understanding the impact of the lack of content knowledge, referred to as lack of cognitive mastery, can be important in uncovering elementary preservice teachers’ lack of interest and confidence to teach science. Preservice teachers who do not master the science content they will be responsible for teaching may subsequently not be comfortable teaching science (Britner & Pajares, 2006). They may actually have a limited capacity “to judge how important science content is” (Howitt, 2007, p. 56) and therefore develop and pass on negative attitudes toward science to their students (Bergmen & Morphew, 2015; Cobern & Loving, 2002). It is also probable that preservice elementary teachers will not see science taught or modeled in college science courses using methods important to science pedagogy. Most college science courses are lecture-based and “can ‘make or break’ future elementary teachers’ attitudes and abilities in their own classrooms” (Bergman & Morphew, 2015, p. 74).

Also problematic is that many college science courses utilize separate laboratory experiences that may or may not be directly linked to the lecture content. The absence of a link between hands-on experimentation and lecture content prevents the establishment of those connections necessary to attain mastery of science concepts. The disparate approach to these courses often contributes to the feelings of disinterest and low self-efficacy in science (Reisert & Kielbasa, 1999). Recent research on improving teachers’ attitudes toward science indicates, “that improving attitudes is a first and essential step for teacher professional development in science education” (van Aalderen-Smeets & van der Molen, 2015, p. 711). For these reasons, courses should be implemented that promote mastery of content and positive attitudes in science so that elementary teachers do not avoid teaching science or rely on teaching strategies adopted from other content areas which may not reflect best practices in the content of science (Appleton, 2003).

It can be argued that once preservice teachers learn science content from already established college science course then the science methods courses offered through university or college education departments will provide the pedagogy necessary to prepare them to confidently and effectively teach science. While science methods courses do provide instruction in hands-on, inquiry-based methods of teaching science, novice science teachers resort to using the same lecture-based model employed in their university science courses. This occurs in spite of those same novice teachers believing that using hands-on methods of science teaching are more interesting and fun for their students (Fones, Wagner & Caldwell, 1999). The reality is that science teacher preparation occurs both within science methods and science content courses and that both university science and university education faculties should share responsibility for this preparation (Hechter, 2011). Confidence in teaching science and positive attitudes toward science and science education develop throughout the teacher preparation program and the required science content courses should address these issues while providing opportunities for content mastery.

Methods

The purpose of this study was to explore the impact of a purposefully designed science content course on elementary preservice teachers' science teaching self-efficacy and attitudes toward science and science teaching.

Course Design

The piloted course researched for this study was approved in spring 2015 as a university science course offered through the College of Arts and Science but taught in the Department of Curriculum and Instruction's science laboratory. The 2015-16 implementation of the course served as a pilot and data gathered during this time will be used to inform decisions concerning both content and course effectiveness of future course offerings. This course specifically presented life science and chemistry concepts necessary to effectively teach K-5 science in Texas. While the topics were chosen based on K-5 state and national standards (NGSS Lead States, 2013; TEA, 2009) the content was developed and presented using instructional strategies that promoted deep understanding of the scientific concepts required for effective science instruction of elementary school students. The instructor of the course was required to have an advanced degree in a core science, as well as experience in teaching K-12 science. The instructor for the pilot course had a master's degree in biology and a doctorate in Curriculum and Instruction, as well as a Texas certification to teach biology and chemistry. The instructional goals of the course included:

1. Elementary preservice teacher mastery of content specific to the life science and chemistry standards as based on the Texas elementary science content standards for grades K-5 (TEA, 2009), the National Science Teachers Association (NSTA, 2003) and the NGSS Lead States (2013),
2. Instructional modeling by the course instructor of varied and effective science education instructional strategies, and
3. Improvement of elementary preservice teacher attitudes and confidence toward science and science teaching.

Guidelines from the National Research Council (NRC, 2005) were also utilized. These guidelines recommend that laboratory experiences be integrated into instructional units to "gauge the students' developing understanding and to promote their self-reflection on their thinking" (NRC, 2005, p. 82). The course met two times each week, with each session lasting two hours and forty-five minutes. This extended time allowed for the laboratory experience to be embedded into each class session ultimately providing a seamless transition between hands-on and collaborative laboratory activities, discussion, and interactive lecture. The course was designed to be very collaborative; therefore, students were grouped at tables of three to four students. This arrangement allowed students to collaboratively formulate questions and engage in discussions.

Each class session was planned using the 5E lesson-planning model, developed by the Biological Sciences Curriculum Study (BSCS) (Bybee, Gardner, Van Scotter, Powell, Westbrook, & Landes, 2006), which is an inquiry-based model, designating instructional units according to the following guidelines:

1. Begin with an activity that **engages** students and uncovers prior conceptions and misconceptions,
2. Progress to an **exploration** of content activity (typically a laboratory experience),
3. **Explain** the content (student FIRST, then teacher: discussion/lecture)
4. Follow with an application or **elaboration** of content (often a laboratory experience with discussion), and
5. Include an ongoing **evaluation** (specific and purposeful questioning, written analysis, quizzes, etc.).

The 5E lesson plan instructional model was chosen because of the emphasis on the use of inquiry. A written probe was included as a part of the "engage" portion of each lesson to determine student understanding of content presented during that session. Many of Paige Keeley's science probes (2005-09) were used, even though they are written for grades K-12, because the students lacked basic science content knowledge. After the probes were administered, students then participated in collaborative exploration activities that often involved the collection of data, followed by an analysis of trends, predictions, and subsequent development of ongoing questions. The students were required to present their findings before the instructor began an explanation of the new content. Interactive lecture was often the mode of delivery for that explanation and usually lasted only 20-30 minutes per class session. Students were then given the opportunity to apply their new knowledge during an exploration/application activity. Formative evaluation, in addition to the probe, consisted of purposeful questioning of students and written assignments completed during laboratory activities. There was no textbook that met the requirements of the wide range of content included in this course; therefore, electronic resources were used extensively.

Participants

Thirteen female students participated in the course during spring 2016 and were given the option to participate in the research by signing a consent form at the beginning of the semester. Students who opted not to participate were identified at the end of the semester and their information was removed from the final analysis. Twelve students completed the information required for analysis of the STEBI-B and eleven students completed the end of course questionnaire. Ten of the thirteen students were classified as freshmen and had taken no prior college science courses. Three of the students were classified as sophomores and had previously taken a college-level science course. Ninety-two percent of the students had taken both biology and chemistry in high school.

Data Collection

Data were collected using a pre- and post-administration of the Science Teaching Efficacy and Beliefs Instrument-B (STEBI-B) version for preservice teachers developed by Enochs and Riggs (1990). The test was administered once during the first week of the semester and again during the last week of the spring 2016 semester. The STEBI-B is a twenty-three-question instrument that measures a preservice teachers' beliefs concerning their ability to teach science. The questions are Likert-type with a scale of 1-5, with 1 corresponding to Strongly Disagree and 5 corresponding to Strongly Agree. Thirteen of the questions are written in positive form and twelve are written in negative form. For purposes of analysis, the negative form questions were reversed scored (Enochs & Riggs, 1990). The questions on the STEBI-B are divided into two types, those designated as measuring Personal Science Teaching Efficacy (PSTE), which is the preservice science teachers' belief that they can effectively teach science, and those designated as measuring Science Teaching Outcome Expectancy (STOE), which is the preservice teachers' perceived ability to positively affect their (future) students' outcomes (Enochs & Riggs, 1990).

The Wilcoxon Signed Ranks test for dependent samples was chosen to analyze the STEBI-B scores due to the small sample size. Twelve students participated in the pre- and post-STEBI-B; therefore, a nonparametric statistical test was used to determine if there was a statistically significant difference between pre- and post- test scores on questions designated as addressing PSTE or STOE. This statistical test was implemented using a maximum allowable Type I error rate ($p < .001$, $a = .05$).

Additional data were collected using an electronically administered questionnaire during the last week of the semester. Eleven students completed this information. The questionnaire allowed students the opportunity to share their attitudes in an open-ended format that supplemented the data obtained through the STEBI-B analysis. The questionnaire consisted of the following questions:

1. How has your participation in this course influenced your confidence in understanding scientific concepts?
2. How has your participation in this course influenced your attitude toward science as a body of knowledge?
3. How has your participation in this course influenced your attitude toward teaching science to elementary students?
4. How do you believe your participation in this course will influence the quality of your science instruction?

Results

STEBI-B Analysis

The STEBI-B was utilized to determine if there had been a change in science teaching efficacy for the participants who completed the piloted science course. The small class sample size dictated that both the descriptive and inferential statistics be provided. There were only twelve students (of the original thirteen) who participated in both the pre-and post-STEBI-B. Table 1 provides the basic STEBI-B statistics for those twelve students. Table 2 provides information concerning the ranking of changes on the pre- and post-test. This information was used for the Wilcoxon Signed Ranks Test (Table 3). Table 2 illustrates that on the STOE variable, six students had mean scores that decreased from pre- to post-test, five increased, and one student had the same scores on both the pre- and post-tests. For the PSTE variable, 11 students, approximately 92%, showed an increase in their mean scores from pre- to post-test, with only one showing a decrease. The Wilcoxon Signed Ranks Test in Table 3 provides evidence for a statistical difference in pre- and post- STEBI-B PSTE scores but illustrates no difference in the pre- and post-STEBI-B STOE scores.

Table 1
Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Pre-STOE	12	35.41	5.07	26.00	45.00
Post-STOE	12	34.75	3.84	29.00	44.00
Pre-PSTE	12	41.33	8.15	30.00	58.00
Post-PSTE	12	52.00	5.60	44.00	61.00

Table 2
Ranks

Question/Test		N	Mean Rank	Sum of Ranks
STOE Post –	Negative Ranks	6[a]	6.00	36.00
STOE Pre	Positive Ranks	5[b]	6.00	30.00
	Ties	1[c]		
	Total	12		
PSTE Post –	Negative Ranks	1[d]	4.50	4.50
PSTE Pre	Positive Ranks	11[e]	6.68	73.50
	Ties	0[f]		
	Total	12		

Note.
a. STOE Post < STOE Pre
b. STOE Post > STOE Pre
c. STOE Post = STOE Pre
d. PSTE Post < PSTE Pre
e. PSTE Post > PSTE Pre
f. PSTE Post = PSTE Pre

Table 3
Wilcoxon Signed Ranks Test

	STOE Post -STOE Pre	PSTE Post – PSTE Pre
Asymp. Sig. (2-tailed)	.789	.007
Exact Sig. (2-tailed)	.836	.004
Exact Sig. (1-tailed)	.418	.002
Point Probability	.024	.000

Questionnaire Analysis

Table 4 provides specific comments gathered from the end of semester questionnaire. Representative quotes for each question are included in the table. The positive response rate for question one (influence of the course on their confidence in understanding science concepts), two (influence of the course attitude toward science as a body of knowledge), and four (influence of the course on the quality of their science teaching) was each ninety-one percent. The positive response rate for question three (influence of the course on their attitude toward teaching science to elementary students) was one hundred percent.

Table 4
Questionnaire Analysis Results

Questions And Student Quotes	Positive Response (*N*=11)	Neutral Response (*N*=11)	Negative Response (*N*=11)
How has your participation in the ISCI course influenced your confidence in understanding scientific concepts?	91%	9%	0%
"Before taking this class, I honestly did not remember most of the science I was taught before college. Going into the TA year, I was very nervous that I would not be prepared to teach science at all. After taking this class, though, I can say that I feel 100% confident in my ability to teach science."			
"My participation in the ISCI course has made me feel extremely confident in understanding scientific concepts. I feel like I finally understand every science concept I have ever been taught. I have always learned the information taught to me just deep enough to excel at tests. After this course, every concept seems clear to me. I didn't learn the concepts just for a test; I learned them for life."			
How has your participation in the ISCI course influenced your attitude toward science as a body of knowledge?	91%	9%	0%
"I have always thought I wasn't good at science, but after this class seeing that breaking down and taking appropriate time explaining concepts really helped me grasp them."			
"Science has always been one of my least favorite subjects, and I am now extremely fascinated."			
How has your participation in the ISCI course influenced your attitude toward teaching science to elementary students?	100%	0%	0%
"After taking this class, I am no longer scared of the thought of me teaching science to elementary students. This class has given me the confidence that I will need to teach it."			
"I almost forgot that science could actually be fun. This class has reminded me that there are so many different techniques and projects that are fun for students to participate in, but that also successfully teach the content. Science does not have to be boring. In fact, if it is, you are teaching it wrong."			
How do you believe your participation in the ISCI course will influence the quality of your science instruction?	91%	9%	0%
"I used to despise science. I was really bad at it in high school. I feel having more knowledge in science areas will help me to teach effectively."			
"Not only do I now understand the material much better now, but also I understand that there isn't one way to teach science. Students learn and understand things differently, so I have realized you cannot be closed minded about which way you teach a concept in science. You have to be open to change your lesson to help the students grasp it the best they can."			

Discussion

Evidence gathered from preservice elementary teachers after a one-semester pilot of a science content course formulated specifically to address K-5 elementary science concepts indicates that these preservice elementary teachers showed improvement in their science teaching self-efficacy. The research also provides evidence that preservice elementary teachers developed a more positive attitude toward both science and science education. Yet to be determined is whether the students would have developed a positive attitude regardless of the college science course completed. The specific quotes from the elementary preservice teachers provide evidence that, in some cases, the change in attitude and self-confidence over the course of the semester toward both science and science teaching was an extreme change. Both the STEBI-B analysis and questionnaire responses indicate that preservice teacher perceptions of their science teaching effectiveness improved as a result of completing this course. While the STEBI-B PSTE score changes were statistically significant, the STOE scores were unchanged. Recalling that the PSTE measures the preservice science teachers' belief that they can effectively teach science, while the STOE measures their perceived ability to positively affect their (future) students' outcomes, it is important to understand why the two measurements might differ. One possible explanation for this difference in scores may be attributed to the preservice teachers' enrollment in this course as freshmen or sophomores. The students in this course were primarily freshmen and had not participated in a field experience related to teaching, so were only aware of their own attitudes and efficacy toward teaching science. They had no prior field experiences that would have allowed them to understand how their confidence and ability to teach science would also promote positive outcomes in their students' learning of science. It is possible that once the elementary preservice teachers begin clinical experiences during their junior year they would then see evidence of student learning due to the their own confidence and ability to teach science. The reference point for student learning is difficult to establish as freshman and sophomores when they are not working directly with groups of elementary students. While these preservice teachers appear confident that they have mastered the content required to effectively teach elementary students life science and chemistry, they are not aware of how that ability may affect student outcomes in their future elementary classrooms. Most telling is the change in attitude toward science and science education. One hundred percent of the participating elementary preservice teachers claimed a positive change in their attitudes toward teaching science and 91% claimed a positive change in their attitude toward science. It was discouraging to hear the negative attitudes toward science expressed by the preservice teachers at the beginning of the semester. They were reluctant to participate in inquiry experiences and wanted the content presented in lecture format, basically "Tell me what I need to know". These preservice teachers did not want to construct their own understanding of science concepts through experiences. It was at least a month into the semester before they were comfortable with utilizing the inquiry process to learn science. Modeling inquiry and the integration of interactive lecture with hands-on experiences and scaffolded laboratory experiences was foreign to how they had learned science previously. The final changes in their attitudes were very positive and very encouraging. Although this was a small study on a piloted college science course, the results show that big changes in self-efficacy and attitudes toward science and science education can occur when the course is designed to both allow for mastery of content and be interesting and fun. These elementary preservice teachers now look forward to teaching science instead of dreading that responsibility.

Limitations

The small sample size of this study is a limitation to extrapolating results to other populations of elementary preservice teachers. Efforts to minimize the statistical limitations were made by using the

Wilcoxon Signed Ranks test. The results of this pilot were necessary at this university to provide immediate evidence of the impact one course could have on the science preparation of elementary teachers so that arguments could be made to continue offering the course, as well as providing support for the development of a second course to address physics and earth/space concepts.

Constraints on the actual implementation of the course included the problem of differentiating instruction to address student differences in science preparation and the students' depth of science knowledge. While this is an issue in all courses, it was particularly problematic in this course. Many of the science concepts addressed appear superficially to be very basic, yet it was within those basic concepts that misconceptions were evident. In one section of this course, student knowledge ranged from students with advanced science knowledge to those who did not understand what it meant to be "warm-blooded" or why the "2" was necessary in the formula for water, H_2O.

Another instructional constraint was the limited availability and subsequent need for development of effective, interesting, and relevant laboratory experiences that addressed basic science concepts, yet promoted a deep understanding of those concepts. The laboratory experiences utilized in this pilot course were inquiry-based, meaningful and relevant, required minimal laboratory skills, and promoted student confidence in and attitudes toward science, yet these experiences should continue to be improved so that they address science concepts on a continuum from a basic level to a collegiate level of understanding. This would ensure that the most basic of science concepts is mastered, preparing the preservice teacher to teach the concepts with both a depth of understanding and improved attitudes toward teaching science (Tessier, 2010).

Conclusion

The piloted science content course used for this research provided valuable data for assessing both preservice elementary teachers' confidence in teaching science and their attitudes toward science as a body of knowledge. While the sample size was small, the evidence supports the need for such a course and predicates the need for further research. The evidence also supports the need for experiences necessary for these preservice teachers to overcome their discomfort in being required to teach content for which they do not feel they are fully prepared. One student, who admitted trepidation in taking a college science course, shared her personal experience:

> "I feel very confident in understanding scientific concepts after taking this course. I was a little nervous when I came into this class because I didn't have stellar science teachers in high school. My participation in this course has really helped clarify misconceptions and helped me better understand scientific concepts."

This course encouraged students to uncover their own science misconceptions and share uncertainties concerning science and science education, while allowing them to experience the mastery of science content through discovery, inquiry, and collaborative laboratory experiences. The requirement of this course for training future elementary science teachers is important to the future of elementary science students. It is the responsibility of elementary teacher preparation programs to produce teachers who are prepared to be effective and confident teachers in all content areas, including science. Therefore, it is essential that teacher preparation programs include college science courses designed to teach content that is specific to elementary science standards and that also improve science teacher self-efficacy and attitudes toward science. The lack of inclusion of such courses essentially affects not only preservice teachers, but also all elementary students who they have the opportunity to teach. There can be no weak link in science education; the preparation must begin in the elementary schools with a solid foundation in science.

Future research should track the freshman and sophomore preservice teachers involved in this study and determine whether the improved science teaching efficacy and confidence toward teaching science continue through the elementary science methods course taken during the junior year. Studies should also include measuring the impact of the science content course on the preservice teachers' ability to apply the information, both content and modeled pedagogy, learned during the science content course. The success of this course in improving science teaching efficacy and confidence toward teaching science will only be impactful if it continues throughout these preservice elementary teachers' careers.

References

Appleton, K. (2003). How do beginning primary school teachers cope with science? Toward an understanding of science teaching practice. *Research in Science Education*, *33*(1), 1–25.

Bergman, D. J., & Morphew, J. (2015). Effects of a science content course on elementary preservice teachers' self-efficacy of teaching science. *Journal of College Science Teaching, 44*(3), 73-18.

Britner, S. L. & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*(5), 485-499.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E Instructional Model: Origins, effectiveness, and applications; Executive Summary*. Colorado Springs, Colorado: BSCS. Retrieved from http://www.bscs.org

Cobern, W. W., & Loving, C. C. (2002). Investigation of preservice elementary teachers' thinking about science. *Journal of Research in Science Teaching, 39*, 1016–1031.

Enochs, L., & Riggs, I. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90*, 694-706.

Fidler, C. (2012). College science for preservice elementary teachers: What is the best approach? *Journal of College Science Teaching, (42)*2, 16-17.

Fones, S. W., Wagner, J. R., & Caldwell, E. R. (1999). Promoting attitude adjustments in science for preservice elementary teachers. *Journal of College Science Teaching, 28*(4), 231.

Hechter, R. P. (2011). Changes in preservice elementary teachers' personal science teaching efficacy and science teaching outcome expectancies: The influence of context. *Journal of Science Teacher Education*, *22*, 187-202.

Howitt, C. (2007). Pre-service elementary teachers' perceptions of factors in an holistic methods course influencing their confidence in teaching science. *Research in Science Education, 37,* 41-58.

Keeley, P. (2005-09). *Uncovering Student Ideas in Science* (Vol. 1-4). Arlington, VA: NSTA Press.

National Research Council. (2005). *America's Lab Report*. Washington, DC: National Academy Press. Retrieved from www.nap.edu/catalog/11311/americas-lab-report-investigations-in-high-school-science

National Science Teachers Association. (2003). *Standards for Science Teacher Preparation*. Retrieved from https://www.nsta.org/preservice/docs/NSTAstandards2003.pdf

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states.* Washington, DC: The National Academies Press. Retrieved from http://www.nextgenscience.org/

Palmer, D. H. (2011). Sources of efficacy information in an inservice program for elementary teachers. *Science Education, 95*(4), 577-600.

Reisert, P. S., & Kielbasa, M.E. (1999). Improving science education for future teachers. *Journal of Research in Science Teaching, 52*(5), 710-734.

Steinberg, R., Wyner, Y., Borman, G., & Salame, I. I. (2015). Targeted courses in inquiry science for future elementary school teachers. *Journal of College Science Teaching, 44*(6), 51-56.

Tessier, J. (2010). An inquiry-based biology laboratory improves preservice elementary teachers' attitudes about science. *Journal of College Science Teaching, 39*(6), 84-90.

Texas Education Agency. (2009). *Texas essential knowledge and skills for science, chapter 112, subchapter a., elementary*. Retrieved from http://ritter.tea.state.tx.us/rules/tac/chapter112/

van Aalderen-Smeets, S. & van der Molen, W. (2015). Improving primary teachers' attitudes toward science by attitude-focused professional development. *Journal of Research in Science Teaching, 52*(5), 710-734.