European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available on-line at: www.oapub.org/edu

10.5281/zenodo.159471 Volume 2 | Issue 6 | 2016

PRESERVICE TEACHERS' ALTERNATIVE CONCEPTIONS OF SCIENCE AND THEIR SELF-EFFICACY BELIEFS ABOUT SCIENCE TEACHING

Isil Koc[1i], Robert E. Yager[2]
[1]Istanbul University, Istanbul, Turkey
[2]The University of Iowa, IA, USA

Abstract:
This study was mainly conducted to investigate the extent to which preservice teachers held alternative conceptions in fundamental elementary science concepts from earth/space, life and physical sciences along with their self-efficacy beliefs about science teaching. This study also examined the potential relationship between the numbers of alternative conceptions held by preservice teachers and their self-efficacy beliefs about science teaching. Eighty-six preservice elementary education majors enrolled in the four sections of the science methods courses offered in a large Midwestern university in US participated in this study. Data were collected through the use of Alternative Conceptions in Science Instrument, Science Teaching Efficacy Belief Instrument- Form B (STEBI-B), and a participant information form. The results from the alternative conception instrument indicated that the majority of preservice elementary teachers (67.4%) held a number of alternative conceptions, mostly in the physical science followed by earth/space, and then life science. On the other hand, the analysis of the self-efficacy instrument revealed generally positive self-efficacy beliefs. Findings from the study also confirmed that science courses completed in high school and college do not seem to have influenced participants' numbers of alternative conceptions regarding earth/space, life and physical sciences and self-efficacy beliefs about science teaching. Overall, the results of the study regarding self-efficacy beliefs suggest that more consideration should be given to identifying and modifying the alternative conceptions of science so that teachers can better help their students to arrive at more accurate conceptions.

[i]Correspondence: Isil Koc, Ph.D., Science Education, Hasan Ali Yucel College of Education, Istanbul University, 34470 Vefa, Istanbul-Turkey, E-mail: isilkoc@istanbul.edu.tr

Keywords: alternative conceptions; self-efficacy; preservice teachers; science teaching; teacher education

1. Introduction

Teachers and teaching quality are often considered the most critical elements of student success in learning science. In particular, what the teacher knows and can do in the classroom is the most important factor resulting in student accomplishments (Wong, 2004). However, just as for elementary students, many elementary teachers simply do not enjoy science and do not feel comfortable teaching it (Vaidya, 1993). In addition, elementary teachers do not always feel that the science curriculum is a high priority (Tilgner, 1990). And when it is addressed in the classroom, it is often not taught in a way that enhances and encourages students' achievement (Riggs, & Enochs, 1990). Jarett (1998) assumed that science education is more than just a set of activities and there are many things a teacher needs to know in order to teach science effectively. According to Tosun (2000), lack of content knowledge is one of the main obstacles to teaching science effectively in elementary schools.

Teacher content knowledge is an essential element in the learning process (Haidar, 1997). While the No Child Left Behind (NCLB) Act of 2001 emphasized the need for increased content knowledge of teachers for teaching science effectively, preservice and inservice elementary teachers have generally been found to possess a lack of conceptual and factual science information (Brown, & Schwartz, 2009; Trend, 2000) as well as inadequate skills in the content area of science (Ellis, 2001). Furthermore, besides little understanding of basic concepts of science it has been shown that elementary teachers hold alternative conceptions for a variety of science concepts (Atwood, & Atwood, 1995, 1996; Brown, & Schwartz, 2009; Burgoon, Heddle, & Duran, 2011; Dove, 1996; Kikas, 2004; Petcovic, & Ruhf, 2008; Preece, 1997; Schoon, 1995; Schoon, & Boone, 1998; Sodervik, Mikkila-Erdmann, & Vilppu, 2014; Stocklmayer, & Treagust, 1996; Trend, 2000, 2001; Trumper, 2003).

Beyond lack of science content knowledge, attitudes and beliefs held by elementary teachers toward science and science teaching play a critical role in shaping the patterns of instruction that they use and which also become critical elements in the achievement of scientific literacy for all students (Ritter et al., 2001). In particular, elementary teachers who judge their own abilities to be lacking in science teaching (belief) accordingly develop a dislike for science teaching (attitude) (Riggs, & Enochs, 1990). As a result, this strong relationship between attitudes and beliefs affects behavior patterns among elementary teachers with regard to science and science teaching. As

Bandura (1977) stated, teachers' beliefs are possible contributors of behaviour patterns with respect to confidence and self-efficacy. The teachers who do not believe in their abilities to teach science (low self-efficacy) and have doubts about students' abilities to learn science (low outcome expectancy) may result in avoiding their science instruction whenever possible. Therefore, it is assumed that efficacy beliefs are potentially powerful variables, which ultimately influence both the amount of instructional time teachers spend on science as well as the resulting achievement students attain in science at the elementary school level (Enochs et al., 1995).

The reasons for the reluctance to teach science in terms of poor attitudes and lack of confidence have been attributed to elementary teachers' low level of science content knowledge (Bleicher, & Lindgren, 2005; Smith, 2000). In particular, Arambula-Greenfield and Feldman (1997) assumed that strong conceptual level of knowledge in teaching science contents favourably affects elementary teachers' belief and attitudes. Strong science content knowledge relates to higher levels of science teaching self-efficacy beliefs (Ginns, & Watters, 1999; Riggs, 1995). Additionally, it helps establish higher levels of science teachers' self-efficacy beliefs by reducing anxiety about science teaching and promoting more positive attitudes toward science (Czerniak, & Chiarelott, 1990).

The continued correlation between interest in science and the number of science courses successfully completed perhaps reflects an enduring interest in science that induced some preserves teachers to take more science courses in college. Although content knowledge has been mentioned as a factor affecting teachers' attitudes and beliefs, some previous researches have mentioned some doubts concerning the notion that completing more science courses help preservice teachers become more positive about teaching science (Feistritzer, & Boyer, 1983; Shrigley, 1974; Skamp, 1989; Stephans, & McCormack, 1985). Surprisingly, some recent studies have also refuted the idea that more science knowledge results in more positive attitudes and more accurate beliefs regarding science teaching (Bleicher, & Lindgren, 2005; Jarrett, 1999).

Considering these concerns, the present research effort focuses on the relationships that might exist between the beliefs held by preservice elementary teachers regarding their abilities to affect science and science learning among elementary students and their personal levels of science understanding. As Stevens and Wenner (1996) assumed, research directed toward better defining links between content knowledge and beliefs might provide further impetus for developing curricula that will more adequately serve to prepare elementary teachers.

2. Purpose

The purpose of this study was to investigate the preservice elementary teachers' scientifically accurate and alternative conceptions with respect to selected earth/space, life and physical science concepts. This study also examined preservice elementary teachers' self-efficacy beliefs about science teaching. Finally, an emphasis is placed upon exploring the relationship between these two issues.

The main research questions addressed in this study were:

(1) What alternative conceptions do preservice elementary teachers hold with regard to fundamental earth/space, life and physical science concepts?
(2) In which of the areas of science (i.e. earth/space, life and physical) do preservice elementary teachers have more alternative conceptions?
(3) How are the differences in the number of alternative conceptions held by preservice elementary teachers related to preservice elementary teachers' self-reported choices concerning the number of high school/college science courses completed?
(4) What self-efficacy beliefs do preservice elementary teachers express about the teaching science?
(5) How are the subcomponents of the Science Teaching Efficacy Beliefs Instrument related to preservice elementary teachers' self- reported choices concerning the number of high school/college science courses completed?
(6) Do relationships exist between the number of alternative conceptions that preservice elementary teachers bring to a science methods course and their science teaching self-efficacy beliefs?

3. Methods

3.1 Research Design

This study is descriptive in nature and the survey method was used to determine the alternative conceptions and self-efficacy beliefs of preservice elementary teachers within the quantitative research approach. In particular, survey method is a research approach that aims to describe a situation that existed in the past or still existing as it is (Cohen, & Manion, 1994).

3.2. Participants

The sample of this study consisted of 86 preservice elementary teachers, who were enrolled in four sections of the science methods courses offered in a large Midwestern

university in US. The majority of the participants in the study were undergraduates (97.7%), specifically juniors (20.9%) and seniors (76.8%) in college, who had completed a substantial portion of the science coursework required by their respective programs and would be student teaching for one full academic year or for one full semester (90.7%). The ages of participants ranged from 19 (2.3%) to 35 (1.2%) with an average age of 21 (50.0%). The majority of the participants (94.2%) in the sample were Caucasian (non-Hispanic) (94.2%). There were 81 females (94.2%) and five males (5.8%). Given that over 94% of the participants in this study were females and Caucasian, no attempts were made to compare and differentiate results by gender and ethnicity. Number of science courses that participants completed in high school ranged from one to seven, and in college, from one to eight. In particular, 3 (3.5%) participants completed two or fewer science courses, 54 (62.8%) participants completed three or four courses, and 29 (33.7%) participants completed five to seven courses during high school. On the other hand, the number of science courses completed in college by participants was fewer than in high schools. Curiously, 35 (40.7%) participants completed two or fewer science courses, 41 (47.7%) participants completed three or four courses, and 10 (11.6%) participants completed five to eight science courses in college. These demographic variables were applied as grouping variables to test for possible effects on changes in alternative conceptions.

3.3 Data Collection

Data for the study were collected during the first week of the classes by both the researcher and instructors. At first, preservice elementary teachers completed a brief information form. Participants then completed the Alternative Conceptions in Science Instrument (Schoon, & Boone, 1998), and the STEBI-B (Enochs, & Riggs, 1990). An explanation of directions and completion of these instruments required an average of 40 minutes. Classes were scheduled for a minimum of 50 minutes, so the participants felt no constraints. Permission to utilize class time was arranged in cases where the course instructors' schedules permitted the use of a minimum of 50 minutes in length of class time. Despite the fact that participation in the study was voluntary, all preservice elementary teachers (100 %) volunteered to participate in the collection of quantitative data.

3.4 Instruments

3.4.1 Participant Information Form (PIF)

The PIF was used to gather detailed information about preservice elementary teachers so that their responses to the other instruments could be better comprehended. The

form consists of questions including gender, age, ethnicity, grade level, area of specialization, and intended time for student teaching. In addition, quantity of science courses regarding semester hours and credits that each of the preservice elementary teachers completed both in high school and college were requested to see if there was a relationship between the number of courses and the preservice elementary teachers' knowledge of selected science concepts and their science teaching efficacy beliefs.

3.4.2 Alternative Conceptions in Science Instrument

The Alternative Conceptions in Science Instrument (Schoon, & Boone, 1998) was selected to provide information on preservice elementary teachers' knowledge of core concepts that would be covered in most science curricula of elementary schools. This instrument was mainly designed to identify elementary level teachers' common alternative conceptions in science. The instrument mainly consists of 12 multiple-choice items covering independent concepts in the earth/space, life and physical sciences described in the National Science Education Content Standards for elementary level students. The earth/space science area contains six items and tests understanding of concepts that deals with moon, earth and sun relationships concerning seasonal changes; sun rising and setting; lunar phases; the position of planets in the night sky; it also deals the properties of earth minerals; and the geologic time scale. The life science consists of two items and covers such concepts as the plants; and the circulatory system. The physical science domain includes four items. Concepts investigated in these items deals with force and motion considering the position and motion of objects and acceleration of falling bodies; mass; and electricity. Each question includes four possible answers to select from. The answer choices consist of one scientifically accurate response, one common alternative conception that was identified by previous research, and two reasonable and plausible distracters to make a total of four responses for each question. To establish inter-rater reliability, two science educators were asked to choose the scientifically accurate concept in each instrument item. Their responses were then compared to those of the test authors. Inter-rated reliability indicated a correlation coefficient of 1.000 for each of the 12 items indicating that each item on the instrument includes a scientifically acceptable response as stated by the authors.

3.4.3 Science Teaching Efficacy Beliefs Instrument (STEBI-B)

The STEBI-B (Enochs, & Riggs, 1990) was selected to provide information on preservice elementary teachers' self-efficacy beliefs about teaching science. STEBI-B was developed specifically for preservice teachers (Riggs, & Enochs, 1990). It is mainly a five-choice, Likert-type instrument with 23 statements. Responses for each statement range from

"Strongly Agree" to "Strongly Disagree". Thirteen of the items (1, 2, 4, 5, 7, 9, 11, 12, 14, 15, 16, 18, and 22) are positively written and receive a score of 5 if "Strongly Agree" is marked and a score of 1 if "Strongly Disagree" is chosen. On the other hand, 10 of the items (3, 6, 8, 10, 13, 17, 19, 20, 21, and 23) are negatively written and for these items the scoring is reversed: "Strongly Disagree" receives a score of 5 while "Strongly Agree" is scored with a 1.

STEBI-B is divided into two subscales that were consistent with the theory of social learning by Bandura (1977), and applied to science teaching by Gibson and Dembo (1984). These are "Personal Science Teaching Efficacy" (PSTE) scale containing 13 items (2, 3, 5, 6, 8, 12, 17, 18, 19, 20, 21, 22, 23) and "Science Teaching Outcome Expectancy" (STOE) scale containing 10 items (1, 4, 7, 9, 10, 11, 13, 14, 15, 16). The first subscale (PSTE), which measures teachers' beliefs about their own capabilities to teach science, is based on statement such as: "I will continually find better ways to teach science." The second subscale (STOE), which measures teachers' ability to affect science learning, is based on statements such as: "Students' achievement in science is directly related to their teacher's effectiveness in science teaching." Possible scores on the PSTE subscale range from 13 to 65 and STOE scores may range from 10 to 50. High scores on the PSTE indicate a strong personal belief in one's own ability to teach science and high scores on the STOE indicate high expectations with regards to the outcomes of science teaching. STEBI-B was reported as a valid and reliable instrument for measuring science teaching self-efficacy among preservice elementary teachers. Reliability analysis produced the Cronbach's alpha coefficient of .90 for the PSTE subscale, and the Cronbach's alpha coefficient of .76 for the STOE subscale. Within this study, reliability for the sample of 86 preservice elementary teachers was established for the STEBI-B. Resultant Cronbach's alpha coefficient was .88 for the PSTE subscale and .71 for the STOE subscale.

3.5 Data Analysis

In this study, the Statistical Package for the Social Sciences-X (SPSSx, Inc., 1988) was utilized for the purpose of the quantitative data analysis. At first, frequency distributions were both calculated with respect to the Alternative Conceptions in Science and the STEBI-B responses. Frequency distributions of demographic information were also used to investigate whether participants' responses to the other instruments could be better comprehended.

Preservice elementary teachers' self- reported choices concerning the number of high school/college science courses completed with their number of alternative conceptions and science teaching efficacy beliefs including the two subcomponents of

the STEBI-B were investigated using a one-way analysis of variance and a Pearson Product-Moment Correlation Coefficient. A Pearson Product-Moment Correlation Coefficient was also computed to determine the extent of relationship between the number of alternative conceptions in science that are held by preservice elementary teachers and their self-efficacy beliefs toward teaching of science, including the two subcomponents of the STEBI-B.

4. Results

As mentioned in the methodology section, all 86 preservice elementary teachers completed the 12-item-multiple-choice test with respect to selected earth/space, life and physical science concepts. Analysis of the results showed that the preservice elementary teachers had some common alternative conceptions regarding earth/space, life and physical science concepts. Table 1 illustrates the percent of participants who identified common alternative conceptions on the alternative conception instrument.

Table 1: Common alternative conceptions held by participants N=86

	Alternative Conceptions (Item No.)	Participants with Alternative Conceptions (%)
1.	Summer occurs when the earth is nearer to the sun. (1)	97.0
2.	The sun is straight up at noon every day (as seen from their own latitude). (2)	88.4
3.	The earth's shadow causes the phases of moon. (3)	83.7
4.	Heavier balls fall faster than similar lighter balls. (10)	76.7
5.	Blood flowing through human veins is blue. (8)	75.6
6.	Rusted iron weights less than the iron weighed before rusting. (11)	58.1
7.	Any crystal that scratches glass is a diamond. (5)	55.8
8.	Objects dropped from airplanes hit the ground immediately below the point where they were dropped. (9)	48.8
9.	Venus, Mars, and Jupiter can only be seen with the telescope. (4)	46.5
10.	Electric currents in a circuit follow a one-path beginning at a battery and ending at a light bulb. (12)	41.9
11.	Plants get their food from the soil. (7)	18.6
12.	Dinosaurs lived at the same time as cave-men. (6)	5.8

Participants in the study identified a range of 3 (1.2%) to 12 (1.2%) alternative conceptions, which included both common alternative conceptions and distracter responses that were not scientifically accurate, and a range of 0 (1.2%) to 9 (1.2%) scientifically accurate responses on the test. Based on these results, the median score for

the sample was 4.00 (answered accurately) and the standard deviation was 1.55. Characteristics of the individual instrument items are listed in Table 2.

In addition to the common alternative conceptions presented in Table 1, some distracters, which are also not scientifically accurate, were chosen on the test by some preservice elementary teachers. Some examples of the highest percent of distracters included:

- Objects dropped from a flying airplane will hit the ground behind the spot directly below the point where it was dropped (20.9%). (Item 9)
- Rusted iron weights the same as the iron that it came from (14.0%). (Item 11)
- Electric currents in a circuit follow a straight path from each end of a battery (9.3%). (Item 12)

Table 2: Descriptive statistics for individual items of the alternative conceptions instrument N=86

Item Number	Number of Correct Response(s)	Number of Common Alternative Conceptions	Number of Distracter Response(s)
1	1	84	1
2	8	76	2
3	13	72	1
4	44	40	2
5	38	48	0
6	81	5	0
7	68	16	2
8	21	65	0
9	26	42	18
10	20	66	0
11	24	50	12
12	42	36	8

In this study, among the three areas investigated, the life science area received the greatest number of correct responses with an average of 51.7%, followed by earth science (35.9%) and physical science (32.6%). Results revealed that physical science area harborred the most alternative conceptions in comparison to life science and earth/space science areas.

A series of One-way analyses of variance were executed on the data to determine whether there were significant differences in the number of alternative conceptions held by preservice elementary teachers based on participants' number of high school and college science courses that had been completed. Participant responses for the number

of science courses that they completed in high school ranged from one to seven and in college, from one to eight. In order to compare the number of alternative conceptions of preservice elementary teachers who completed fewer science courses to those who completed more science courses both in high school and college, participant responses that reported the participant information form were categorized into the three groups. The groups were defined as those who completed: one or two science courses (1); three or four courses (2); and four or more courses (3). Based on the results, no significant differences in the number of alternative conceptions that are held by preservice elementary teachers were found based on participants' number of high school (F= 1.135, p= .326) or college science (F= 1.723, p= .185) courses completed. The results suggested that completing more science courses either in high school or in college does not significantly affect the preservice elementary teachers' number of alternative conceptions with regard to fundamental science concepts in earth/space, life and physical sciences.

Individual item scores for the STEBI-B ranged from 1 to 5 and were added together to produce a total score that ranged from 57 to 92 out of a possible range of 23 to 115. As described previously, STEBI-B contains two independent subcomponents. These are: (1) personal science teaching efficacy (PSTE), which reflects teachers' beliefs in their own capabilities to teach science, and (2) science teaching outcome expectancy (STOE), which reflects teachers' ability to affect their students' science learning. Two different scores were also obtained for PSTE and STOE subscales. Participants' responses to PSTE indicated that scores ranged from 33 to 57 out of a possible range of 13 to 65 with a total means of 44.50 and a standard deviation of 5.58. On the other hand, participant responses to STOE subscale indicated scores a range from 24 to 42 out of a possible range of 10 to 50 with a total mean of 32.60 and a standard deviation of 3.80.

According to the data summarized in Table 3, the subcomponent means in this study were more favorable with the PSTE (Mean= 44.50) subscale. The mean score for individual items on PSTE subcomponent (Mean= 3.42) was high according to the five-point Likert-type scale. In comparison, the mean score was lower for the STOE subcomponent (Mean= 3.26) according to the five-point Likert-type scale.

An analysis of participants' responses on each of the 23 statements on the STEBI-B scale indicates that 18 of the individual items resulted in means above 3.00 and no items had means below 2.00. Three of the statements in the PSTE subcomponent had means above 4.00. In contrast, none of statements in the STOE subcomponent had means above 4.00. The sample demonstrated the highest means (Mean= 4.35) on item 2 of the scale -"I will continually find better ways to teach science." and the lowest means (Mean= 2.36) on item 19 -"I wonder if I will have the necessary skills to teach science."

Table 3: Data summary for participants' STEBI-B subscale scores

Subcomponent(s)	Mean	SD
PSTE (13 items)	44.50	5.58
STOE (10 items)	32.60	3.80
Total		
Science Teaching Efficacy Beliefs (23 items)	77.10	7.57
Positive Wording Statements (13 items)	44.08	4.48
Negative Wording Statements (10 items)	33.02	4.35

In order to explore the potential relationship between these two subcomponents, a Pearson product-moment correlation coefficient was generated. The developers of the STEBI-B claim to have produced an instrument capable of measuring two correlated but independent subscales with which to measure preservice teacher beliefs. Such a claim can be reasonably confirmed in this study. In particular, the subscale scores indeed produce a significant positive correlation with one another even though measure different aspect of the construct of teacher beliefs. This result is consisted in the social learning theory espoused by Bandura (1977). Besides, data of this study regarding the relationship between STEBI-B subscales and the number of science courses that completed in high school and college suggest that science courses completed in high school and college do not appear to influence preservice elementary teachers' efficacy beliefs regarding science teaching.

One of the purposes of this study was to investigate the relationship between alternative conceptions and science teaching self-efficacy beliefs. A t-test was conducted to compare STEBI-B Instrument and its subcomponents with the number of alternative conceptions held. Table 4 presents the preservice elementary teachers' mean measure of the STEBI-B based on the number of responses on the Alternative Conceptions in Science Instrument that were not scientifically accurate. There is no definitive pattern exposed in this data. But, it appears that participants who held three out of a possible 12 alternative conceptions had the highest STEBI-B measure (Mean= 92.00). But, one participant who held 12 out of a possible 12 alternative conceptions held the lowest STEBI-B measure (Mean= 57.00).

Table 4: STEBI-B mean scores by number of alternative conceptions held by participants N=86

Number of Alternative Conceptions	N	Mean	SD
0	-	-	-
1	-	-	-
2	-	-	-

3	1	92.00	-
4	2	85.50	2.12
5	3	70.67	10.02
6	22	77.36	5.46
7	14	77.93	6.07
8	20	78.85	7.10
9	18	75.89	8.80
10	4	74.50	6.35
11	1	65.00	-
12	1	57.00	-

Similarly, Table 5 presents the STEBI-B measure of participants for each subcomponent on the scale based on the number of responses on the alternative conception test that were not scientifically accurate. A more PSTE measure indicates a more strong personal belief in participant's ability to teach science and a more STOE measure indicates participant's more expectations as regards the outcomes of science teaching. The participants with the highest and the lowest STEBI-B mean also had the highest and the lowest measure for all of the two subcomponents.

Table 5: Subcomponent STEBI-B measures by number of alternative conceptions held by participants N=86

		PSTE		**STOE**	
Number of Alternative Conceptions	**N**	**Mean**	**SD**	**Mean**	**SD**
0	-	-	-	-	-
1	-	-	-	-	-
2	-	-	-	-	-
3	1	57.00	-	35.00	-
4	2	51.00	1.41	34.50	.71
5	3	41.33	5.86	29.33	4.73
6	22	45.10	3.96	32.27	3.67
7	14	44.57	4.75	33.36	4.09
8	20	45.45	5.73	33.40	3.28
9	18	43.11	6.43	32.78	4.21
10	4	43.50	5.26	31.00	1.83
11	1	36.00	-	29.00	-
12	1	33.00	-	24.00	-

A Pearson Product-Moment Correlation Coefficient was utilized to determine whether a relationship existed between the number of alternative conceptions held by preservice elementary teachers based on their responses to the Alternative Conception in Science

Instrument and their science teaching efficacy beliefs based on their responses to the STEBI-B. It was expected that if a relationship did exist, it would be a negative or inverse relationship meaning that the higher the number of alternative conceptions held the lower STEBI-B scores or the lower the number of alternative conceptions in science held the higher STEBI-B scores.

Table 6 presents the correlation coefficients of participants' STEBI-B scores and the number of alternative conceptions. While, there is no significant relationship between the participants' number of alternative conceptions and the STOE scores, there is a significant inverse relationship at the .05 level between the participants' number of alternative conceptions and the total STEBI-B and PSTE scores.

Table 6: Correlation coefficients of participants' STEBI-B, PSTE, STOE scores and number of alternative conceptions N=86

STEBI-B and Subcomponents	Number of Alternative Conceptions
STEBI-B	-.257*
PSTE	-.286*
STOE	-.094

*Correlation is significant at the .05 level (2-tailed).

5. Conclusion, Discussion and Implications

It has been exposed previously that elementary teachers hold alternative conceptions for a variety of science concepts. The preservice elementary teachers who participated in this study held many of the same common alternative conceptions that had been identified and reported in the earlier studies. Analysis revealed that out of a possible 12 correct responses on the test, the relatively low mean score of 4.49 was found. In particular, all of the preservice elementary teachers held three or more alternative conceptions despite the fact that most had completed one or more science content courses. Examples of some common alternative conceptions were presented in Table 1. For instance, in one of the items, preservice elementary teachers were asked about the color of venous blood within the human body. The desired response was "dark red". However, only 24.4 % of the participants answered this item correctly. Over half of the participants (75.6%) believed that "blood inside the body is blue." When asked why it is warmer in the summer, a majority of participant (97.7%) selected the incorrect answer that "because the earth is nearer to the sun in the summer." Only 1.2% chose the correct response. Another common alternative conception found in this study was the acceleration of falling objects. Of the participants, 76.7% claimed that "heavier objects would hit the floor sooner than the lighter one." These results advocate that the

majority of preservice elementary teachers did not obtain a satisfactory understanding of basic science concepts. In general, over half of the preservice elementary teachers in this study entered a science methods course with alternative conceptions of science concepts regarding seasonal changes, sun rising and setting, lunar phases, hardness of minerals, the function of blood, the effect of rust on mass, the laws of motion and the path of electricity. To a lesser extent, preservice elementary teachers also maintained alternative conceptions regarding the positions of planets in the night sky, how plants obtain food, and the existence of dinosaurs in relationship to humans on geologic time scale. Concepts within each area of science were also examined in this study. Research of alternative conceptions held by preservice and inservice elementary teachers revealed that alternative conceptions are common particularly in earth/space and physical sciences (Schoon, 1995).

The results of the data analysis suggested that preservice elementary teachers harbor alternative conceptions mostly in physical science area followed by earth/space and then life science. The presence of unchanged alternative conceptions is a situation that researchers and educators need to think about it. Why do preservice elementary teachers who will be elementary teachers in the near future continue to keep these ideas and why are educators not helping them eliminate their alternative conceptions? Unfortunately, the results are still consistent with early findings of the McCormick (1989) and the National Science Teachers Association (1989) that elementary teachers do not possess adequate science backgrounds or even a basic knowledge of science concepts. The items on the Alternative Conceptions in Science Instrument were designed to evaluate knowledge of core concepts that would be covered in most elementary science curricula. These negative findings are particularly alarming. Despite the great amount of work done in the past years to identify common alternative conceptions and to devise means of dealing with alternative conceptions in the classroom, students are still leaving high school and college science courses carrying many alternative conceptions with them. If the preservice teachers do not understand elementary science concepts, do not have proper knowledge, how can they be expected to teach their students and what conceptions are they entrenching by their lack of understanding. Because if these preservice teachers have alternative conceptions and they carry them into their own classrooms, then they will never be able to convey the right information to their students. Therefore, teacher educators should give more attention towards elimination of these and other alternative conceptions of the prospective teachers. As parallel to Doran's (1972) assumption, teacher educators should determine which alternative conceptions are common among preservice elementary teachers when planning science instructions.

In exploring the relationship that might exist between the number of science courses completed in high school and college and the number of alternative conceptions, analyses of data failed to show any significant relationships between these variables. Neither the number of high school science courses nor the number of college science courses completed were associated, in any way, with preservice elementary teachers' number of alternative conceptions regarding earth/space science, life science and physical science concepts. This result seems to suggest that taking more science courses would not significantly decrease preservice elementary teachers' number of alternative conceptions regarding earth/space, life and physical sciences. Stevens and Wenner (1996) suggested that the completion of traditional college science courses does not always affect students' understanding of science. Therefore, institutions, which prepare teachers, should not simply add additional science courses to elementary education programs believing these additional courses will increase the knowledge of science concepts. The number of courses may not provide the solution. The lack of science knowledge among preservice elementary teachers demonstrates the need for courses in high schools and colleges that develop an in-depth understanding of science concepts. These courses as described by McDevitt, Heikkinen, Alcorn, Ambrosio and Gardner (1993) should be taught using methods that relate concepts, avoid lecturing and memorizing, build upon what students already know, and pay attention to development of science concepts and overcome alternative conceptions.

Preservice elementary teachers' responses to STEBI–B indicate generally high levels of personal teaching efficacy and outcome expectancy. For instance, concerning the PSTE subscale, while a majority (86%) of the participants indicated a confidence in their ability to teach science effectively, 36.1% claimed to understand science concepts well enough to teach science. Participants also demonstrated a moderate level of uncertainty (29.1%) about their abilities to understanding science concepts well enough to teach science. The majority (96.5) of the participants believed that they would continuously find better ways to teach science. Similarly, 72.1% asserted that they could effectively monitor science experiments. Participants also indicated their willingness to welcome students' questions. Ninety-three per cent thought they welcomed student questions when teaching science and 45.4% felt they were able to answer such questions. These responses showed that the preservice elementary science teachers were confident in their general teaching competency, but they harbored some doubts concerning their ability to teach science at conceptual level. Furthermore, concerning STOE subscale it appeared that preservice elementary teachers were willing to assume the responsibility for students' science achievement (47.7%) because they believe that

the inadequacy of a student's science background could be overcome by effective teaching (81.4%)

The developers of the STEBI-B claim to have produced an instrument capable of measuring two correlated but independent subscales with which to measure preservice teacher beliefs. Such a claim can be reasonably confirmed in this study. In particular, the subscale scores indeed produce a significant positive correlation with one another even though measure different aspect of the construct of teacher beliefs. This result is consisted with Enoch's and Riggs's (1990) study findings and also consisted in the social learning theory espoused by Bandura (1977) indicating related but independent variables.

One might conclude that the more science preservice elementary teachers exposed to, the greater their self-efficacy beliefs. This claim is also supported by a number of studies that preservice elementary teachers should complete more science content and methods courses (Arambula-Greenfield, & Feldman, 1997; Czerniak, & Chiarelott, 1990; Ginns, & Watters, 1999; Riggs, 1995). However, Jarrett (1999) reported no relationship between the number of science courses completed by teachers and their level of understanding of science concepts, nor their attitudes and their confidence and comfort level for teaching science. Additionally, one implication from Bleicher's and Lindgren's (2005) study was that increasing the quantity of science content courses that preservice elementary teachers are required to complete may not be sufficient to overcome their reluctance to teach science if some of their learning does not take place in a constructivist environment. Data of this study regarding the relationship between STEBI-B subscales and the number of science courses that completed in high school and college suggest that science courses completed in high school and college do not appear to influence preservice elementary teachers' efficacy beliefs regarding science teaching. It might be assumed that science teacher educators should structure existing and any new courses to include experiences that make students aware of, and able to confront, their existing beliefs about their ability to teach science.

In exploring the relationship that might exist between the number of alternative conceptions that are held by preservice elementary teachers and their science teaching efficacy beliefs, analysis of data showed that those with the lowest number of alternative conceptions had relatively high STEBI-B, PSTE and STOE mean scores. In further exploration, Table 6 provides evidence of statistically significant relationships between the number of alternative conceptions and preservice elementary teachers STEBI-B and PSTE mean scores. This finding leads to the conclusion that the holding of alternative conceptions is associated with low science teaching efficacy. At this point, this study adds a new dimension to Shrigley's work (1974), which found a low

correlation between science knowledge and attitude toward science, and Stephans and McCormack's (1985) and Wenner's (1993) work, which found negative relationships between science knowledge and science teaching efficacy. Overall, the relationship may be caused by several factors. Holding of alternative conceptions may interfere with preservice elementary teachers' learning process, which may also influence their broader understanding of science. This could result in a less confident view of their own abilities to teach these particular concepts. In addition, the holding of alternative conceptions may negatively influence the subsequent learning process. It was widely believed that some people see scientific phenomena presented in science courses through the lenses of their alternative conceptions, and, consequently, they may have difficulty learning new materials related with it. To these people, science may seem confusing or incomprehensible and they may feel less able to teach science to others. A possible explanation for the observed relationship between the number of alternative conceptions and teacher's confidence in his/her ability to teach science was previously offered by Schoon and Boone (1998); they found that the holding of alternative conceptions may function as a barrier to the learning of more science, learning about science, and feeling good about one's own abilities to teach science. Most people are comfortable with their own alternative conceptions, because they believe that what they know is true. Yet, alternative conceptions, as Schoon and Boone (1998) suggested may act as critical barriers to learning more science.

The study findings, which related to alternative conceptions part, revealed that preservice elementary teachers demonstrated an inaccurate understanding of several core science concepts that are identified in the National Science Education Content Standards as key components of scientific literacy in elementary level students. In particular, over 80% of the participants in this study held alternative conceptions of concepts that require an understanding of moon-sun-earth relationships. Additionally, over 50% of the participants in the sample held alternative conceptions of all of the six concepts assessed in physical science. These results imply that, specifically, physical science and earth/space science are problems in the preparation of scientifically literate elementary teachers. The results of this study confirm Schoon and Boone's (1998) study findings that the existence of common alternative conceptions in science continues to be a considerable problem among preservice elementary teachers and must be considered by individuals involved in teacher preparation programs.

The alternative conceptions held by these preservice elementary teachers were maintained when they started a science methods course despite their experiences in primary and secondary schools and even with the completion of science content courses at the university level. Most of the participants completed at least one science content

course and a large percentage had completed over three science courses. Science education methods instructors cannot assume that preservice elementary teachers beginning a course have a solid foundation in science even if they have finished university science courses. This dilemma leaves the science methods course as one of the most important contributors to the successful preparation of elementary science teachers. The challenge that remains for science teacher educators is to help prospective elementary teachers alter the conceptions that are most likely to interfere with successful elementary science instruction. At this point, science teaching strategies must be modeled in teacher preparation programs that use preservice elementary teachers' alternative conceptions as a focal point for science learning, provide the opportunity for teachers to work directly with science materials, allow these teachers time to question and reflect on the viability of their conceptions, and give them the opportunity to discuss their ideas with others in order to change their alternative conceptions and build meaningful understanding of science concepts.

Developing self-confidence (i.e., self-efficacy) among preservice elementary teachers for teaching science is of paramount importance. Results of this study indicated that STEBI-B is a valid and a reliable instrument for studying preservice elementary teachers' beliefs about science teaching and learning. With this instrument, a more complete perspective of elementary science teaching is possible. For instance, the preservice elementary teachers who are low in STOE should receive a much different training than those who are low in PSTE. Training to increase STOE might focus on teacher expectations and their relationship to student achievement, while training to enhance PSTE should deal with improvement of teachers' actual science teaching skills.

Recognizing that there may be many causes of low self-efficacy beliefs among preservice elementary teachers with regard to science teaching, the data presented in this study may suggest that one of those causes might be holding of alternative conceptions of science. Overall, the results of the study considering the self-efficacy beliefs suggest that consideration be given to identifying and modifying preservice elementary teachers' alternative conceptions so that they could better help their own students in arriving at more accurate conceptions.

References

1. Arambula-Greenfield, T., & Feldman, A. (1997). Improving science teaching for all students. *School Science and Mathematics*, *97*(7), 377-386.

2. Atwood, V. A., & Atwood, R. K. (1995). Preservice elementary teachers' conceptions of what causes night and day. *School Science and Mathematics, 95*(6), 290-294.
3. Atwood, R. K., & Atwood, V. A. (1996). Preservice elementary teachers' conceptions of the cause of seasons. *Journal of Research in Science Teaching, 33*(5), 553-563.
4. Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavior change. *Physchological Review, 84*(2), 191-215.
5. Bleicher, R. E., & Lindgren, J. (2005). Success in science learning and preservice science teaching self-efficacy. *Journal of Science Teacher Education, 16*(3), 205-225.
6. Brown, M., & Schwartz, R. (2009). Connecting photosynthesis and cellular respiration: Pre-service teachers conceptions. *Journal of Research in Science Teaching, 46*, 791-812.
7. Burgoon, J. N., Heddle, M. L., & Duran, E. (2011). Re-examining the similarities between teacher and student conceptions about physical science. *Journal of Science Teacher Education, 22*(2), 101-114.
8. Cohen, L., & Manion, L. (1994). *Research methods in education* (4th Ed.). London: Routledge.
9. Czerniak, C. M., & Chiarelott, L. (1990). Teacher education for effective science instruction- a social cognitive perspective. *Journal of Teacher Education, 41*(1), 49-58.
10. Doran, R. L. (1972). Misconceptions of selected science concepts held by elementary school students. *Journal of Research in Science Teaching, 9*(2), 127–137.
11. Dove, J. (1996). Student teacher understanding of the greenhouse effect, ozone layer depletion and acid rain. *Environmental Education Research, 2*(1), 89-100.
12. Ellis, J. D. (2001). A dilemma in reforming science education: Responding to students' concerns or striving for high standards. *Journal of Science Teacher Education, 12*(3), 253-276.
13. Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90*(8), 694-706.
14. Enochs, L. G., Scharmann, L. C., & Riggs, I. M. (1995). The relationship of pupil control of preservice elementary science teacher self-efficacy and outcome expectancy. *Science Education, 79*(1), 63-75.
15. Feistritzer, E. C., & Boyer, E. L. (1983). *The conditions of teaching: A state by state analysis*. Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching.

16. Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 569-582.
17. Ginns, I. S., & Watters, J. J. (1999). Beginning elementary school teachers and the effective teaching of science. *Journal of Science Teacher Education, 10*(4) 287-313.
18. Haidar, A. H. (1997). Prospective chemistry teachers' conceptions of the conservation of matter and related concepts. *Journal of Research in Science Teaching, 34*(2), 181-197.
19. Jarrett, O. S. (1998). Playfulness: A motivator in elementary science teacher preparation. *School Science & Mathematics, 98*(4), 181-187.
20. Jarrett, O. S. (1999). Science interest and confidence among preservice elementary teachers. *Journal of Elementary Science Education, 11*(1), 47-57.
21. Kikas, E. (2004). Teachers' conceptions and misconceptions concerning three natural phenomena. *Journal of Research in Science Teaching, 41*(5), 432-448.
22. Kruger, C., & Summers, M. (1988). Primary school teachers' understanding of science concepts. *Journal of Education for Science Teaching, 14*(3), 259-265.
23. McCormick, K. (1989, June). Battling scientific literacy: Educators seek consensus, action on needed reforms. ASCD Curriculum Update, 1-7.
24. McDevitt, T. M., Heikkinen, H. W., Alcorn, J. K., Ambrosio, A. L., & Gardner, A. L. (1993). Evaluation of the preparation of teachers in science and mathematics: Assessment of preservice teachers' attitudes and beliefs. *Science Education, 77*(6), 593-610.
25. National Science Teachers Association (1989, May-June). *Deluge of science education reports issued: Agreed on problems and varied solutions.* NSTA Report.
26. No Child Left Behind Act of 2001, Pub. L. No. 107-110, 115 Stat. 1425-2093 (2002).
27. Petcovic, H. L., & Ruhf, R. J. (2008). Geoscience conceptual knowledge of preserves elementary teachers: Results from the Geoscience concept inventory. *Journal of Geosicence Education, 56*(3), 251-260.
28. Preece, P. F. (1997). Force and motion: Preservice and practicing secondary science teachers' language and understanding. *Research in Science and Technology Education, 15*(1), 123-128.
29. Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637.
30. Riggs, I. M. (1995, April). The characteristics of high and low efficacy elementary teachers. Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco, CA.

31. Ritter, J. M., Boone, W. J., & Rubba, P. A. (2001) Development of an instrument to assess prospective elementary teacher self-efficacy beliefs about equitable science teaching and learning (SEBEST). *Journal of Science Teacher Education, 12*(3), 175-198.
32. Schoon, K. J. (1995). The origin and extent of alternative conceptions in the earth and space sciences: A survey of preservice elementary teachers. *Journal of Elementary Science Education, 7*(2), 27-46.
33. Schoon, K. J., & Boone, W. J. (1998). Self-efficacy and alternative conceptions of science of preservice teachers. *Science Education, 82*(5), 553-568.
34. Shrigley, R. L. (1974). The attitude of preservice elementary teachers toward science. *School Science and Mathematics, 74*(3), 243-250.
35. Shrigley, R. L. (1977). The function of professional reinforcement in supporting a more positive attitude of elementary teachers toward science. *Journal of Research in Science Teaching, 14*(4), 317-322.
36. Skamp, K. (1989). General science knowledge and attitudes towards science and science teaching of preservice primary teachers: Implications for preservice science units. *Research in Science Education, 19*(1), 257-267.
37. Smith, D. C. (2000). Content and pedagogical content knowledge for elementary science teacher educators: Knowing our students. *Journal of Science Teacher Education, 11*(1), 27-46.
38. Sodervik, L., Mikkila-Erdmann, M., & Vilppu, H. (2014). Promoting the understanding of photosynthesis among elementary school student teachers through text design. *Journal of Science Teacher Education,* 25, 581-600.
39. Stepans, J., & McCormack, A. (1985, October). *A study of scientific conceptions and attitudes toward science of prospective elementary teachers: A research report.* Paper presented at the annual meeting of the Northern Rocky Mountain Educational Research Association Jackson Hole, WY.
40. Stevens, C., & Wenner, G. (1996). Elementary preservice teachers' knowledge and beliefs regarding science and mathematics. *School Science and Mathematics, 96*(1), 2-9.
41. Stocklmayer, S. M., & Treagust, D. F. (1996). Images of electricity: How do novices and experts model electric current? *International Journal of Science Education, 18*(2), 163-178.
42. Tilgner, P. J. (1990). Avoiding science in the elementary school. *Science Education, 74*(4), 421-431.
43. Tosun, T. (2000).The beliefs of preservice elementary teachers toward science and science teaching. *School Science and Mathematics, 100*(7), 374-379.

44. Trend, R. D. (2000). Conceptions of geological time among primary teacher trainees, with reference to their engagement with geoscience, history and science. *International Journal of Science Education, 22*(5), 539-555.
45. Trend, R. D. (2001). Deep time framework: A preliminary study of U.K. primary teachers' conceptions of geological time and perceptions of geoscience. *Journal of Research in Science Teaching, 38*(2), 191-221. Trumper, R. (2003). The need for change in elementary school teacher training: A cross- college age study of future teachers' conceptions of basic astronomy concepts. *Teaching and Teacher Education, 19*(3), 309-323.
46. Vaidya, S. R., (1993). Restructuring elementary and middle school science for improved teaching and learning. *Education, 114*(1), 63-70.
47. Wenner, G. (1993). Relationship between science knowledge levels and beliefs toward science instruction held by preservice elementary teachers. *Journal of Science Education and Technology, 2*(3), 461-468.
48. Wong, H. K. (2004). Induction programs that keep new teachers teaching and improving. *NASSP Bulletin, 88*(638), 41-58.