Cypriot Journal of Educational Sciences

Volume 11, Issue 3, (2016) 144-159

http://sproc.org/ojs/index.php/cjes/

Preservice teachers' alternative conceptions in elementary science concepts

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Suggested Citation:

Koc, I., & Yager, R. E. (2016). Preservice teachers' alternative conceptions in elementary science concepts. *Cypriot Journal of Educational Science*. *11*(3), 144-159.

Received July 03, 2016; revised August 07, 2016; accepted September 13, 2016.

Selection and peer review under responsibility of Prof Dr. Huseyin Uzunboylu & Assoc. Prof. Dr. Cigdem Hursen, Near East University.

Abstract

This study was conducted to investigate the extent to which preservice teachers held alternative conceptions in elementary science concepts. Eighty-six preservice elementary teachers participated in this study. Twelve preservice elementary teachers participated in follow-up interviews. Data were collected through the use of Alternative Conceptions in Science Instrument (Schoon, & Boone, 1998), a participant information form and utilization of interviews. The results indicated that the majority of preservice elementary teachers (67.4%) held a number of alternative conceptions, mostly in the physical sciences. Various sources of alternative conceptions emerged during the interviews. Findings from the study also confirmed that science courses completed do not seem to have influenced participants' alternative conceptions. Overall, the results of the study suggest that more consideration should be given to identifying and modifying of the alternative conceptions of science so that teachers can better help their students to arrive at more accurate conceptions.

Keywords: Alternative conceptions, preservice teachers, science teaching, teacher education

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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, 1996; Brown, & Schwartz, 2009; Burgoon, Heddle & Duran, 2011; Dove, 1996; Kikas, 2004; Petcovic & Ruhf, 2008; Preece, 1997; Schoon & Boone, 1998; Sodervik, Mikkila-Erdmann & Vilppu, 2014; Trend, 2001; Trumper, 2003).

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 preservice 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; McCormick, 1989; 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. For instance, 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. Additionally, Jarrett (1999) found no relationship between the number of science courses completed by teachers and their level of understanding of science concepts, nor their attitudes and confidence and comfort level for teaching science.

In response to the importance of fostering effective science teaching at the elementary level, this study was designed to investigate alternative science conceptions when preservice teachers enter a science method course. If the alternative conceptions examined in this study exist among preservice teachers, it would not be enough to concentrate on the "how-to" teach in these courses; instructors

must also focus on changing these particular alternative conceptions since they are likely to impede the preservice elementary teachers' abilities to teach science effectively in the future.

This study is important for it will not only provide information involving preservice elementary teachers' knowledge of science concepts, but will ultimately affect the quality of instruction in elementary schools. By placing the burden of improving science education on teachers and teacher education programs, it becomes important to examine alternative science conceptions. Therefore, investigation of alternative science conceptions among preservice teachers is an important key in understanding how to overcome barriers in science teaching, and to improve science teaching in elementary schools.

1.1. Purpose of the Study

The purpose of this study was to investigate preservice elementary teachers' alternative conceptions with respect to fundamental earth/space, life and physical science concepts. The study was guided by the following research questions:

(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) What are the sources of the most common science alternative conceptions that are held by preservice elementary teachers?

(4) 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?

2. Theoretical Framework

2.1. Alternative Conceptions

The term "alternative conception" has been used to describe a conception, which is inconsistent with or even contradictory to currently accepted scientific views (Atwood & Atwood, 1996; Driver & Easley, 1978; Dykstra, Boyle & Monarch, 1992; Pardhan & Bono, 2001, Zirbel, 2004). Alternative conceptions have also been referred to by researchers as "alternative frameworks" (Driver & Easley, 1978), "children's science" (Gilbert, Osborne & Fensham, 1982), "erroneous ideas" (Fisher, 1985), "intuitive ideas" (Preece, 1984), "misconceptions" (Hancock, 1940), "naïve knowledge" (Champagne, Gunstone & Klopfer, 1983)**, "**subsuming concepts or preconceptions" (Ausubel, 1968) and "prescientific conceptions" (Good, 1991). For consistency in this study, the more neutral term "alternative conceptions" was selected since the ideas are individual's mental constructs, which make sense to the individual and work for the individual to make sense of new knowledge (Pardhan & Bano, 2001).

Considering the descriptive literature from various science disciplines, alternative conceptions seem to have a number of consistent characteristics. Of these characteristics include:

- they are deeply rooted and resistant to change despite whether or not formal scientific instruction is encountered and continue into adulthood (Champagne et al., 1983; Duit & Treagust, 1995),

- they appear to serve as filters through learning new things because their variant conceptions provide a faulty foundation for the formation of new insights (Nussbaum, & Novick, 1982; Schoon & Boone, 1998),
- they differ from mistakes or errors where learners can easily recognize and change when presented with an accepted conception (Schmidt, 1997),
- they have been developed over a long period of time (Schmidt, 1997), and
- individuals are usually unaware that they possess alternative conceptions since they provide a meaningful, sensible, and coherent view of the world for that individual (Fisher, 1985; Trumper, 2001).

Science educators suggest several possible sources that could be responsible for the development of alternative conceptions. These sources appear to fall into three categories:

- naïve ideas resulting from everyday experiences and the unscientific usage of everyday language,
- incomplete and erroneous views forming as a result of incorrect concept information by the learner during formal schooling, and
- alternative conceptions that are learned when incorrect information is taught (Mak, Yip & Chung, 1999; Sanders, 1993).

In terms of a concept that is incorrectly taught, textbooks and teachers have been singled out as two possible sources of alternative conceptions. Textbooks themselves can be guilty of spreading alternative conceptions as famous physicist and Nobel Prize winner Dr. Richard Feynman remarks ".. but that's the way all the books were: They said things that were useless, mixed-up, ambiguous, confusing, and only partially correct. How anybody can learn science from these books I don't know because it's not science" (p.298). Research also supports the idea that science textbooks as a vehicle for the presentation of formal knowledge contribute to the development of alternative conceptions (Barrow, 1990; Kikas, 1998; 2004; Mayer, 2001)**.** Specifically, diagrams and models illustrated in the textbooks are used to gain a better understanding; however, if not properly constructed, they may give rise to alternative conceptions (Mayer, 2001). In addition to science textbooks, teachers themselves may serve as another major source of the development of students' alternative conceptions by unwittingly sharing their own conceptions (Groves & Pugh, 1999; Mak et al., 1999; Wandersee, Mintzes & Novak, 1994).

2.2. Alternative Conceptions Held by Preservice Teachers

In recent years, a great deal of interest in science education has been paid to the teacher alternative conceptions on specific science contents to inform teaching practice. Kagan (1992) assumed that preservice teachers, like students, bring several alternative conceptions to the study of pedagogy and that these conceptions are resistant to change. Research supports that several alternative conceptions that have been found to be common among students also exist in teachers (Burgoon, Heddle & Duran, 2011; Galvin, Simmie, O'Grady, 2015; Groves & Pugh, 1999; Sadler, Sonnert, Coyle, Smith, Miller, 2013; Trend, 2000; Wandersee et al., 1994).

Atwood and Atwood (1995) expressed that the frequency with which alternative conceptions were expressed by future teachers is a problem, which should be addressed with instructions, using models along with verbal explanations. The most likely age group to hold alternative conceptions tends to be elementary students, because they have the least experience (Trumper, 2001). In general, elementary

science teachers appear to leave their students' alternative conceptions uncorrected rather than to deal with them. Gang's (1993) in-depth interview with 24 science teachers revealed that all the teachers agreed on the view that "such alternative conceptions are very few, and it does not matter very much if we leave them uncorrected".

Holding alternative conceptions could be viewed as a lack of scientific literacy (Hazen & Trefil, 1991; Rutherford & Ahlgren, 1990) and would be a serious problem for teachers, who would be expected to help students construct scientific understandings of scientific phenomena. Thus, for preservice teachers who are preparing to be future teachers, holding alternative conceptions about concepts they are expected to teach could matter a great deal (Atwood & Atwood, 1995). Arditzoglou and Crawley (1990) proposed that preservice teachers need to have their alternative conceptions identified, examined and remediated.

3. Methods

3.1. 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.

3.2. Instruments

3.2.1. 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 science, life science, 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.

3.2.2. Participant Information Form

A Participant Information Form was used to gather detailed information about preservice elementary teachers so that their responses to the instrument could be better comprehended. The form consists of questions including gender, age, ethnicity, grade level, 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.

3.2.3. Interview Protocol

The preservice teachers for the interview were purposely selected from the four sections and interviewed by the first researcher after the administration of the questionnaires. The aims of the interviews were to gather further information and insights about trends identified in the questionnaires, and to ascertain participants' justifications of their responses to the questionnaires that examined to what extent common alternative conceptions are held by preservice elementary teachers. The interview was semi-structured so as to allow the researchers to probe for clarification, justification, extension, or to respond to the intensity of the participant's responses (Guba, & Lincoln, 1981). In particular, during the interviews participants were given the opportunity to respond to questions and to further explain their responses before the next question was asked. If answers were unclear, probing questions were used to give respondents a chance to clarify answers and to generate more accurate representations of their views. Questions, such as "Can you tell me more about that?" or "Could you clarify what you mean?" were acceptable. The interviews ranged from 30 minutes to 50 minutes in length, with an average time of 40 minutes and were audio taped for transcription and analysis.

3.3. Data Collection

Data for the study were collected during the first week of the classes by both the researchers and instructors. At first, preservice elementary teachers completed a brief information form. Participants then completed the Alternative Conceptions in Science Instrument (Schoon & Boone, 1998). An explanation of directions and completion of these instruments required an average of 25 minutes. Despite the fact that participation in the study was voluntary, all preservice elementary teachers (100 %) volunteered to participate in the collection of quantitative data. After the administration of the questionnaires, 12 preservice elementary teachers were purposely selected by the researchers for participation in further interview sessions. Selection of preservice teachers for interviews was based on the high, moderate and low scores attained on both instruments. Interviews were semi-structured and conducted by the researchers outside of class. Individual interviews lasted an average of 40

minutes. All interviews were audio-taped with the permission of the interviewees. The audio-tape records were transcribed for later analysis.

3.3. Data Analaysis

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 calculated with respect to the Alternative Conceptions in Science Instrument 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 were investigated using a One-way analysis of variance and a Pearson product-moment correlation coefficient.

For the purpose of the qualitative data analysis, participants' responses to the interview questions were transcribed and used as part of the database for this study. To discern similarities and distinctions in the data, each audio-tape record was coded systematically based on topics, themes, and issues. In this way, several categories were developed. These categories included (1) alternative conceptions about selected science concepts, and (2) sources of alternative conceptions.

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 science, life science and physical science concepts. Analysis of the results showed that the preservice elementary teachers had some common alternative conceptions regarding earth/space science, life science, 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.)	Percent of 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.

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)

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.

In order to determine the sources of some of the alternative conceptions identified on the Alternative Conceptions in Science Instrument, preservice elementary teachers, who agreed to be interviewed, were requested to further explain their responses to the selected instrument items first. Participants were then asked to respond to a number of questions to identify where their alternative conceptions may have originated from. Concepts dealing with the circulatory system, moon-earth-sun relationships, and force and motion were chosen for this investigation. These concepts were selected because of the low scores that they received and because of the numbers of respondents who selected choices that represented common alternative conceptions.

The first item selected from the Alternative Conceptions in Science Instrument was Question 8, which asked for the blood color that flows through human veins. Of the 12 participants interviewed, seven participants stated on the test that blood color was blue inside the body. When asked to explain why they believed it to be blue, the participants responded with one or a combination of the following responses:

"*When I look at my wrist and see that it is blue."*
"It's because when I first learn about the oxygenated and deoxygenated blood, I was taught that the deoxygenated blood is darker than the oxygenated blood, and in those diagrams I mean which are in our textbooks all the vessels that carry deoxygenated blood are colored blue while the vessels that carry oxygenated are colored red."

The color of blood was further explored by asking participants why blood is red rather than blue when you cut yourself. The typical response was that chemical reactions between the blood and gas cause the blood to turn from blue to red. Only five of the participants that were interviewed had correctly stated it as being composed of red cells in a straw colored liquid. Here are some examples of responses given by preservice elementary teachers during interview sessions:

"Before venous blood is exposed to air, it is exposed to air."
"Blood reacts with the oxygen in the air and turns red."
"Carbon dioxide in the air chemically combines with blood and causes it to turn red."
"Deoxygenated blood is blue, when the oxygen in the blood had been used by the muscles the blood is the deoxygenated and blue until it is pumped to the lungs where is makes contact with

oxygen, which turns it red again. This is why when you get a cut blood is red... because of the oxygen in the air."
"It was always red."

Finally, when participants were asked where they learned this information, a majority of participants stated that they learned it from the teachers and also personal experience (i.e., "when I look at my wrist and see that it is blue.") Two participants said that they received their information from the readings that oxygen reacted with blood and turned it red. Another one stated that he had learned from the diagram of the human circulatory systems in the textbooks that commonly illustrate venous blood as blue and arterial blood as red. Table 2 provides a breakdown of the responses given according to the perceived sources of the alternative conceptions.

Table 2. Sources of alternative conceptions based on interviews N= 12

	Interview concepts			
Source(s)	Circulatory system	Moon-Earth-Sun relationships	Force and motion	Total
Teacher	4	2	1	7
Textbook	7	9	3	19
Experience	8	6	1	15
Connections/Inferences	6	7	8	21

Note. Table reflects more than one source of alternative conceptions in many cases.

The second item selected from the Alternative Conception in Science Instrument was Question 1, which asked the reason why summer is warmer than winter. All 12 of the participants interviewed had stated on the test that summer is warmer than winter as because the earth is nearer the sun. When asked to explain what causes the seasons for regions of the earth that have summer, fall, winter, the earth's elliptical path around the sun was given as the reason in a general way. Following are some examples regarding this alternative conception.

"The sun is not in the center of earth's orbit, thus causing earth to be closer or farther away from the sun at different times."
"The distance of the earth from the sun causes seasons."
"Seasons depend how far we are from the sun. During the summer we are close and during the winter we are farther away."
"The earth revolves around the sun so different times of the year the different regions of the world are at a different distances from the sun that creates seasons."

In addition, four responses attributed the seasons to the tilt of the earth on its axis. Criteria for determining a scientific conception was based on the following explanation from Rutherford and Ahlgren (1990):

"The earth's one year revolution around the sun, because of the tilt of the earth's axis, changes how directly sunlight falls on one part or another of the earth. This difference in heating different parts of the earth's surface produces seasonal variation in climate." (p.38)

Even preservice elementary teachers stated earth's tilt has something to do with the seasons; unfortunately, that information did not prove to be functional for explaining the causes of seasons. A list of common responses given by participants follows:

"The Earth's tilt causes earth to be much closer to the sun at certain times of the year."
"It is caused by the tilting of the earth's axis either toward or away from the sun."

In fact, the tilt does not make any significant difference in the distance of earth to the sun. So the participants' responses were considered to include alternative conceptions. As a final point, when asked how they learned these explanations for the causes of seasons, a number of participants stated that this explanation originated from the diagrams that represent incorrect explanations of the seasonal change in most of the elementary school textbooks. In addition, the concept of the causal links between closeness to a heat source and its effect on temperature was reasoned out as the source of the alternative conception about seasonal changes. For instance, some of the participants stated their personal experience that a hand near a stove gets hot and a hand kept away from the stove is cool. So it would be expected that without refuting this logical thinking, the preservice elementary teachers would generalize this concept with respect to seasonal changes.

The final questions asked of the preservice elementary teachers interviewed concerned the concept of force and motion. Item 10 on the Alternative Conceptions in Science Instrument asked participants to predict which balls (same-sized and shaped but different weights) will hit the ground first if they are released at the same time from the same height. Of the 12 participants interviewed, 11 participants stated on the test that the heavier ball would hit the floor first. Only one participant gave the correct response stating that *"How fast something falls does not depend on its mass so both objects would fall at the same speed."* And her explanation was *"Mass does not affect the speed of falling objects, assuming there is only gravity acting on it."* The 11 out of 12 participants were inclined to say that the heavier one would hit the ground first because they presumed that *"Objects with a greater mass will fall faster". "Objects with a greater mass will fall faster"* was a common explanation among participants that represents the ancient alternative conception in which objects fall at a rate that depends on their weight. Another explanation, which is a known as a common alternative conception was *"Heavier objects exert more force."* When participants were asked how they learned these explanations, the majority of participants stated that their everyday experience tells them that. *"Memorizing without understanding", "finding physics laws unreasonable",* and the problem with *"applying physics concepts in real situations"* was also mentioned by participants as causes of leading to these commonsense concepts. Based on these explanations, it can be concluded that preservice elementary teachers made incorrect connections between the concepts that they were being exposed to even if they were constantly in contact with scientifically accurate information.

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). As revealed in Table 3, 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 science, life science, and physical science.

Table 3. Analysis of variance for number of alternative conceptions held by participants based on the number of high school and college science courses completed

Group(s)	Sum of squares	df	Mean square	F	Sig.
		NHSSC			
Between	5.470	2	2.735	1.135	.326
Within	200.018	83	2.410		
Total	205.488	85			
		NCSC			
Between	8.191	2	4.095	1.723	.185
Within	197.298	83	2.377		
Total	205.488	85			

Note. NHSSC= number of high school science courses, NCSC= number of college science courses.

5. Discussion

The preservice elementary teachers who participated in this study, held many of the same common alternative conceptions that had been identified and reported in 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 science and physical science (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.

As stated previously, a semi-structured interview was conducted with 12 preservice elementary teachers for further investigation regarding the concepts that appeared to have the most alternative conceptions surrounding them. Concepts dealing with the circulatory system, the moon-earth-sun relationship, and the force and motion were chosen for this investigation because of the low scores that they received and because the large numbers of participants who selected options that represented common alternative conceptions. Interview results revealed that there are several sources for common alternative conceptions. These sources are teachers, who pass along alternative conceptions as explanations for phenomena, textbooks that mislead students by the way information is written or portrayed, experience and first hand observations that would appear on the surface to provide explanations, and connections and inferences that are drawn from teachers, textbooks and experience. A breakdown of the responses given according to the perceived sources of alternative conceptions was provided in Table 2. It is often said that the goals of science education are to develop accurate science concepts, remedy inaccurate ones and ensure that these concepts are used properly. However, the results of the follow-up interviews supported the fact that the educational process itself contributes to the source of formation and strengthening of alternative conceptions. These findings were supported by relevant research findings in the literature (Barrow, 1990; Groves & Pugh, 1999; Kikas, 1998; 2004; Koc, 2013; Mak et al., 1999; Mayer, 2001; Wandersee et al., 1994).

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 science, life science, and physical science. Stevens and Wenner (1993) 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.

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.

6. Conclusion and Recommendations

The findings from this study 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 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. Overall, the results of the study 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

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

Arditzoglou, S. Y., & Crawley, F. E. (1990). A descriptive study of alternative life and physical science conceptions of preservice elementary teachers. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Atlanta, GA.

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.

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.

Ausubel, D.P. (1968). *Educational psychology: A cognitive view.* New York, NY: Holt, Rinehart, & Winston.

Barrow, L. H. (1990). Misconceptions of students and teachers in chemical equilibrium. *International Journal of Science Education, 13(4),* 487-494.

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.

Brown, M., & Schwartz, R. (2009). Connecting photosynthesis and cellular respiration: Pre-service teachers conceptions. *Journal of Research in Science Teaching, 46*, 791-812.

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.

Champagne, A. D., Gunstone, R. F., & Klopfer, L.E. (1983)**.** Naïve knowledge and science learning. *Research in Science and Technology Education*, *1(2),* 173-183.

Czerniak, C. M., & Chiarelott, L. (1990). Teacher education for effective science instruction- a social cognitive perspective. *Journal of Teacher Education, 41(1),* 49-58.

Driver, R. & Easley, J. (1978). Pupils and paradigms: A review of literature related to conceptual development in adolescent science students. *Studies in Science Education,* 5, 61-84.

Doran, R. L. (1972). Misconceptions of selected science concepts held by elementary school students. *Journal of Research in Science Teaching, 9(2),* 127–137.

Dove, J. (1996). Student teacher understanding of the greenhouse effect, ozone layer depletion and acid rain. *Environmental Education Research, 2(1),* 89-100.

Duit R., & Treagust D. F. (1995). Students' conceptions and constructivist teaching approaches. In B. J. Fraser, & H. J. Walberg (Eds.), *Improving science education* (pp.46-69). Chicago, IL: The University of Chicago Press.

Dykstra, D. I., Boyle, C. F., & Monarch, I. A. (1992). Studying conceptual change in learning physics. *Science Education, 76(6),* 615-652.

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.

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.

Fisher, K. M. (1985). A misconception in biology: Amino acids and translation. *Journal of Research in Science Teaching, 22(1),* 53-62.

Galvin, E., Mooney Simmie, G., & O'Grady, A. (2015). Identification of misconceptions in the teaching of biology: A pedagogical cycle of recognition, reduction and removal. *Higher Education of Social Science, 8(2),* 1-8.

Gang, S. (1993). On students' misconceptions and a "special self-regulation". *The Physics Teacher, 31(7)*, 414-418.

Gilbert, J. K., Osborne, R. J., & Fensham, P. J. (1982). Children's science and its consequences for teaching. *Science Education, 66(4),* 623-633.

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.

Good, R. (1991). Editorial. *Journal of Research in Science Teaching, 28(5)*, 387.

Groves, F. H., & Pugh, A. F. (1999). Elementary preservice teacher perceptions of the greenhouse effect. *Journal of Science Education and Technology, 8(1),* 75-81.

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.

Hancock, C. H. (1940). An evaluation of certain popular science misconceptions. *Science Education, 24(*4), 208-213.

Hazen, R. M., & Trefil, J. S. (1991) *Science matters: Achieving scientific literacy*. New York, NY: Anchor Books.

Hershey, D. R. (2004). *Avoid misconceptions when teaching about plants. American Institute of Biological Sciences, from* http://www.actionbioscience.org/education/hershey.html

Jarrett, O. S. (1998). Playfulness: A motivator in elementary science teacher preparation. *School Science and Mathematics, 98(4),* 181-187.

Jarrett, O. S. (1999). Science interest and confidence among preservice elementary teachers. *Journal of Elementary Science Education, 11(1)*, 47-57.

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27(1),* 65-90.

Kikas, E. (1998). Pupils' explanations of seasonal changes: Age differences and the influence of teaching. *British Journal of Educational Psychology, 68(4),* 505-516.

Kikas, E. (2004). Teachers' conceptions and misconceptions concerning three natural phenomena. *Journal of Research in Science Teaching, 41(5),* 432-448.

Koc, I. (2013). *Countering misconceptions*. In O. Strelova, I. Hristov, K. Mortan, P. Peeva, R. Sam, N. Sam, E. Galay, & E. Atasoy (Eds.), The science and education at the beginning of the 21st century in Turkey. Volume: 2 (pp. 439-447). Sofia, Bulgaria: St. Kliment Ohridski University Press.

Mak, S. Y., Yip, D. Y., & Chung, C. M. (1999). Alternative conceptions in biology-related topics of integrated science teachers and implications for teacher. *Education Journal of Science Education and Technology, 8(2),* 161-170.

Mayer, R. E. (2001). *Multimedia learning*. Cambridge, UK: Cambridge University Press.

McCormick, K. (1989, June). *Battling scientific literacy: Educators seek consensus, action on needed reforms.* ASCD Curriculum Update, 1-7.

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.

National Science Teachers Association (1989, May-June). *Deluge of science education reports issued: Agreed on problems and varied solutions.* NSTA Report.

No Child Left Behind Act of 2001, Pub. L. No. 107-110, 115 Stat. 1425-2093 (2002).

Nussbaum, J., & Novick, S. (1982). Alternative frameworks, conceptual conflicts and accommodation: Toward a principled teaching strategy. *Instructional Science, 11(3),* 183-200.

Pardhan, H., & Bano, Y. (2001). Science teachers' alternate conceptions about direct- currents. *International Journal of Science Education, 2(3),* 301-318.

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.

Preece, P. F. (1984). Intuitive science: Learned or triggered? *European Journal of Science Education, 6(1),* 7-10.

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.

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.

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.

Rutherford, F. J., & Ahlgren, A. (1990). *Science for all Americans*. New York, NY: Oxford University Press.

Sadler, P. M., Sonnert, G., Coyle, H. P., Cook-Smith, N., & Miller, J. L. (2013). The influence of teachers' knowledge on student learning in middle school physical science classrooms. *American Educational Research Journal*, *50(5),* 1020-1049.

Schmidt, H. J. (1997). Students' misconceptions. Looking for a pattern. *Science Education,* 81, 123-135.

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.

Schoon, K. J., & Boone, W. J. (1998). Self-efficacy and alternative conceptions of science of preservice teachers. *Science Education, 82(5),* 553-568.

Shrigley, R. L. (1974). The attitude of preservice elementary teachers toward science. *School Science and Mathematics, 74(3),* 243-250.

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.

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.

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.

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.

Stevens, C., & Wenner, G. (1996). Elementary preservice teachers' knowledge and beliefs regarding science and mathematics. *School Science and Mathematics, 96*(1), 2-9.

Tilgner, P. J. (1990). Avoiding science in the elementary school. *Science Education, 74(4),* 421-431.

Tosun, T. (2000). The beliefs of preservice elementary teachers toward science and science teaching. *School Science and Mathematics, 100(7),* 374-379.

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.

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. (2001). A cross-college age study of science and nonscience students' conceptions of basic astronomy concepts in preservice training for high-school teachers. *Journal of Science Education and Technology, 10(2),* 189-195.

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.

Vaidya, S. R., (1993). Restructuring elementary and middle school science for improved teaching and learning. *Education, 114(1),* 63-70.

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 177-210). New York, NY: Macmillan Publishing Company.

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.

Wong, H. K. (2004). Induction programs that keep new teachers teaching and improving. *NASSP Bulletin, 88(638),* 41-58.

Zirbel, E. L. (2004). Framework for conceptual change. *Astronomy Education Review, 3(1),* 62-76.