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Understanding of Basic Science Concepts: Does Taking More Science Courses Matter?

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Abstract

This study aimed to examine and compare pre-service elementary and science teachers’ understanding of basic science concepts. A total of 353 fourth-year elementary and science education majors (272 female and 81 male), from a large public university in northwestern Turkey, participated in the study. A Scientific Knowledge Test, which was compiled from the National Science Foundation’s Survey of Public Attitudes Toward and Understanding of Science and Technology, was used as the data collection instrument. Results showed that science education majors scored significantly higher on the Scientific Knowledge Test. Participants from the two programs had similar views on astrology and human evolution. Approximately 89 percent of them rated astrology as ‘scientific’ and only 24 percent endorsed human evolution. Semi-structured interviews were conducted to examine their views on these two topics. Interview findings showed that pre-service elementary and science teachers have similar misconceptions about astrology, evolution, and nature of science. It was concluded that although taking more science courses provides better understanding of basic science concepts, there are still critical misconceptions to overcome and teacher education programs need to address these issues.

1. Introduction

As the world has become more science and technology driven, it is crucial for citizens to become more scientifically literate, in order to be competitive in the international arena (National Science Foundation, 2010). It is also important for K-12 teachers to be well-equipped when providing quality science instruction in the 21st century (National Science Teachers Association, 2011). Being scientifically literate requires not only a knowledge of science, but also a knowledge of how science functions, evolves, and how it relates to society (Lederman, 1992). Scientifically literate people should be able to act in a scientific manner in everyday life, and should be able to think critically about pseudoscience and non-science (Martin, 1994). With this notion, teachers, especially science teachers, are expected to be informed about pseudoscience, such as astrology and intelligent design, when teaching the general public.

Investigating teachers’ views on pseudoscience and evolution is important, because teachers have a large-scale influence on society, and their beliefs influence their own instructional practices (Eve & Dunn, 1990; Trani, 2004).
Therefore, it might be useful to examine their understanding of scientific concepts, as well as pseudoscientific views. This study attempts to examine if increased science instruction makes any difference in pre-service teachers’ scientific knowledge, and their views on astrology and evolution.

There is a widespread acceptance of pseudoscience, such as the belief in astrology, ‘intelligent design’, and alternative cures among the public (Losh & Nzekwe, 2011; Preece & Baxter, 2000). In the 2008 Survey of Science and Technology: Public Attitudes and Understanding, 37% of Americans regarded astrology as ‘scientific’ or ‘somewhat scientific’. The percentage was lower among college graduates (22%). Fewer Americans see astrology as ‘scientific’ compared to previous years. Respondents who were more likely to perceive astrology as scientific, were less likely to understand the concept of science and inquiry (NSF, 2010). Losh and Nzekwe (2011b) reported that students, who reject pseudoscientific claims, are more often the ones who also follow scientific media (e.g. newspapers, magazines) more frequently.

As popular as pseudoscience is, evolution has been deeply unpopular in most parts of the world. The negative attitudes toward evolution, among science teachers, is a recurring problem in different countries (Curry, 2009; Deniz, Donnelly, & Yilmaz, 2008; Hokayem & BouJaoude, 2008; Kim & Nehm, 2011; Kutschera, 2008; Peker, Comert, & Kence, 2010). Few studies investigating elementary teachers’ views on evolution yielded similar results (Losh & Nzekwe, 2011a; Rice & Kaya, 2012). Among the few studies with Turkish samples, Peker and colleagues (2010) found that only 28% of the college students accepted evolution. The number is very similar to the Turkish public’s view, which is 25% (Martin et al., 2006). In another study, Deniz and colleagues (2008) found the acceptance of evolution levels to be ‘low’ among Turkish pre-service biology teachers. There are currently no studies examining Turkish elementary teachers’ beliefs about evolution, let alone comparing them with those of science teachers.

Among the reasons for rejecting evolution, religiosity (Evans, 2008; Eder et al., 2011; Hokayem & BouJaoude, 2008; Kim & Nehm, 2011) and lack of nature of science (NOS) knowledge (BouJaoudea et al., 2011; Lombrozo et al., 2008; Trani, 2004) emerge as the influential factors. In terms of education, studies found a positive correlation between the amount of formal education and the acceptance of evolution (Brumfield, 2005; Eder et al., 2011). Therefore, it was hypothesized that science education majors would have higher rates of belief in evolution. The present study aimed to examine the following questions:

1. Are there any differences between pre-service elementary and science teachers’ levels of scientific knowledge?
2. Are there any differences between pre-service elementary and science teachers’ views on astrology and evolution?

2. Method

2.1. Participants

The participants of this study were 353 fourth-year students, 202 of whom were enrolled in elementary education, and 151 were enrolled in science education programs at a large public university in Western Turkey. There were 272 females and 81 males, and the participants were at an average age of 22. After the administration of the Scientific Knowledge Test, 35 of these participants (21 from elementary education and 14 from science education programs) were selected on a voluntary basis and interviewed to elaborate on some of their answers, such as the answers regarding astrology and the theory of evolution.

Pre-service elementary teachers at the current university had taken 5 science courses throughout their 4-year program. These were: General Biology, General Chemistry, General Physics, Science Laboratory, and Science Teaching Methods. The pre-service science teachers had completed over 100 credits of science courses, including such courses as, Nature and History of Science, Genetics and Biotechnology, Astronomy and Evolution.
2.2. Data Collection and Analysis

Data was collected between 2009-2011. A 26-item Scientific Knowledge Test compiled from the National Science Foundation’s (2010) *Survey of Public Attitudes: Toward and Understanding of Science and Technology*, which is also given to a representative sample in the U.S. approximately every two years, was used as a data collection instrument. The test included life, earth and physical science questions. Nine of these questions were added to the survey in 2008. Test items were translated into Turkish and checked by two language specialists. The test was administered to a group of 30 students, before administering to the larger study group, to ensure that each item was well understood. Based on the feedback from the smaller group, minor changes were made in some of the statements. The questions were in True/False, short answer, multiple choice and open-ended formats. The highest possible score on the test was 27, with one of the open-ended items worth 2 points. The KR-20 reliability of the test was found as 0.77. For each cohort, the test was administered by the author; the test administration time was approximately 15-20 minutes.

For the purpose of the current study, the following items in the test were analyzed separately:
- *Astrology is:* (A) Scientific (B) Sort of scientific (C) Not at all scientific
- *Human beings as we know them today developed from earlier species of animals.*

For the second part of data collection, semi-structured interviews were conducted. Interviews were audio-taped with participants’ consent and were transcribed afterwards. Each interview lasted between 8-10 minutes. Interview questions were listed in the *Results* section.

All quantitative data was analyzed using SPSS-15. Descriptive statistics were computed for the Scientific Knowledge Test and responses for the astrology and evolution items. Comparative analyses were conducted through t-test and Chi-square test. Semi-structured interviews were conducted in order to receive detailed information on pre-service teachers’ views of astrology and evolution. Descriptive codes identified through the question topic revealed commonalities among responses (Bogdan & Biklen 2003). Responses were coded by two researchers and the codes resulted in the emergence of specifically defined classifications.

3. Results

As seen in Table 1, science education students received significantly higher scores (M=22.00) than the elementary education students (M=18.66) on the Scientific Knowledge Test (p < 0.001). Among elementary education majors, correct responses were below 50% on questions related to lasers, antibiotics, atmospheric pressure, and experimentation. For science education students, correct responses to all Scientific Knowledge Test items were above 50%.

<table>
<thead>
<tr>
<th>Major</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Df</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Elem. Ed.</td>
<td>202</td>
<td>18.66</td>
<td>2.77</td>
<td>351</td>
<td>11.83**</td>
</tr>
<tr>
<td>Sci. Ed.</td>
<td>151</td>
<td>22.00</td>
<td>2.41</td>
<td></td>
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** p < 0.001

Student responses for astrology and evolution were tallied as ‘1’ and ‘0’. Participants who rated astrology as ‘not at all scientific’ received 1, while others received 0. For evolution questions, respondents, who marked the statement ‘Human beings as we know them today developed from earlier species of animals’ as ‘true’, received 1 and the others received 0. Eighty eight percent of elementary and 91% of science pre-service teachers rated astrology as either scientific or somewhat scientific. These numbers are overwhelmingly high compared to 22 percent of US college graduates, who perceived astrology as being scientific (NSF, 2010). Seventy eight percent of elementary education and 70 percent of science education students did not accept the statement that humans descended from earlier animals. According to the crosstabulation Chi-square test, these percentages were not significantly different (p = 0.051). In other words, the views on astrology and evolution were similar among science education and elementary education majors.
In order to further examine participants’ responses to the astrology and evolution items, 35 participants (approximately 10% of the participants) were interviewed on voluntary basis. Of these 35 participants, 21 were from elementary education and 14 were from science education program.

Following questions were asked during the interview sessions:

1. Is astrology scientific? Why?
2. What is your position regarding evolution?
3. Have you had any instruction on evolution in school? Do you support teaching of evolution in schools?

On astrology, all but two students perceived astrology to be scientific or somewhat scientific. Some excerpts include:

“I don’t really believe in astrology but I think it is somewhat scientific because it uses scientific terminology”.

“There is a lot of research about it, it is not proven yet but moon, stars, and planets affect peoples’ mood and behavior”.

The two students, who rated astrology as ‘not scientific at all’, mentioned that they attended a workshop on astronomy:

“I think most people confuse astrology with astronomy. The difference should be emphasised at schools and people should be educated. Our professors at the astronomy workshop clearly explained the difference and told us that there is no way astrology can be scientific”.

When asked about their position regarding evolution, almost all students mentioned they reject human evolution due to their religious beliefs. Some participants stated that they do not have adequate knowledge on the topic. The lack of knowledge on evolution and nature of science (NOS) was apparent in participants’ answers, especially those of elementary education majors, such as:

“Theory of evolution has not been proven 100 percent yet, there are a lot of gaps in the theory”.

“There are not enough fossils to support the theory (evolution). There aren’t any transitional fossils, for example”.

None of the 35 participants who were interviewed received any instruction on human evolution throughout their K-12 and undergraduate education. They mentioned that their teachers always skipped that topic in school or asked them to study themselves. Science education majors received the Evolution course during their fourth year in the program. However, students indicated they never discussed topics on human evolution in this course. Most science education majors indicated that they feel ill-prepared to teach evolution and they wished to have learned more on the topic.

All but two of the participants supported the teaching of evolution in schools; however, they were wary of it, such as:

“Teachers should not be imposing anything on students, they should be objective about evolution. Rather than focusing on human evolution, they should be emphasising other aspects of evolution”.

4. Conclusions

This study examined the differences between elementary and science education seniors in their scientific knowledge, and their views on pseudoscience and evolution. Given the amount of science courses taken, it was expected that science education majors would have higher scientific knowledge scores, lower rates of belief in pseudoscience and higher rates of belief in evolution. Results showed that science education majors scored significantly higher than elementary education majors on the scientific knowledge test. However, there was no difference between majors in terms of their responses to the items related to astrology and evolution.

As highlighted by several researchers (e.g. Kallery, 2011; Losh & Nzke, 2011b; Martin, 1994), pseudoscientific beliefs have become an epidemic, which is too serious to be neglected by the scientific community. It is known that teachers carry their beliefs into their classrooms, and knowing these teachers could pass on their faulty beliefs about science and pseudoscience, is concerning - especially as young children are easily affected by
their teachers’ views (Kallery, 2011). It was clear from the interviews that prospective teachers are probably confusing astrology with astronomy, or consider astrology as a branch of astronomy. Through critically evaluating their students’ views, science educators can help understand these two terms; and also, what ‘scientific’ means and how ‘scientific method’ works.

Similar to a previous study (BouJaoudea et al., 2011), prospective teachers in this study, too, had conflicting views on evolution, religious beliefs, and teaching evolution in classrooms. Most of them stated that they reject evolution because of their religious beliefs and admitted (or indicated) that they have inadequate knowledge on the topic. Teacher education programs often fail to educate science teachers on the topic of evolution. Therefore, they hold many misconceptions regarding evolution (Smith, 2010). Evans (2008) stated that people are often confused, rather than resistant, about evolution, due to their religious beliefs; such was the case in this study. In fact, several pre-service teachers in the current study, stated that they are open to learning more about evolution in their classrooms. Interview findings showed that prospective teachers have more positive attitudes toward the aspects of evolution, which does not include humans, but includes rather plants and other animals. However, it seems that even these aspects are not being taught in Turkish K-12 public schools.

While investigating the underlying factors of pre-service teachers’ views on astrology and evolution, the current study has found that prospective teachers have inadequate knowledge of NOS. Many believed that theories should be ‘proven’ in order to be valid and widely acceptable, and that the theory of evolution lacks evidence, experimentation and ‘has not been proven’ yet. Similar findings have been reported by BouJaoudea and colleagues (2011), even for professors of science. These findings suggest that teacher education programs should focus on explicit teaching of NOS in their science courses and provide opportunities to experience and evaluate ‘real’ science.

References


