Exploring the Factors Related to Acceptance of Evolutionary Theory among Turkish Preservice Biology Teachers and the Relationship between Acceptance and Teaching Preference

Hasan Deniz
University of Nevada Las Vegas, United States

Elif Adibelli Sahin
University of Nevada Las Vegas, United States

Abstract

We explored the factors related to acceptance of evolutionary theory among preservice Turkish biology teachers using multiple regression analysis and the relationship between acceptance of evolutionary theory and preference for teaching evolution using nonparametric Kruskal-Wallis test. We found that factors such as understanding of evolutionary theory, thinking dispositions, and parents' educational level were positively correlated with acceptance of evolutionary theory and the religiosity was negatively correlated with acceptance of evolutionary theory. Religiosity was the single most important factor that explained the variance in acceptance of evolutionary theory. Preservice teachers who preferred to teach evolutionary theory had significantly higher acceptance scores than preservice teachers who preferred to teach creationism.

Keywords: evolutionary theory, preservice biology teachers, epistemological belies, thinking dispositions

Correspondence concerning this article should be addressed to: Hasan Deniz, University of Nevada Las Vegas, 4505 S. Maryland Parkway Leas Vegas NV 89154, hasan.deniz@unlv.edu

Introduction

The theory of evolution was considered one of the greatest intellectual achievements of Western science. Ruse and Travis (2009) emphasized the importance of evolutionary theory in the history of science.

> The discovery of evolution is one of the greatest intellectual achievements of Western thought, ranking with the calculus and general and specific relativity among scientific discoveries that changed indelibly how we see our world. From seeing nature as fixed forever in form and composition to seeing it as forever changing, we have been transformed utterly by discovering and understanding evolution. (p. ix)

The theory of evolution has been consistently supported by major science education reform documents as a unifying theme in biology and an important part of scientific literacy (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). Major science education organizations such as National Association of Biology Teachers (2008) and National Science Teachers Association (2003) in the United States have also

published position statements to ensure the place of evolution in biology curriculum. Despite the overwhelming support from the national science education policy documents for treating evolutionary theory as an overarching theme in biology, the standards for teaching evolutionary theory varies considerably across the states in the United States. For example, Lerner (2000) reported that only 10 states have very good-excellent evolution education standards, 14 states have good standards, 7 states have satisfactory standards, 6 states have unsatisfactory standards, and 13 states have standards that are worse than unsatisfactory.

More recently evolution has been identified as one of four disciplinary core ideas in life sciences in the Next Generation Science Standards (NGSS Lead States, 2013). Biological evolution in the Next Generation Science Standards (NGSS) includes four disciplinary core ideas:
- Evidence of Common Ancestry and Diversity
- Natural Selection
- Adaptation
- Biodiversity and Humans

The NGSS takes a learning progressions approach and describes what students need to know by the end of grades 2, 5, 8, and 12 for each component. As many states move towards adopting the NGSS, this decision adds another layer of complexity to teaching science in general and teaching evolution in particular because the curriculum materials aligned with the NGSS are yet to be developed. The NGSS are expressed as performance expectations integrating science and engineering practices, crosscutting concepts, and disciplinary core ideas. The NGSS provides an overarching framework but it does not specify curriculum. The NGSS are the policies that must be translated to curriculum and instruction. The NGSS are not actionable unless they are translated into curriculum and teachers feel comfortable in teaching the curriculum aligned with the NGSS (Bybee, 2013).

The NGSS (policy) → Curriculum → Instruction (Classroom Practice)

It is certain that evolution continues to be considered as a major or overarching idea in life sciences curriculum, but it is less certain to what extent evolution will be taught in actual classrooms even if the evolution curriculum aligned with NGSS is ready.

Despite national efforts to make evolutionary theory as an integral part of biology curriculum, the public acceptance of evolutionary theory in the United States is very similar to the public acceptance of evolutionary theory in Turkey. Both Turkey and the United States have very low levels of public acceptance of evolutionary theory compared to Scandinavian and European countries (Miller et al., 2006). Turkey has a national curriculum for all subjects. Evolutionary theory does not have a significant place in biology curriculum and it is taught briefly in an isolated manner as a last biology unit in the last year of high school education (Peker, Comert, & Kence, 2010).

National and state level science education policy documents and standards can potentially influence the curriculum and instruction in science courses. However, science teachers play a crucial role in translation of national and state level standards in actual classroom settings.

Standards endorse teaching of evolutionary theory, but biology teachers do not always focus on evolutionary theory (Aguillard, 1999; Weld & Mcnew, 1999; Moore, 2004; Randak, 2001). Rutledge and Mitchell (2002) reported that even though Indiana developed state standards for the teaching of evolution that are considered as being excellent by Lerner (2000), 43% of 552 biology teachers participated in the study avoided or briefly mentioned evolution in their classroom. It is possible to think that that certain teachers can place a special emphasis on teaching evolutionary theory even though the standards may not strongly endorse the teaching of evolutionary theory. For example, Kilic (2012) reported that some Turkish biology teachers cited personal desire and occupational satisfaction as reasons for their intentions to teach evolutionary theory despite the poor treatment of evolutionary theory in the national biology curriculum. Therefore, the teachers can be seen as a "missing link" between the scientific status of the evolutionary theory and the poor acceptance of the evolutionary theory among general public (Nehm & Schoenfeld, 2007). Biology teachers' acceptance of evolutionary theory is related to how much time they spend on teaching evolutionary theory within the classroom (Aguillard, 1999; Eve & Dunn, 1990; Shankar & Skoog, 1993). For this reason, it is important to know what factors influence biology teachers' acceptance of evolutionary theory.

Demastes, Good and Peebles (1995) described the conceptual ecology for biological evolution. Acceptance of evolutionary theory is part of this conceptual ecology, and this conceptual ecology also contains the following five components: (1) the prior conceptions related to evolution-understanding of evolutionary theory, (2) the learner's scientific orientation-the degree to which the learner organized his/her life around scientific activities, (3) the learner's views of the nature of science (epistemological beliefs about science), (4) learner's view of biological world in competitive and causal terms as opposed to aesthetic terms, and (5) the learner's religious orientation. Based on evolution education literature, we identified 5 more factors that are related to acceptance of evolutionary theory. These include students' (1) reasoning levels (Lawson & Thompson, 1988; Lawson & Weser, 1990; Lawson & Worsnop, 1992; Woods & Scharmann, 2001), (2) perceptions of the impact of the evolutionary theory (Brem, Ranney, & Schindel, 2003), (3) epistemological beliefs (Sinatra, Southerland, McConaughy, & Demastes, 2003), (4) thinking dispositions (Sinatra et al., 2003), and (5) parent's educational level (Deniz, Donnelly, & Yilmaz, 2008). A comprehensive review of the literature enabled us to identify a total of ten factors that are related to one's acceptance of evolutionary theory. Among these ten factors, understanding of evolutionary theory, epistemological beliefs, thinking dispositions, parent's education level and religious orientation easily lent themselves to quantitative measurement. Given the number of participants (n = 126), it was convenient for us to choose these five factors to explain the variance in acceptance of evolutionary theory among preservice Turkish biology teachers. In addition to these five factors we thought participants' biology self-efficacy beliefs (Baldwin, Ebert-May, & Burns, 1999) might also be related to their acceptance of evolutionary theory. We hypothesized that participants with stronger biology self-efficacy beliefs would be more likely to accept evolutionary theory. We also hypothesized that participants would be more likely to accept evolutionary theory as their years spent in the biology education program increase.

Nehm and Schonfeld (2007) suggested that the field of evolution education faces three main challenges: (a) understanding the interrelationships among cognitive, affective, epistemological, and religious factors that are related to peoples' views about evolution, (b) designing,

implementing, evaluating evolution education curriculum that reflects contemporary evolution understanding, and (c) reducing antievolutionary attitudes. This study is specifically designed to address the first challenge.

The overall purpose of this study is two-fold. First, it explores the nature of relationship between acceptance of evolutionary theory and factors such as understanding of evolutionary theory, thinking dispositions, parents' educational level, religious orientation, epistemological beliefs, biology self-efficacy beliefs, and years spent in biology education program. Secondly, it examines the relationship between preservice biology teachers' preference for teaching evolutionary theory and factors such as preservice biology teachers' acceptance of evolution, understanding of evolution, and religious orientation. Researchers separately investigated the factors that are related to acceptance of evolutionary theory and the relationships between teachers' preference for teaching evolutionary theory and factors such as understanding and acceptance of evolutionary theory, and religious orientation. This study simultaneously explores these two lines of research.

The specific research questions are as follows:
1. To what extent factors such as understanding of evolutionary theory, thinking dispositions, parents' educational level, religious orientation, epistemological beliefs, biology self-efficacy beliefs, and years spent in biology education program can explain the variance in acceptance of evolutionary theory?
2. What is the nature of relationship between preservice biology teachers' preference for teaching evolutionary theory and factors such as acceptance and understanding of evolutionary theory, and religious orientation?

Literature Review

In this section, we presented the five factors that are potentially related to the acceptance of evolutionary. We also presented a subsection that described the nature of relationship between the acceptance of evolutionary theory and teachers' preference for its teaching.

Understanding of Evolutionary Theory
Researchers came into different conclusions about the nature of the relationship between acceptance and understanding of evolutionary theory. Some researchers found no relationship between understanding and acceptance of evolutionary theory (Bishop & Anderson 1990; Demastes, Settlage Jr., & Good 1995; Brem, Ranney, & Schindel 2003; Sinatra, Southerland, McCounaughy, & Demastes, 2003) while others reported a positive relationship (Deniz et al., 2008; Johnson & Peebles 1987; Rutledge & Mitchell, 2002; Rutledge & Warden 2000). One can conclude from these studies that the relationship between understanding and acceptance is complicated.

Jensen and Finley (1997) reported that students' understanding of Darwinian evolution can be increased by using a historically rich curriculum coupled with an emphasis on student collaboration during problem solving, but they also reported that students were still using some ideas that were inconsistent with Darwinian evolution even after the instruction. Sharmann and Harris (1992) reported that secondary teachers showed a significant increase in their overall

understanding and acceptance of evolutionary theory after a 3-week institute that focused on nature of science, science content, and problems common to the teaching of evolutionary theory. Deniz and Sefcheck (2009) also found that ninth grade biology students also significantly improved their overall acceptance and understanding of evolutionary theory after an evolution unit.

Akyol et al. (2012) explored the relationship between Turkish preservice science teachers' understanding and acceptance of evolutionary theory by collecting data from 415 preservice science teachers. Akyol et al. (2012) found a positive relationship between preservice science teachers' acceptance and understanding of evolutionary theory. Akyol et al. (2012) also reported that preservice teachers' sophisticated nature of science views are positively correlated with both acceptance and understanding of evolutionary theory.

Peker, Comert, and Kence (2010) investigated the relationship between acceptance and understanding of evolutionary theory and the influences of several demographic and socioeconomic variables on acceptance and understanding of evolutionary theory. They collected data from 1098 freshman and senior undergraduate students from biology, biology education, and elementary science education departments at 11 public universities in Turkey. The findings showed a significant relationship between acceptance and understanding of the theory. They also showed that students' acceptance of the evolutionary theory was significantly related to regular access to Internet at home, mother's education level, gender, desire to know more about evolution but not by their family income, their ownership of PC, their father's education level, the high school type they graduated, and the size of the city where their university was located.

Epistemological Beliefs

Epistemological beliefs are conceptualized in different ways, but these different conceptualizations can be classified into two major categories: unidimensional epistemological beliefs models (Perry, 1999; Baxter Magolda, 1992; King & Kitchener, 1994) and multidimensional epistemological beliefs models (Hofer, 1997; Hofer & Pintrich, 1997; Schommer, 1990). Proponents of unidimensional epistemological beliefs models assume an epistemological development continuum from a dualistic objectivist view of knowledge to a more subjective relativistic view (Hofer & Pintrich, 1997). Proponents of multidimensional epistemological beliefs models challenged the view that epistemological beliefs develop from dualistic view to relativistic view by following a predictable trajectory of stages between dualism and relativism. They claimed that epistemological beliefs can best be captured more than one dimension and these dimensions differ depending upon the context (Hofer, 1997; Hammer & Elby, 2002). For example, Hofer's (1997) epistemological beliefs model have four dimensions: (a) certainty-simplicity of knowledge (e.g., truth is unchanging in science); (b) justification for knowing (e.g., I am more likely to accept ideas of someone with first-hand experience than the ideas of researchers in science); (c) source of knowledge (e.g., sometimes you just have to accept answers from the experts in science even if you don't understand them); (d) attainability of truth (e.g., scientists can ultimately get to truth). We anticipated that people with more sophisticated epistemological beliefs are more likely to accept evolution as a scientifically valid theory.

Thinking Dispositions

Thinking dispositions are related to one's degree of open-minded or reflective thinking (Stanovich & West, 1997; Sá, West, & Stanovich, 1999). Thinking dispositions indicate openness to belief change, cognitive flexibility (reflectiveness), tendency to consider alternative opinions and evidence, and searching and processing of information that goes against one's beliefs. Sinatra et al. (2003) and Deniz et al. (2008) found that thinking dispositions are related to one's degree of acceptance of evolutionary theory. Considering the findings from previous research we expected that participants who have a high degree of open-minded or reflective thinking would be more likely to accept evolutionary theory.

Parents' Educational Level

Costa (1995) underscored the importance of compatibility between school and family cultures in learning science. Both Deniz et al. (2008) and Peker et al. (2010) found that parents' educational level is related to preservice science teachers' acceptance of evolutionary theory in Turkey. However, Grose and Simpson (1982) reported that the educational level completed by the father or the occupation of mother and father did not correlate significantly with attitude toward evolution.

Religious Orientation

Researchers consistently reported negative relationship between religious orientation and attitudes toward evolutionary theory. Grose and Simpson (1982) found that students in an introductory college biology class who perceived that their church generally influenced their thought had lower attitudes toward evolution. Osif (1997) reported that that the importance of religion in biology teachers' lives is positively correlated with Biblical literalism including the rejection of the evolutionary theory. Nehm and Schoenfeld (2007) reported that religious orientation of biology teachers were significantly negatively correlated with understanding of nature of science specific to evolution and understanding of evolution.

Acceptance of Evolutionary Theory and Teachers' Preference for Its Teaching

Research indicated that teachers' subject matter knowledge influence their curricular and instructional decisions (Carlsen 199; Shulman 1987). In certain cases, subject matter knowledge is necessary but not sufficient condition for successful instruction. This general conclusion certainly holds true for the subject matter of evolution (Rutledge & Mitchell, 2002). Acceptance of evolutionary theory is a good predictor of instructional approach taken toward evolution (Aguillard, 1999; Eve & Dunn, 1990; Rutledge & Mitchell, 2002; Shankar & Skoog, 1993). In these studies, teachers who accept evolutionary theory are more likely to spend more time on it and treat it as a central organizing principle of their classes. Nehm and Schonfeld (2007) found that science teachers improved their knowledge of evolutionary theory and nature of science views as a result of 14-week intervention organized around evolutionary theory and nature of science themes, but this did not translate into higher preference for teaching evolutionary theory. Nadelson and Nadelson (2010) classified K-8 teachers' personal beliefs about evolutionary throtu into three categories as: *incompatible, unsure, and compatible*. They found that belief compatibility with evolutionary theory is related to perceptions of the importance of teaching evolutionary theory as part of the life science curriculum. In other words, teachers who accept evolutionary theory are more likely to perceive it an integral part of the life science curriculum. Kahyaoglu (2013) investigated preservice elementary teachers (K-5) and preservice science

teachers' (grades 6-8) attitudes toward teaching evolutionary theory. Kahyaoglu (2013) found that preservice teachers in both groups hold negative attitudes toward teaching evolutionary theory. Kilic (2012) compared and contrasted 12 German and 25 Turkish biology teachers' attitudes toward evolutionary theory and intentions to teach the theory. Kilic (2012) found that German teachers had higher intentions to teach evolutionary theory than their Turkish counterparts and their intention to teach evolution is primarily related to their attitudes towards evolution. German teachers thought that they were institutionally required to teach evolutionary theory, whereas Turkish teachers thought that both Ministry of Education and society did not expect them to teach evolution. Kilic (2012) reported that 6 German and 9 Turkish teachers cited personal desire and occupational satisfaction as reasons for their intentions to teach evolutionary theory.

Methodology

Participants

A total of 126 preservice biology teachers (95 female, 31 male) with a mean age of 21.5 years (ranging from 18 to 26) from a university in the western Turkey participated in the study. Participants enrolled in the same 5-year biology education program, which offered science content courses primarily during the first four years and pedagogy courses the second half of the fourth year and during the fifth year. The educational levels represented were: 28 students in year 1 (22.2 %), 26 students in year 2 (20.6 %), 16 students in year 3 (12.7 %), 25 students in year 4 (19.8 %), and 31 students in year 5 (24.6%). This particular biology education program uses a cohort model. Students all begin their courses in the fall semester and then move through the program in a set schedule so that they take courses with the same group of students each semester. Participants enrolled in the biology education program were chosen because of its convenience to the authors.

Context of the Study

This section provides a brief overview of Turkey, including its geographical location, educational system, and evolution education. Turkey, officially named as the Republic of Turkey, is a democratic and secular country located in southeastern Europe and southwestern Asia with the majority of its area occupies Anatolia. According to the last population and housing census in 2011, the total population of Turkey amounted to about 74.5 million people (Turkish Statistical Institute, 2013). There are no statistics of Turkish citizen's religious beliefs published by the Presidency of Religious Affairs and the Turkish Statistical Institute. However, the Eurobarometer Poll (2005) reported that the vast majority of the Turkish population is Muslim and declared their belief in a God. Based on the Gallup Poll in 2006 to 2008, Turkey was categorized as *More religious*, in which over 65 percent of people believe that religion is important in their daily lives (Crabtree & Pelham, 2009).

The Turkish education system consists of two main parts: formal and non-formal education. Formal education includes pre-primary education, primary education, lower-secondary education, upper-secondary education, and higher education institutions. Pre-primary education is a broad term applied to non-compulsory education for children in the age group of 3 to 5. Primary education is compulsory for every Turkish child in the age group of 6 to 13 and free of charge in state schools. Primary education institutions consist of four years of compulsory primary school and four years of compulsory lower secondary schools or middle schools. The

students who graduate from 4 plus 4 years of compulsory education continue their studies at general, vocational, and technical education institutions, based on their primary and lower secondary education. After this four-year and compulsory upper level secondary education or high school education, students have the right to take University Selection and Placement Examinations (Ministry of National Education [MoNE], 2014). Turkish primary and secondary education, recently termed as "4+4+4", follows a national curriculum prepared by Ministry of Education. Therefore, it is highly influenced by political changes in the country.

In Turkey, the evolutionary theory was first introduced into the biology curriculum as a result of Turkey's first president's initiatives to unify and secularize education system in 1920s and 1930s (Sayin & Kence, 1999). During this period, creationism and compulsory religious instruction were not present in the Turkish education system (Sayin & Kence, 1999) and evolution was covered in the first units of biology textbooks in a detailed manner (Kaya, 2013). After the 1980 military coup, approach toward teaching evolution changed dramatically. The Ministry of Education introduced creationism to the biology curriculum in 1985 (Peker, Comert, & Kence, 2010). Even though evolution was still in the biology textbooks in the mid 1980s, it was presented in a non-scientific way (Sayin & Kence, 1999).

Current state of evolution education in Turkey is not very different from that in the mid 1980s. The central theory of biology is generally presented very briefly in an isolated manner and covered as the last unit in the last year of high school education when most students are absent because of their preparation for national university entrance exam(s) (Peker et al., 2010). The national curriculum suggested the topic of "Origin of Life and Evolution" at the 12th grade through five standards (MoNE, 2013). As in secondary education, it is hard to talk about the presence of high quality evolution education in higher education institutions as evidenced by the dearth of compulsory or elective classes on evolution in the departments of biology, molecular biology and genetic, and anthropology at state and private universities in Turkey (Kaya, 2013).

Materials

The understanding of evolutionary theory, acceptance of evolutionary theory, epistemological beliefs, thinking dispositions, and biology self-efficacy measures were all translated and adapted into Turkish by the first author. These measures were validated through factor analysis by Deniz et al. (2008) in a previous study. The paper and pencil version of these measures was administered to the preservice biology teachers in each cohort at the same time during the class time. They were not asked to provide their names or any other identifier during the administration of the measures.

Demographics. Students initially responded to four demographics items, which determined the years they spent in the biology education program, their mother's educational level, their gender and their age. Mother's educational level was measured using six possible options: elementary-1, middle school-2, high school-3, college-4, masters-5, and doctorate-6.

Evolutionary theory-creationism teaching preference. Participants' preference for teaching evolutionary theory and/or creationism in schools was determined by the following question.
  a. Creationism and evolution should always be taught together in the same class

b. Only creationism should be taught in schools, not evolution.
c. Only evolution should be taught in schools, not creationism.
d. Creationism and evolution should both be taught in school, but they should be taught in separate classes.
e. Neither creationism nor evolution should be taught in schools.

Acceptance measure. Preservice biology teachers' acceptance of evolution was measured by the Measure of Acceptance of the Theory of Evolution (MATE) developed by Rutledge and Warden (1999). Participants responded to 20 items based on a 4-point Likert scale (4= "strongly agree," 3= "agree," 2= "disagree," 1= "strongly disagree"). High items ratings reflected a higher acceptance of theory of evolution. The MATE questionnaire revealed a good level of internal consistency with a Cronbach alpha value of .90.

Understanding measure. Preservice biology teachers' understanding of evolutionary theory was measured by the modified form of an existing scale. This scale consists of 21 multiple-choice questions that were used by Rutledge and Warden (2000). These 21 items were originally developed by Johnson (1985). This scale measured the following evolutionary concepts: natural selection, extinction processes, homologous structures, coevolution, analogous structures, convergent evolution, intermediate forms, adaptive radiation, speciation, evolutionary rates, the fossil record, biogeography, environmental change, genetic variability, and reproductive success. Cumulative scores were determined for the teachers' understanding of evolutionary theory based on the number of correct responses. A score of 21 represented a very high understanding of evolutionary theory, while a score of 0 indicated no understanding of evolutionary theory.

Thinking dispositions measure. Participants also completed a 41-item actively open-minded thinking (AOT) composite scale (Stanovich & West, 1997; Sá, Stanovich, & West, 1999). The actively-open minded thinking (AOT) composite scale was created by combining the following scales: flexible thinking, belief identification, absolutism, dogmatism, and categorical thinking. Preservice teachers again responded to each question using a 4-point Likert scale (4= "strongly agree," 3= "agree," 2= "disagree," 1= "strongly disagree"). High item ratings on the AOT composite indicate openness to belief change and cognitive flexibility, whereas low scores indicate resistance to belief change and cognitive rigidity (Sá, Stanovich, & West, 1999). The internal consistency of the AOT measure was satisfactory with a Cronbach alpha value of .81.

Religious orientation question. Participants' religiosity was measured by the following question:
Which of the statements below does best represent your religious position?
    a. I am not religious at all-1 point
    b. I am somewhat religious-2 points
    c. Religion is an important part of my life-3 points
    d. Religion is a very important part of my life-4 points

Epistemological beliefs measure. Students' epistemological beliefs were measured by Hofer's (1997) four-dimensional epistemological beliefs questionnaire. This measure consists of 18 items, each to be rated by students on a 1 (*strongly disagree*) to 5 (*strongly agree*) Likert

scale. This epistemological belief instrument contains four different subscales: (a) certainty/simplicity of knowledge (8 items), (b) justification for knowing (4 items), (c) source of knowledge (4 items), and (d) attainability of truth (2 items). For each of the four subscales, the items indicate the following views: certainty/simplicity of knowledge (e.g., truth is unchanging in science); justification for knowing (e.g., I am more likely to accept ideas of someone with first-hand experience than the ideas of researchers in science); source of knowledge (e.g., sometimes you just have to accept answers from the experts in science even if you don't understand them); attainability of truth (e.g., scientists can ultimately get to truth). The Cronbach's alpha values for the four subscales were .72, .57, .50, and .65, respectively. These reliability scores may seem low, but they are acceptable in epistemological beliefs research (Chai, Deng, Wong, & Qian, 2010).

Biology self-efficacy measure. Science self-efficacy beliefs were measured by an instrument which was specifically designed to measure biology self-efficacy of non-major college students (Baldwin, Ebert-May, & Burns, 1999). This measure consists of 23 items, each to be rated by students on a 1 (*not at all confident*) to 5 (*totally confident*) scale. The instrument has three dimensions: (a) methods of science (8 items), (b) generalization to other science courses and analyzing data (9 items), and (c) application of science concepts and skills (6 items). For each of the three subscales, the items indicate the following views: methods of science (e.g., How confident are you that you could read the procedures for an experiment and feel sure about conducting the experiment on your own?); generalization to other science courses and analyzing data (e.g., How confident are you that you will be successful in another science course?; How confident are you that you could analyze a set of data?); application of science concepts and skills (e.g., How confident are you that you could explain something that you learned in this science course to another person?). The reliability estimates of the subscales were good because all Cronbach's alpha values were over .90.

Data Analysis

The data analysis process involved three main steps. The first step was a preparation for further parametric and nonparametric analyses. It included the calculation of descriptive statistics such as means, standard deviations, frequency distributions, maximum and minimum scores and Cronbach's alpha values for each instrument and the control of the parametric and nonparametric test assumptions such as the normality of sampling distributions, linearity, and the shape of distributions.

The second step pertained to our research question concerning how understanding of evolutionary theory, mother's educational level, thinking dispositions, religious orientation, epistemological beliefs, biology self-efficacy beliefs, and years spent in biology education program would explain acceptance of evolutionary theory among preservice Turkish biology teachers. Multiple regression was used for this purpose. The multiple regression approach enables one to examine a relationship between a dependent variable and multiple independent variables simultaneously. It also helps one to identify how much of the variance in the dependent variable is explained by all the independent variables combined, and also to identify the unique variance explained by a single independent variable. To answer our research question we performed a hierarchical (or sequential) multiple regression. Hierarchical (or sequential) multiple regression started with a single independent variable (understanding of evolutionary theory), and

then we added other independent variables such as thinking dispositions, mother's educational level, and religiosity scores step by step to the regression model to see if the variance explained is significantly increased with the addition of each independent variable. The religiosity scores were purposefully entered into the model as the last independent variable because in his previous study the first author and his colleagues (Deniz et al., 2008) did not examine the effect of a very important variable (i.e., religion) on acceptance of evolution in the context of Turkey. Following the same sequence followed in Deniz et al's (2008) study and adding religiosity enabled us to determine unique contribution of one more independent variable to acceptance of evolution among Turkish preservice biology teachers. Contrary to our initial expectations, epistemological beliefs, biology self-efficacy beliefs, and years spent in the biology education program were not significantly correlated with the acceptance of evolutionary theory. Therefore, they were not included in the multiple regression analysis.

The third and final step was related to our research question regarding whether the distribution of evolution acceptance, understanding of evolution, and religiosity scores would be the same across the categories of evolution teaching preferences. The Kruskal-Wallis test, a nonparametric equivalent to one-way ANOVA, was used for this purpose. After a significant Kruskal-Wallis test, multiple comparisons between pairs of evolution teaching preferences were conducted using a stepwise, step-down procedure in SPSS. The procedure enabled one to reduce the number of comparisons made, thus reducing the frequency of Type I and II errors. Differences in evolution acceptance, understanding of evolution, and religiosity scores were analyzed using the nonparametric test because of a small number of samples per group.

Results

The findings of this study were presented in four sections: descriptive findings, correlations among the study variables, the findings of the parametric test (i.e., a hierarchical multiple regression), and the findings of the nonparametric tests (i.e., the Kruskal-Wallis tests).

Descriptive Findings

Means, standard deviations, and maximum and minimum of the study variables, which entered into the regression model, were calculated and presented in Table 1.

Table 1
Means, standard deviations, maximum, and minimum scores of the variables which entered in the regression model

Variable	Mean	*SD*	Maximum	Minimum
Acceptance of Evolution (MATE)	50.79	10.64	77	25
Understanding of Evolution	8.62	2.27	14	3
Thinking Dispositions (AOT)	111.76	10.65	146	82
Mother's Education Level	1.94	1.05	5	1
Religiosity	2.79	0.84	4	1

Acceptance. Preservice teachers' acceptance of evolutionary theory was measured by the MATE instrument as described in the data analysis. Recall that the MATE instrument returns a

whole-number scale ranging from 20 to 80 because the participants responded a total of 20 items on a 4-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3=Agree, and 4 = Strongly Agree). As indicated in the Table 1, the mean MATE score across participants was 50.79 (n = 120; SD = 10.64). This corresponds to an average of 2.5 per item on the MATE, which aligns with moderate acceptance. However, the MATE scores obtained from individual participants showed a wide range of acceptance. They spanned almost the entire MATE score from a low score of 25 to a high of 77. Majority of the participants (65 %) did not indicate strong agreement or strong disagreement on the evolutionary theory because their overall scores were between 41 and 59.

Understanding. Preservice teachers' understanding score was obtained by summing their correct responses to the 21 items on the corresponding scale. The mean understanding score across the participants was 8.62 (n = 126; SD = 2.27), which corresponds to less than half of the questions. According to the understanding scores from individual participants, 77 percent of them correctly answered at most 10 out of 21 questions. Moreover, overall understanding score of the participants did not exceed 14, which corresponds to 65% of the questions. These findings showed that majority of the participants did not have a solid understanding of evolutionary theory.

Thinking dispositions. The participants' thinking disposition scores were measured by summing their responses to the 41-item AOT measure on a 4-point Likert scale, with high item ratings indicating openness to belief change and cognitive flexibility. The mean thinking disposition score across participants was 111.76 (n = 120; SD = 10.65), which corresponds to an average of 2.72 per item on the AOT. This infers that on average the participants showed moderate agreement on statement indicating openness to belief change and cognitive flexibility. According to the frequency distribution, none of the participants were placed themselves at the two extremes on thinking dispositions scale.

Mother's education level. Mother's educational level of the participants was measured on a 6-point scale, with a higher number indicating a higher level of education for their mother. The mean mother's education level score across the participants was 1.94 (n = 126; SD = 1.05). This corresponds to middle school education on the scale for mother's education level. Along with the mean score, the mother's education level scores from individual participants also revealed that almost half of the mothers had only elementary education. Only six percent of the participants' mothers earned higher education degrees (undergraduate, master, and/or doctorate).

Religiosity. The participants' religiosity was measured on a 4-point scale, with a higher score indicating the importance of religion in their life. The mean religiosity score was 2.79 (n = 126; SD = 0.84). This infers that on average religion is an important part of the participants' lives. The frequency distribution for the religiosity also supported the importance of religion in our sample because only 6 out of 126 participants selected that they are not religious at all.

Correlations Among the Study Variables

Even though intercorrelations among all study variables were calculated to decide which one to enter in the regression model, due to its cumbersome nature only the variables that are significantly correlated with acceptance of evolution were presented in Table 2.

Table 2
Intercorrelations among acceptance of evolution, understanding of evolution, thinking dispositions, mother's education level, and religiosity

Measure	1	2	3	4	5
1. Acceptance of evolution	1.00				
2. Understanding of evolution	.24**	1.00			
3. Thinking dispositions	.32**	.20*	1.00		
4. Mother's education level	.30**	.04	.21*	1.00	
5. Religiosity	-.68**	-.07	-.25**	-.30**	1.00

*p<.05, **p<.01.

Knowledge and acceptance. We found a modest significant positive correlation between participants' understanding of evolutionary theory and their acceptance ($r = .24$, $p < .01$). This indicates that participants who have more knowledge about evolutionary theory are more likely to accept it.

Thinking dispositions and acceptance. Thinking dispositions were positively correlated with acceptance of evolutionary theory ($r = .32$, $p < .01$). This indicates that participants with cognitive flexibility and openness to belief change are more likely to accept evolutionary theory.

Mother's education level and acceptance. We found a significant positive correlation between mother's education level and participants' acceptance of evolutionary theory ($r = .30$, $p < .01$). It seems that mothers' education level is positively correlated with students' acceptance of evolutionary theory.

Religiosity and acceptance. Religious orientation was found to be strongly negatively correlated with acceptance of evolutionary theory ($r = -.68$, $p < .01$). This indicates that participants who stated that religion is very important part of their lives are more likely not to accept evolutionary theory.

Epistemological beliefs and acceptance. None of the epistemological beliefs subscales were significantly correlated with the acceptance of evolutionary theory. This finding was contrary to our initial expectation because epistemological beliefs about science were hypothesized to be correlated with the acceptance of evolutionary theory (Sinatra, Southerland, McConaughy, & Demastes, 2003).

Biology self-efficacy beliefs and acceptance. None of biology self-efficacy beliefs subscales were significantly correlated with the acceptance of evolutionary theory. This finding was also contrary to our initial expectations. We thought that participants with more developed biology self-efficacy beliefs would be more likely to accept evolutionary theory. Biology self-efficacy measure was designed for nonmajors, but our participants were all preservice biology

teachers. This might have caused us not to find any relationship between biology self-efficacy beliefs and acceptance of evolutionary theory.

Years spent in biology education program and acceptance. It was found that years spent in the biology education program were not related to acceptance of evolutionary theory. However, years spent in the biology education program were found to be related to understanding of evolutionary theory ($r = .35$, $p < .01$). Students who spent more time in the program were more likely to get more questions correct in multiple-choice understanding of evolutionary theory test. It can be thought that years spent in the biology education program would result in an increase in understanding of evolutionary theory, and this increase in turn would lead to a high degree of acceptance. For this reason, years spent in the biology education program might be indirectly related to acceptance of evolutionary theory.

Hierarchical Multiple Regression Findings

As indicated in the Table 3, results of multiple regression analysis indicated that understanding of evolutionary theory alone explained 5.3 % of the variance, $F(1, 125) = 7.33$, $p < .01$. Standardized regression coefficient associated with understanding of evolutionary theory is ß = .25, $p < .01$. Addition of thinking disposition to the regression model increased the variance explained. Understanding of evolutionary theory and thinking disposition together accounted for 12.2 % of the variance, $F(2, 124) = 8.94$, $p < .01$. Standardized regression coefficients associated with understanding of evolution and thinking disposition are ß = .19, $p < .05$ and ß = .28, $p < .01$, respectively. Addition of mother's education to the previous regression model further increased the variance explained. Understanding of evolutionary theory, thinking dispositions, and mother's education level together explained 17.9 % of the variance, $F(3, 123) = 9.27$, $p < .01$. Standardized regression coefficients associated with understanding of evolutionary theory, thinking dispositions, and mother's education level are ß = .19, $p < .05$; ß = .23, $p < .05$; and ß = .26, $p < .01$, respectively. Addition of religiosity to the previous model tremendously increased the variance explained. All four factors together explained 50.5 % of the variance, $F(4, 122) = 30.08$, $p < .01$. Standardized regression coefficients associated with understanding of evolutionary theory, thinking dispositions, mother's education level, and religiosity are ß = .18, $p < .05$; ß = .11, $p = .12$; ß = .10, $p = .14$; and ß = -.61, $p < .01$ respectively. In the final model, only two variables (understanding of evolution and religiosity) significantly contributed to the explanation of variance in acceptance of evolution. Although the correlation between thinking dispositions and acceptance was 0.32 and the correlation between mother's education level and acceptance was 0.30 these two variables did not significantly contribute to the regression after the addition of religiosity to the regression model. It should be noted that understanding of evolutionary theory made a significant contribution to the explanation of variance in acceptance of evolutionary theory in all regression models. Deniz et al. (2008) found that understanding, thinking dispositions, and parent's education level together only explained 10.5 % of the variance in acceptance of evolutionary theory. This indicates that religious orientation is the single most important factor related to preservice biology teachers' acceptance of evolutionary theory.

Table 3
Summary of hierarchical (or sequential) regression analyses for variables explaining acceptance of evolutionary theory

Variable	B	SE B	ß	Adjusted R^2
Step 1				.053
Understanding	1.12	.41	.25**	
Step 2				.122
Understanding	0.86	.41	.19*	
Thinking disposition	0.28	.09	.28**	
Step 3				.179
Understanding	0.87	.39	.19*	
Thinking disposition	0.23	.09	.23*	
Mother's education	2.56	.87	.26**	
Step 4				.505
Understanding	0.80	.30	.18*	
Thinking disposition	0.11	.07	.11	
Mother's education	1.04	.70	.10	
Religiosity	-7.73	.90	-.61**	

$R^2 = .053$ for Step 1; $\Delta R^2 = .069$ for Step 2; $\Delta R^2 = .057$ for Step 3; $\Delta R^2 = .326$ for Step 4.
B = Unstandardized regression coefficient; $SE\ B$ = Standard error of B; ß = Standardized regression coefficient.
*p<.05, **p<.01

Kruskal Wallis Tests Findings

  Evolution acceptance and teaching preferences. One part of our second research question was whether and/or how the acceptance of evolutionary theory varies among preservice biology teachers who had different preference for teaching evolutionary theory and/or creationism in schools. The Kruskal-Wallis test indicated a significant difference among the four categories of teaching preferences ($H = 25.84$, $p < .001$). The stepwise stepdown procedure for multiple comparisons of teaching preferences yielded in only one homogeneous subset: creationism and evolution together and creationism and evolution in separate classes. This means that there was no significant difference in the distribution of evolution acceptance scores between teachers who preferred to teach creationism and evolution together and those who preferred to teach them in separate classes ($p = .24$). However, teachers who preferred to teach only creationism in their classrooms had significantly lower evolution acceptance scores than those who preferred to teach both creationism and evolution. Moreover, teachers who preferred to teach only evolution in their classrooms had significantly higher evolution acceptance scores than those who preferred to teach both creationism and evolution. The Figure 2 represents the mean total evolution acceptance score of each teaching preference. According to the figure, the mean total score on the MATE was 38.44 out of 80 for teachers who preferred to teach only creationism in their schools ($n = 9$, $SD = 4.42$). This corresponds to an average of 1.9 per item on the MATE, which aligns with "Disagree" on the Likert scale. This implies that on average teachers who preferred to teach only creationism in their schools did not accept the theory of evolution. Supportively, the mean total score on the MATE for teachers who preferred to teach only evolution in their schools was 61.43 out of 80 ($n = 15$, $SD = 12.23$). This corresponds to an average of 3.1 per item on the MATE, which aligns with "Agree" on the Likert scale. This infers

that on average teachers who preferred to teach only evolution in their schools also accepted the theory of evolution.
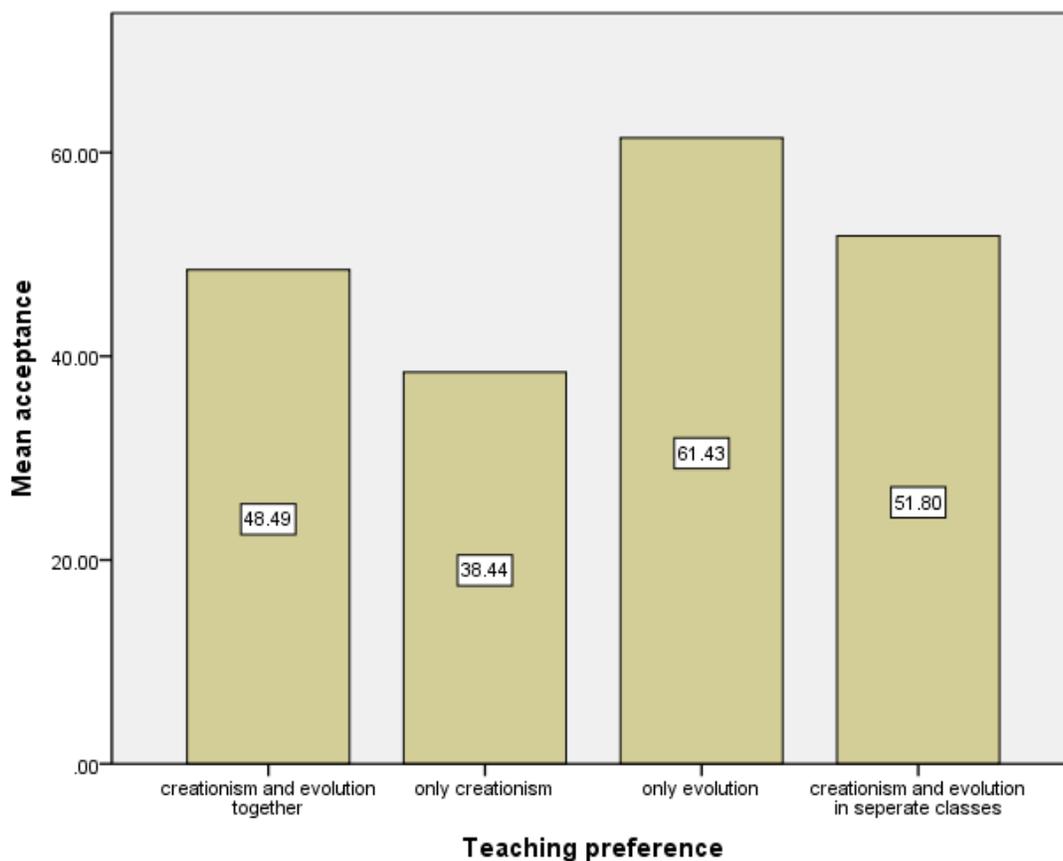

Figure 1. Mean total scores of evolution acceptance according to evolution teaching preferences.

Understanding of evolution and teaching preference. Another part of our second research question was whether and/or how the understanding of evolutionary theory varies among preservice biology teachers who had different preference for teaching evolutionary theory and/or creationism in schools. The Kruskal-Wallis test indicated no significant difference among the four categories of teaching preferences ($H = 3.68$, $p = .30$). Teachers who preferred to teach creationism and/or evolution in their schools did not significantly differ from each other in terms of their understanding of evolution.

Religiosity and teaching preferences. The last part of our second research question was whether and/or how the religiosity varies among preservice biology teachers who had different preference for teaching evolutionary theory and/or creationism in schools. The Kruskal-Wallis test was significant ($H = 25.13$, $p < .001$), with a mean religiosity of 2.00 for only evolution teaching preference, 2.74 for creationism and evolution in separate classes teaching preference, 2.91 for creationism and evolution together teaching preference, and 3.78 for only creationism (See Figure 3). As in the evolution acceptance, the stepwise stepdown procedure showed that the teaching preferences of creationism and evolution together and creationism and evolution in separate classes comprised a homogeneous subset. This infers that teachers who preferred to

teach creationism and evolution together or in separate classes did not significantly differ from each other in terms of their religiosity. Compared to those who preferred to teach both creationism and evolution, teachers who preferred to teach only evolution had significantly lower religiosity scores, while teachers who preferred to teach only creationism had significantly higher religiosity scores.
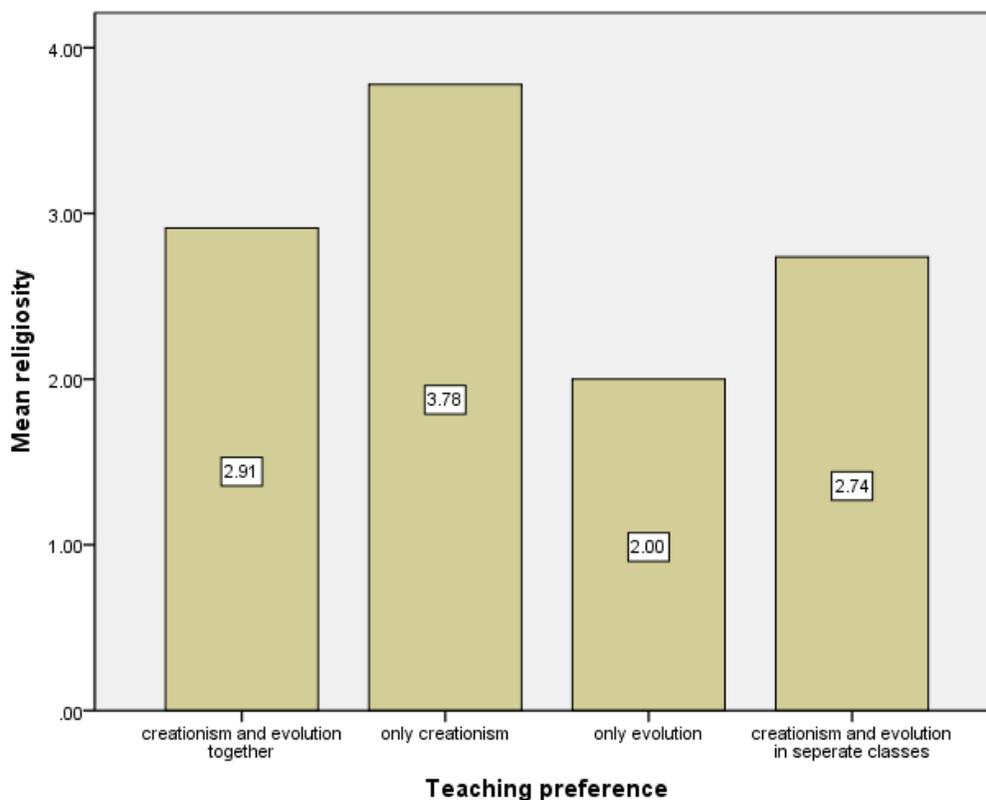

Figure 2. Mean religiosity scores according to evolution teaching preferences.

Discussion

Thinking dispositions, understanding of evolution, and parents' education level were found to be positively correlated with acceptance of evolutionary theory, but religiosity was found to be negatively correlated with acceptance of evolution. These results suggest that participants with a better of understanding of evolutionary theory are more likely to accept it. Similarly, participants with more sophisticated thinking dispositions are more likely to accept evolutionary theory. In other words, if a particular person is open to revise his or her ideas on a specific topic based on evidence, this particular person is also more likely to accept the theory of evolution. Parents' education level was found to be positively correlated with acceptance of evolutionary theory. Parents with higher levels of education may provide an environment in which their children can grow up in a way that they are more open to contemporary scientific ideas. Our findings with regard to the relationships among acceptance and understanding of

evolutionary theory, thinking dispositions, and parent's education level are similar to the findings reported in Deniz et al. (2008). Deniz et al. (2008) found that understanding, thinking dispositions, and parent's education level together explained only 10.5 % of the variance in acceptance of evolutionary theory. The current study makes a significant contribution to the literature because the inclusion of religious orientation in the regression model dramatically changed the variance explained in acceptance of evolutionary theory. In the current study, religious orientation, understanding, thinking dispositions, and parents' education together explained 50.5 % of the variance in acceptance of evolutionary theory. This suggests that religious orientation is the single most important factor that can explain the variance in preservice biology teachers' acceptance of evolutionary theory.

It should be kept in mind that religious orientation is negatively correlated with the acceptance of evolutionary theory. Therefore, participants with strong religious orientation are less likely to accept evolutionary theory as scientifically valid. Participants with strong religious orientation may think that accepting evolutionary theory as a scientifically valid theory may not be compatible with their religious beliefs. This can be due to the fact that they tend to literally interpret their religious resources. We think that certain approaches can diminish the tension between religious orientation and acceptance of evolutionary theory. For instance, nature of science instruction can help the teachers resolve their personal science-religion conflicts by helping them to understand that science and religion are different ways of knowing and they are not necessarily at odds with each other. Nature of science instruction emphasizing the boundaries of science can help teachers come to the conclusion that their acceptance of evolutionary theory does not harm their religious beliefs. Coming to grips with nature of science ideas such as science is a limited way of knowing and science cannot answer questions about the supernatural may help resolve this unnecessary tension between science and religion. Another important nature of science understanding that can help religious people reduce their apprehensive attitude toward evolutionary theory is recognizing the difference between methodological and philosophical materialism. Scientists operate according to methodological materialism. In other words, they do not invoke supernatural explanations when doing science and explaining natural phenomena. Although scientists may or may not have personal religious beliefs they have to be silent about the existence of supernatural when doing science. Contrary to the methodological materialism, proponents of the philosophical materialism do not accept supernatural. In other words, philosophical materialists deny the existence of God and therefore they are atheists. All scientists are methodological materialists but not all scientists are philosophical materialists. In fact, some scientists accept the theistic evolution position.

It is clear that teachers' understanding of evolutionary theory, parent's educational level, thinking dispositions, and religious orientation are all related to their acceptance of evolutionary theory. Our results clearly indicate that there is also a relationship between preservice biology teachers' acceptance of evolutionary theory and their preference for its teaching. Preservice biology teachers with higher acceptance of evolutionary theory scores are more likely to prefer to teach evolutionary theory and preservice biology teachers with lower acceptance of evolutionary theory scores are less likely to prefer to teach it. Conversely, preservice biology teachers with higher religious orientation scores are less likely to prefer to teach evolutionary theory and preservice biology teachers with lower religious orientation scores are more likely to prefer to teach evolutionary theory. It is interesting to note that only 15 participants (12%) endorsed the

idea that only creationism should be taught in schools, not evolution. Other participants agreed to teach some sort of creationism at the schools. However, the percentage of preservice biology teachers who endorse to teach some amount of creationism is only 16.6 percent in a study conducted in Germany (Großschedl, Konnemann, & Basel, 2014).

Among the variables explaining the variance in acceptance of evolutionary theory, parent's education level and religiosity are the variables that are outside the realm of any teacher education program's intervention. However, teacher education programs can focus on increasing teachers' content knowledge about evolutionary theory and their nature of science views in an attempt to increase teachers' acceptance of evolutionary theory. Teachers with poor understanding of evolutionary theory are not well prepared to teach evolution effectively even if they attempt to teach it (Balgopal, 2014). Teachers with more sophisticated nature of science views and thinking dispositons are more likely to consider alternative views on the same issue because they understand the subjective and the tentative character of scientific knowledge. We think that teachers with strong religious orientation can accept evolutionary theory and teach it if they achieve sophisticated nature of science views and thinking dispositions, and increased understanding of evolutionary theory.

Limitations of the Study

We used a correlational research design to explore the factors that are related to acceptance of evolutionary theory and the relationship between preservice biology teachers' acceptance of evolutionary theory and their preference for its teaching. Our research design does not allow us to make causal explanations. Our findings are based on quantitative analysis of self-reported data. We used variables which easily lent themselves to quantitative measurement to explain the variance in acceptance of evolutionary theory. We used the MATE instrument to measure acceptance of evolutionary theory. Even though this instrument is frequently used in evolution education research some researchers raised some concerns about its validity with respect to its ability to discriminate between acceptance and knowledge (Smith, 2010). We measured our participants' religious orientation with one question. One question may not be enough to fully capture the religious orientation of the participants. Future studies may consider using a more robust religious orientation instrument including a number of items. Future studies that employ mixed methods might provide further insights about the nature of relationship between teachers' acceptance of evolutionary theory and their preference for its teaching.

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