Preservice Secondary Science Teachers’ Acceptance of Evolutionary Theory and Factors related to Acceptance

Hasan Deniz and Lisa A. Donnelly

**Introduction**

Evolution has been endorsed as a unifying concept in biology by major science education policy documents (American Association for the Advancement of Science [AAAS] 1993; National Research Council [NRC] 1996; National Science Teachers Association [NSTA] 2003; National Research Council [NRC] 2011). However, suggestions made in policy documents are not necessarily followed in actual classroom settings. Research has shown that how evolution is taught within the classroom is influenced by teachers’ acceptance of evolutionary theory (Aguillard 1999; Eve and Dunn 1990; Shankar and Skoog 1993). In particular, these studies indicate that biology teachers’ acceptance of evolutionary theory is related to what extent they will use evolution as a unifying concept in their classrooms. The purpose of this study was to explore the relationships between acceptance of evolutionary theory and the factors that might influence it.

Our previous research explored how understanding of evolutionary theory, epistemological beliefs, and actively open-minded thinking dispositions would explain acceptance of evolutionary theory among preservice secondary science teachers. We (Deniz and others 2008) examined these variables in an earlier study among preservice biology teachers in a predominantly Muslim country. That study found that understanding of evolutionary theory and thinking dispositions could predict acceptance of evolutionary theory among preservice biology teachers to a certain extent. However, because of low internal consistency coefficients of the epistemological beliefs instrument’s subscales in the previous study, we were not able to use epistemological beliefs to make any prediction. In this study, we used a different epistemological beliefs instrument to be able to explain more variance in acceptance of evolutionary theory. We hypothesized that understanding of evolutionary theory, thinking dispositions, and epistemological beliefs together would account for a significant percentage of variance in acceptance of evolutionary theory in the United States context.

**Understanding and Acceptance of Evolutionary Theory**

Many researchers have distinguished between acceptance of evolution and the understanding of evolution (Cobern 1994; Sinatra and others 2003). The relationship between understanding and accepting evolution has not been fully resolved. Some studies indicate no relationship between understanding and acceptance (Bishop and Anderson 1990; Brem and others 2003; Demastes and others 1995; Sinatra and others 2003), while others suggest a positive relationship (Johnson and Peeples 1987; Rutledge and Warden 2000). Although
the relationship between understanding and acceptance of evolutionary theory is complicated, we expected to find a positive correlation between understanding and acceptance of evolutionary theory.

**Epistemologic Beliefs**

Perry’s (1999) work with undergraduate students at Harvard University initiated the development of epistemologic beliefs as a research agenda based on the epistemologic development of college students. Although Perry’s original scheme included nine stages, researchers classified these nine stages under four main categories: dualism, multiplicity, relativism, and commitment to relativism. In the dualism stage, thinking is characterized by bipolar terms such as right-versus-wrong or good-versus-bad. People in the dualism stage have no difficulty in distinguishing right from wrong or good from bad. However, as people are exposed to conflicting ideas from different authorities, they start to question dualistic thinking and develop a certain level of acceptance of uncertainty. This acknowledgment of uncertainty marks an important difference between the dualism and multiplicity stages. In the relativism stage, people tend to think that there are few issues that can be known for sure. Compared to the departure from dualism to multiplicity, the departure from multiplicity to relativism represents a major transformation in thinking. Thinking becomes contextual rather than fixed. In the commitment to relativism stage, people find relativism disorienting and they make informed decisions among many legitimate alternatives after experiencing genuine doubt.

**Thinking Dispositions**

Thinking dispositions are indicators of one’s degree of open-minded or reflective thinking (Stanovich and West 1997; Sá and others 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 and others (2003) and Deniz and others (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.

**Methodology**

**Participants**

A total of 32 preservice secondary teachers (19 female, 13 male; and 23 undergraduate, 9 master’s) in a large Midwestern university participated in the study. All the participants were enrolled in a secondary science teaching methods course when the data were collected. The science teaching methods course included topics such as national science education standards, nature of science, conceptual change, concept mapping, teaching science through inquiry, preparing lesson plans, questioning techniques, safety, and classroom management. Considering the nature of the science teaching methods course, participants were not taught any evolution content. All of these participants were expected to become secondary teachers after they complete the science teaching methods course. This population was chosen because of convenience. Data for this study were collected with the approval of the Human Research Protection Program at Indiana University.
Data Collection

Understanding of Evolutionary Theory. We measured preservice secondary teachers’ understanding of evolutionary theory using a modified version of an existing scale (Rutledge and Warden 2000) consisting of 21 multiple-choice questions 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.

Two sample questions used to measure participants’ understanding of evolutionary theory are below.

Q5. Marine mammals have many structural characteristics in common with fishes. The explanation that evolutionary theory would give for this similarity is:
   A. Fish and mammals are closely related.
   B. Fish evolved structures similar to those already existing in mammals.
   C. Marine mammals evolved directly from the fishes.
   D. Marine mammals never developed the use of limbs.
   E. Marine mammals adapted to an environment similar to that of the fishes.

Q10. The population of Florida panthers has been drastically reduced by the actions of man. Which of the following most likely threatens their ability to continue to evolve in response to the pressures of their environment?
   A. There is no longer the prospect for over-reproduction.
   B. There is no longer the prospect of a struggle for limited resources.
   C. There is a lack of genetic variation for selection to act upon.
   D. There is no longer the prospect of a trait conferring a reproductive advantage.
   E. There is no longer the prospect of genetic drift occurring.

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.

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 completed this 20-item measure. Participants responded to each item using a 5-point Likert scale (5 = “strongly agree”; 4 = “agree”; 3 = “undecided”; 2 = “disagree”; 1 = “strongly disagree”). MATE asks both positive and negative questions about evolution, and the rating scale is adjusted so that a strong disagreement with an erroneous statement about evolution carries the same score as a strong agreement with a true statement.

Epistemologic Beliefs Measure. Participants completed a 50-item epistemologic beliefs instrument developed by Kelton and Griffith (1986). This instrument is called the Learning Context Questionnaire (LCQ). LCQ was validated by Kelton and Griffith (1986) through
factor analysis for use with college students. LCQ consists of 50 items (26 of which are scored). In this study, we chose to score 26 questions because scoring of these particular 26 questions corresponds to Perry’s (1999) epistemological developmental stages. Preservice teachers responded to each question using a 6-point Likert scale (6 = “strongly agree”; 5 = “moderately agree”; 4 = “slightly agree”; 3 = “slightly disagree”; 2 = “moderately disagree”; 1 = “strongly disagree”).

Researchers assigned participants to Perry stages according to their LCQ scores. Low item ratings on the LCQ indicate a dualistic objectivist view of knowledge, and high item ratings indicate a more subjective relativistic and constructivist view of knowledge. Scores of 26–88 correspond to Perry’s (1999) stage of dualism, 89–101 to multiplicity, 102–114 to relativism, and 115–156 to commitment to relativism.

**Thinking Dispositions Measure.** Participants also completed a 41-item actively open-minded thinking (AOT) composite scale (Stanovich and West 1997; Sá and others 1999). Preservice teachers again responded to each question using a 5-point Likert scale (5 = “strongly agree”; 4 = “agree”; 3 = “undecided”; 2 = “disagree”; 1 = “strongly disagree”). High item ratings on the AOT composite indicate cognitive flexibility and openness to changing beliefs, whereas low scores indicate cognitive rigidity and resistance to changing beliefs (Sá and others 1999).

**Data Analysis**

Mean, standard deviation, and minimum and maximum values for each construct were calculated. Cronbach’s alpha coefficients of measures and intercorrelations among the constructs were also calculated.

We used hierarchical multiple regression to examine how understanding of evolutionary theory, epistemologic beliefs, and thinking dispositions would explain acceptance of evolutionary theory among preservice secondary science teachers. In the hierarchical multiple regression analysis, acceptance of evolutionary theory was the dependent variable, and thinking dispositions and epistemologic belief scores were predictors. Understanding of evolutionary theory was not used in the regression analysis because it was not correlated with the dependent variable, acceptance of evolutionary theory.

**Results**

Mean, standard deviation, minimum, and maximum values for acceptance and understanding of evolutionary theory, thinking dispositions, and epistemologic beliefs appear in Table 1. Intercorrelations among these constructs appear in Table 2.

**Table 1.** Means, standard deviations, maximum and minimum scores of surveys’ responses.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Mean</th>
<th>SD</th>
<th>Min.</th>
<th>Max.</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance of Evolution (MATE)</td>
<td>79.31</td>
<td>13.29</td>
<td>45</td>
<td>100</td>
<td>.95</td>
</tr>
<tr>
<td>Understanding of Evolution</td>
<td>13.03</td>
<td>3.63</td>
<td>5</td>
<td>18</td>
<td>.73</td>
</tr>
<tr>
<td>Thinking Dispositions (AOT)</td>
<td>151.72</td>
<td>14.82</td>
<td>95</td>
<td>184</td>
<td>.81</td>
</tr>
<tr>
<td>Epistemologic Beliefs (LCQ)</td>
<td>102.6</td>
<td>13.02</td>
<td>82</td>
<td>141</td>
<td>.50</td>
</tr>
</tbody>
</table>
Overall, participants accepted evolution as a scientifically valid theory because their mean acceptance of evolution score was almost 80. A score of 20 on the acceptance of evolution instrument indicates that a particular person completely rejects evolution as a scientifically valid theory and a score of 100 indicates that this particular person fully accepts evolution as a scientifically valid theory. None of the participants answered all of the understanding of evolution questions correctly. On average, they correctly answered 13.03 questions out of 21 questions.

Participants had relatively sophisticated thinking dispositions. The lowest possible thinking dispositions score is 41 and the highest possible thinking dispositions score is 205. Our participants’ average thinking dispositions score was 151.72.

Our participants also had relatively sophisticated epistemologic beliefs. The lowest possible epistemologic beliefs score is 26 and the highest possible epistemologic beliefs score is 156. Our participants’ average epistemologic beliefs score was 102.6. According to Perry’s (1999) epistemologic development stages, 2 participants (6.3%) were in dualism stage, 9 participants (28.1%) were in multiplicity stage, 16 participants (50%) were in relativism stage, and 5 participants (15.6%) were in contextual relativism stage. Participants in dualism stage had lower acceptance of evolutionary theory scores compared to the participants in multiplicity, relativism, and contextual relativism stages. See Figure 1.

**Figure 1.** Perry (1999) personal epistemology stages and average acceptance of evolutionary theory values.
Understanding and Acceptance of Evolutionary Theory

We did not find any significant correlation between participants’ understanding and acceptance of evolutionary theory. This indicates that participants who have more knowledge about evolution are not necessarily more likely to accept evolutionary theory.

Epistemologic Beliefs and Acceptance of Evolutionary Theory

We found a significant correlation between participants’ epistemological beliefs and their acceptance of evolutionary theory ($r = .37$, $p < .05$).

Thinking Dispositions and Acceptance of Evolutionary Theory

We found a strong significant correlation between thinking dispositions and acceptance of evolutionary theory ($r = .70$, $p < .01$). This indicates that participants with more cognitive flexibility and openness to belief change are more likely to accept evolutionary theory.

The Hierarchical Multiple Regression Analysis Results

The acceptance of evolutionary theory was correlated with epistemological beliefs and thinking dispositions (see Table 2).

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Acceptance of evolution</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Understanding of evolution</td>
<td>.28</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Thinking dispositions</td>
<td>.70**</td>
<td>.31</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>4. Epistemologic beliefs</td>
<td>.37*</td>
<td>.36*</td>
<td>.54**</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* $p < .05$; ** $p < .01$

Epistemologic beliefs alone accounted for 10.7% of the variance ($F [1, 31] = 4.71$, $p < .05$). Addition of thinking dispositions to the regression model significantly increased the variance explained in acceptance of evolutionary theory. Epistemologic beliefs and thinking dispositions together accounted for 45% of the variance ($F [2, 30] = 13.67$, $p < .01$). There is a correlation between epistemological beliefs and thinking dispositions (see Table 2). Therefore, it cannot be claimed that thinking dispositions alone are responsible for explaining 34.3% variance (45% – 10.7% = 34.3%).

Discussion

Participants’ thinking dispositions and epistemological beliefs are positively correlated with their acceptance of evolutionary theory. It was against our expectations that understanding of evolutionary theory was not correlated with the acceptance. In our previous study which was conducted in a predominantly Muslim country (Deniz and others 2008), we were able to find a modest correlation between understanding and acceptance of evolutionary theory. A similar positive relationship between understanding and acceptance of evolutionary theory was reported by Johnson and Peeples (1987), Rutledge and Warden (2000).
However, the results of this study were consistent with the findings of other studies that reported no relationship between understanding and acceptance (Bishop and Anderson 1990; Brem and others 2003; Demastes and others 1995; Sinatra and others 2003).

Our findings indicated that preservice secondary science teachers with more actively open-minded thinking dispositions and sophisticated epistemological beliefs are more likely to accept evolutionary theory and in turn are more likely to use evolution as a unifying theme in their biology courses.

In this correlational study, it is not possible to identify any causal relationship among acceptance of evolutionary theory, epistemological beliefs, and thinking dispositions. However, it can be concluded that teachers that display actively open-minded thinking dispositions and sophisticated epistemological beliefs will also have a higher acceptance of evolutionary theory. This can, in turn, impact how evolution is taught in actual classroom settings because research indicates teachers’ acceptance of evolution is related to what extent they teach evolution in their own classrooms (Aguillard 1999; Eve and Dunn 1990; Shankar and Skoog 1993).

Results of this study indicated that having a robust conceptual understanding of evolutionary theory is a necessary but not sufficient condition for science teachers to use evolution as a central overarching theme in their classes as suggested by science education policy documents (AAAS 1993; NRC 1996). This study makes it clear that the role of teachers’ thinking dispositions and epistemological beliefs is related to their acceptance of evolutionary theory. These findings are parallel to the findings of other researchers (Deniz and others 2008; Sinatra and others 2003) and suggest that professionals preparing future teachers need to focus on thinking dispositions and epistemological beliefs as least as much as the understanding of evolutionary theory if our goal is to increase the number of classrooms in which evolution appears as a fundamental organizing principle for biology.

**References**


About the Authors

Hasan Deniz is an assistant professor of science education at University of Nevada, Las Vegas, where he teaches undergraduate, masters, and doctoral level courses in the science education program. His research agenda includes epistemological beliefs in science and evolution education.

Lisa A Donnelly is an assistant professor of science education at Kent State University in Kent, Ohio. She formerly taught high school biology and currently conducts research in the teaching and learning of evolution in secondary and undergraduate contexts.

Corresponding Author’s Address

Hasan Deniz
Department of Curriculum and Instruction
University of Nevada, Las Vegas
Las Vegas NV 89154-3005
hasan.deniz@unlv.edu