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Kyriacos Athanasiou, Penelope Papadopoulou

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Abstract

In this study, we explored some of the factors related to the acceptance of evolutionary theory among Greek university students training to be teachers in Early Childhood Education, using conceptual ecology for biological evolution as a theoretical framework. We examined the acceptance of evolutionary theory and we also looked into the relationship between the acceptance and parents’ educational level, thinking dispositions and frequency of religious practice as independent variables. Students’ moderate acceptance of evolutionary theory is positively correlated with the frequency of religious practising and thinking dispositions. Our findings indicate that studying a controversial issue such as the acceptance of evolutionary theory in a multivariate fashion, using conceptual ecology as a theoretical lens to interpret the findings, is informative. They also indicate the differences that exist between societies and how socio-cultural factors such as the nature of religion, as part of the conceptual ecology, influence acceptance of evolution and have an influence on evolution education.

Key words: Evolution teaching, acceptance, conceptual ecology, Greek education students.

Introduction - Theoretical framework
Conceptual change has been shown to be both an affective and intentional process. Intentional conceptual change has been defined as “goal-directed and conscious initiation and regulation of cognitive, metacognitive and motivational processes to bring about a change in knowledge” (Sinatra, Southerland, McConaughy & Demastes, 2003; Sinatra & Pintrich, 2003). Learners are thought to possess a network of related conceptions (conceptual frameworks) through which they understand a topic (Smith, Siegel & McInerney, 1995). Learning is seen as a change in preexisting frameworks, i.e. structural modifications or revisions based upon new experience, information or concepts the learner encounters. According to Posner’s views on conceptual change (1982), the change of major, organizing conceptions within the learner, can be represented with Kuhn’s model on scientific revolutions. The change experienced by the learner is understood to be holistic insofar as one conception is completely abandoned for another, more useful conception.

Posner’s theory of conceptual change has been strengthened by the inclusion of Toulmin’s idea of a conceptual ecology (1973). A conceptual ecology includes fundamental organizing conceptions that serve as the changing conceptual environment in which conceptual change occurs, thus, the conceptual ecology controls and modifies this process (Strike & Posner, 1992). But, this revisionist approach to conceptual change which recognized the limitations of the original Conceptual Change Model and acknowledged a much larger role of affect in cognition, according to Southerland & Sinatra (2005) provided little understanding of affect beyond the acknowledgement of its import. More recent models of cognition, such as the Cognitive Reconstruction of Knowledge Model (Dole & Sinatra, 1998) and the Cognitive–Affective Model of Conceptual Change (Gregoire, 2003), incorporate strong affective components, like motivation, efficacy beliefs, implication...
of self and intentions. According to the second model, acceptance can prohibit the possibility of true conceptual change. Southerland & Sinatra (2005) suggested that continued focus on the intersection of affective and cognitive factors is called for, as we begin to recognize that learning is not solely determined by the characteristics of the content in question or unconscious attributes of the learner (i.e., reasoning ability, background knowledge).

Based on such views, researchers have begun to explore the impact of constructs such as epistemological beliefs, belief identification and willingness to question one’s beliefs, in relation to conceptual change. In other words, they suggest that learning is not controlled solely by external factors (nature of content or instruction), but the learner plays a significant role in choosing to consider alternative points of view. In other words, there are instances, where the conceptual ecology of the learner must be taken into consideration before the teaching strategy is to be organized and applied (Demastes-Southerland, Good & Peebles, 1995).

A typical case of a theory that consists of a body of intercorrelated concepts formatting a conceptual framework is the evolutionary theory. Various studies on evolution education that have been conducted in the recent decade, suggest that acceptance of evolutionary theory is related to a number of different factors. A complex web of connections between acceptance of evolutionary theory and these factors influences one’s degree of acceptance. Science education and science education research are human social activities conducted within institutional and cultural frameworks and we cannot ignore the ways in which student learning is also embedded in those contexts (Lemke, 2001).

Understanding and Acceptance of Evolution- Conceptual ecology
The relationship between understanding and acceptance of evolution has not been fully resolved. Some studies have indicated no relationship between understanding and acceptance (Bishop & Anderson, 1990; Sinatra et al., 2003) whereas others suggested a positive relationship (Johnson & Peeples, 1987; Rutledge & Warden, 2000). Similarly, some studies have suggested that acceptance of evolution can change as a result of evolution instruction (Lawson & Weser, 1990; Matthews, 2001), whereas others suggested that it does not (Bishop & Anderson, 1990; Lawson and Worsnop, 1992). One can conclude from these studies that the relationship between understanding and acceptance is indeed complicated.

More recently, Smith and Siegel (2004), while they agree that belief is a necessary condition of knowledge, they state that the primary goal of science education should be student knowledge and understanding, arguing that this typically involves belief and guides action. When teachers in their teaching about evolution are confronted with students that although evidenced a meaningful understanding still disbelieve, they propose that the appropriate goal is for them to believe (accept) that the theory in question affords the best current scientific account of the relevant phenomena based on the available empirical evidence. Most science educators would agree with this view. But from our own and others experiences, a position of this sort, raises the questions: “which are the relevant phenomena” and how many scientific or other accounts on the appearance, differentiation and spread of living things on earth exist so far? The answer is that, at least for the countries with Christian or Muslim backgrounds, there are only two of them: namely the biblical account and the theory of evolution. In that case, how easy is to avoid telling a class that the history of life, as it is depicted in
Genesis, has no relation to scientific truth, when is literally taken? But when a teacher of Biology teaches in a classroom that the history of life goes back to more than 2.5 billion years ago, doesn’t she come in direct conflict with some of her student’s beliefs? When we present in the classroom the history of fossils, don’t we provoke some of the beliefs that some of the students hold? Is it possible for someone to understand evolution through natural selection, if they do accept that the history of life is nothing but a 7,000 years ago case or that species appeared all at the same time on earth? What we wish to underline is that, when teaching issues like evolution, it is almost impossible to focus only to acquisition of knowledge without making influence on beliefs, and vice versa.

According to Cobern (2004), belief (acceptance) and knowledge stand in critical relationship with each other and with science education. None can stand alone. They are hierarchically related. Knowledge rests on belief. You cannot have one without the other, which is implicit in the definition that knowledge is “justified true belief”. If this is the case, it means that conceptual change on evolution can be achieved in either way: increase in knowledge and/or increase in acceptance. At the same time, based on an extensive review of the literature, we can state that acceptance of evolutionary theory is related to a number of different factors.

In the context of conceptual change perspectives in science education there is an apparent assumption that people can simply change their views on one topic or in one scientific domain without the need to change anything else about their lives or their identities. This, according to Lemke (2001), runs contrary to the experience of sociocultural research. Therefore, studying acceptance of evolutionary theory as a part of the conceptual ecology for biological evolution is more promising than studying...
acceptance of evolutionary theory in isolation. Demastes-Southerland et al. (1995) were the ones to originally describe the conceptual ecology for biological evolution. According to them, acceptance of evolutionary theory is part of this conceptual ecology, which, contains the following five components: (1) prior conceptions related to understanding of evolutionary theory; (2) scientific orientation (degree to which the learner organizes his/her life around scientific activities); (3) view of the nature of science; (4) view of the biological world in competitive and causal terms as opposed to aesthetic terms; and (5) religious orientation.

Lately, Deniz, Donnelly, & Yilmaz, (2008), based on the evolution education literature suggest four other components in someone’s conceptual ecology for biological education, namely, the subject’s reasoning level, perceptions of the impact of the evolutionary theory, epistemological beliefs and thinking dispositions. Epistemological beliefs is a concept related to personal epistemology and indicates what individuals believe about the source, certainty and organization of knowledge, as well as the control and the speed of learning. Another way to express it is the learners’ active participation and persistence in learning (Schommer, 1994). Thinking dispositions, on the other hand, are indicators of one’s degree of open-minded or reflective thinking. According to findings of Sinatra, Southerland, McConaughy & Demastes, (2003), people who have a high degree of open-minded or reflective thinking are more likely to accept evolutionary theory. Furthermore, Deniz et al. (2008) collected data from Turkish students with regard to parents’ educational level because of the suspected relation to acceptance of the evolutionary theory. Taking previous findings under consideration (Costa, 1995), they hypothesized that participants whose parents had obtained higher educational degrees were more likely to accept evolutionary theory. This was found to be true, at least for Turkish society.
Based on these and other findings we explored some of the factors that contribute to the formation of the conceptual ecology of Greek students, in connection to the acceptance of the evolutionary theory. At the same time, we compared to previous relevant American and Turkish studies. We also tried, to find out if we can make any contribution towards the hypothesis that it is not only religion in general that affects someone’s acceptance of the theory of evolution, but the type of religion and its qualitative characteristics, as well. If this hypothesis is found to be true, it may be included among the factors that constitute someone’s conceptual ecology of the evolution theory.

A series of teaching ideas and promising interventions have been previously suggested, as ways of leading to conceptual change of the evolutionary theory (Kampourakis & Zogza, 2009; Ingram & Nelson, 2006). One such idea, recommended by renowned organizations like the AAAS and NRC, is the proposition that a given biology course, should employ evolution as its central unifying theme and framework (American Association for the Advancement of Science, 1993; National Research Council, 1996). Although it has been repeatedly proposed that introductory Biology courses should be organized around this latter principle, rarely has it been applied by scholars, teachers and in textbooks (Alles, 2001). We have chosen this schema to be the one we apply to the introductory course, without interfering with other instructional suggestions, for reasons of statistical simplicity.

Greek society and its educational system are interesting from the biological evolution point of view: the public education system has been up to now very successful in totally exiling evolution education from all its “territory”. This seclusion has been achieved in a two-fold manner: a) the chapter(s) on evolution is always last in rank in all biology textbooks and b) it is not included in the teaching curriculum,
both in high school classes and in the university entrance exams. The latter might be related to the fact that Greek society can be characterized as one of the least “evolutionary” educated societies in the modern world. Of course, there are some vivid exceptions, especially in select private schools, where evolution is not only taught, but its teaching is openly cultivated and research is systematically conducted alongside the theory (Kampourakis & Zogza, 2007, 2009). This lack of proper education may be related to the fact that Greece occupies one of the lower positions on the evolutionary acceptance scale proposed by Miller, Scott, & Okamoto, (2006) being only a few placements above the last two countries in rank, i.e. USA and Turkey. Working with student populations, like Greek students of the present study that come from societies with limited knowledge and acceptance of evolution, can be a useful tool for examining the effects of adoption and/or studying the increase of knowledge on evolution. This we attempted through a Biology course that was organized and applied with the theory of evolution being its central unifying theme and framework. Meanwhile, we tried to study other variables related to the conceptual ecology of evolution education, i.e. frequency of religious practicing, parents’ educational level, parental frequency of religious practicing and students’ thinking dispositions.

The present study

The following are some of the questions that we are attempting to expose in the present research: What is the conceptual ecology of evolution of students in Greece? Is it different from that of some groups of American or Turkish students? We hypothesized that there should be differences among people from different cultures, because different sociocultural backgrounds, religious history or the tradition of each
people have probably an effect on epistemological beliefs, dispositions toward open-mindedness and critical thinking, in different ways. Is there a relationship between individual religious practice and acceptance of evolution? Does someone’s family’s educational level, affect his/her evolutionary acceptance, as seen in the study of Deniz et al. (2008) of Turkish society?

Is there a relationship between students’ understanding of evolution and their acceptance of both animal and human evolution? Our hypothesis was similar to the original hypothesis made by Sinatra, Southerland, McConaughy & Demastes (2002), at the onset of their study, namely that there should exist such a correlation. In that case, why was such correlation not found, while one was found in the study of Deniz et al. (2008) with the students in Turkey? Of course, the question of whether or not one can legitimately distinguish between knowledge and belief is at the very heart of science education teaching and research, wherein researchers have differing views, according to their philosophical and epistemological beliefs and ways of thought (Southerland, Sinatra & Matthews, 2001).

Methodology

Participants

A class of about 350 future teachers in Early Childhood Education participated in one or both sections of the present study. Participants were enrolled in an introductory biology course, in the Early Childhood Education Department of University Athens, Greece. The purpose of the study was explained to the students, as was the fact that their responses would be anonymous as the study focused on group results and not on individual responses. A student in the Early Childhood Education Department has the same educational background in evolution as the average educated individual in Greece, with the probable exception of life sciences students
and scientists. As afore mentioned, Greek society can be characterized as one of the least “evolutionary” educated societies in the modern world and it can be said that the only access high school students have to evolution education, is via newspapers, TV documentaries and any scattered information that teachers might proactively provide them with.

The course

Participants were taught a biology course, that employed evolution as its central unifying theme and framework. For this purpose, the course started with a general chapter on evolution that included: an introduction to the scientific method and the meaning of theory (NOS), ideas about Darwin’s contribution on the notion of the tree of life and the mechanism of evolution by means of natural selection, the role of fossils in understanding the fact that life is very old, adaptation, contemporary evidence on evolution, etc. The first part of the course was completed with a discussion on the case of Mediterranean anemia and the reasons that lay behind the fact that almost 10% of the Greek population are carriers of the trait (contrary to the Northern Europeans, where the trait does not exceed a 1% of the population). The students had to undertake bibliographic and internet research, in order to explore the discrepancy: several came back with the well-known explanation, namely that of the historical existence in the past in areas like Greece, Italy and Turkey, of an environmental factor (malaria) that favored the survival of the fittest part of the population. These happened to be the carriers of the trait that were more adapted to these environmental conditions in the major Mediterranean region (Serjeant, 1989). This finding raised the question of how the sickle-cell anemia carriers appeared in the first place. The question was followed by the introduction of the next unit, i.e. the genesis of mutations as changes in the genetic material of the populations. A fact that
led to the introduction of the sections of variation, adaptation and the rest of the components of a typical chapter on Genetics (i.e. Chromosomes, DNA, Mitosis, Meiosis, genetic engineering, etc.). When this section was completed and the students had already a good idea about the history of life and its tree-like structure, they were more ready to hear about classification of plants and animals, followed by Ecology, etc.

The course was given in lecture form, but it was also available as an e-class, on a site where, amongst other resources, the students could find the lectures in power point. The e-class site was visited on a daily basis by a number of students that ranged from 35-238 throughout the whole semester. Students had to read for their final exam from a choice of textbooks, one of which was written by one of the authors of this study and follows the same rationale like the one mentioned for the course lectures.

Procedure

We surveyed students during the winter semester of the academic year 2008/09. The survey was administered on the first day (pre-course survey) and at the end of the course (post-course survey). 168 students completed the pre-course questionnaires, whereas 112 completed the post-course survey. The responses were used in our subsequent analyses. The assessments are shown in Table 1. All the questionnaires received at the post-course survey were paired to their 112 counterparts of the pre-course survey. In table 2, we present the measurements for the 112 questionnaires that are paired with their counterparts. In fact, the group of the 112 students that participated in both of the surveys yielded higher results compared to that of the 168 students in both knowledge and acceptance. Apparently, they were the ones with higher eagerness to respond and thus having more interest and predisposition towards the education on evolution. We planned and carried out the
post-course survey, when students had finished their first contact with the evolution
theory, in order to examine possible improvement in knowledge and understanding
and its potential influence on acceptance. The number of students that participated by
answering the questionnaires, fell in the range of the ones applied in similar previous
studies, namely the range of 93-132 (Sinatra et al. 2003, Deniz et al. 2008).

Data Collection

Demographics: Students responded to two demographic questions focusing on
their parents’ educational level. Parents’ educational level was measured using six
possible options: illiterate-0, elementary-1; some high school-2; high school graduate-
3; University-4; master’s- and doctorate-5. The highest educational level achieved by
either of the parents was used in the analysis.

Knowledge measure: In order to assess students’ understanding and
knowledge of the evolutionary theory we decided not to use one of the known scales,
for example the one developed by Rutledge and Warden (1999, 2000). The reason for
that is the fact that we had to examine the knowledge of students that were of limited
familiarity with the concepts of the evolutionary theory for two reasons: they were not
students of life science, as it seems to be the case with most of the previous studies
and second, they are coming from a society where evolution is not taught. So, their
understanding of the evolutionary theory was estimated using a scale with 13
questions consisting of two sub-scales, one of 8 questions and a Correct-False-Do not
know probable answer and the other of 5 multiple choice questions. The first subscale
had to do with understanding of very basic principles of the evolutionary theory,
while the second related to the understanding of procedures and practices on the
evolution of populations. Scoring was performed through a scaling where the correct
response to a statement received a score of 1 with a possible scale’s maximum score
equivalent to 13. Wrong responses received a score of 0, so that the scale’s possible
minimum was equal to 0, which represents practically no understanding at all.
Two sample questions of the 13 used to measure student teachers’
understanding of evolution are as follows:
Q6: In contemporary Darwinian Theory it is accepted that characteristics
acquired in an organism’s lifespan would be inherited to its offspring.
A. Correct, B. False, C. Do not know.
Q10. A bat wing and a dog’s forefoot are homologous structures. This implies
that:
A. These structures fulfill the same function
B. Bats are evolved from a dog’s ancestor
C. These are similar structures because of common ancestry
D. The ancestry is not common but the structures fulfill the same function.
Acceptance: To assess Students’ acceptance of evolutionary theory, we used
the MATE scale (Measure of Acceptance of the Theory of Evolution), developed by
Rutledge and Warden (1999, 2000). MATE consists of twenty Likert’s-scaled items
containing statements that addressed the fundamental concepts of evolutionary theory
and the nature of science. That is, the processes of evolution, the available evidence of
evolutionary change, the ability of evolutionary theory to explain phenomena, the
evolution of humans, the age of the earth and scientific community’s view of
evolutionary theory (Rutledge and Sadler 2007). Recently, Smith (2010) questioned
MATE’s validity especially although the PCA results suggest that the items measure a
single factor. he questioned whether or not that factor is acceptance. Even so there
was not a suggestion what else, if not acceptance, this single factor is. Smith (2010)
mentions also a confusion of meanings about “acceptance” and proposes a single item measurement. Nonetheless, we did not change our original choice, mainly, for reasons of better comparisons to similar studies (Trani 2004, Rutledge and Sadler 2007, Deniz et al 2008) conducted with MATE scale as an estimation of acceptance. The five points of the Likert’s-type scale were: strongly agree, agree undecided, disagree, and strongly disagree. To score the MATE we follow Rutledge and Warden (1999) procedure, that is: a) to account for positively and negatively phrased items, the scaling of responses were appropriately reversed so that responses indicative of a high acceptance of evolutionary theory received a score of 5, while answers indicative of a low acceptance receive a score of 1. b) An individual’s score on the MATE was equal to the sum of the scaled responses of all 20 items.

Thinking dispositions measure: Several instruments designed to measure dispositional characteristics have been proposed relevant to thinking and learning about biological evolution. For example, one is the Need for Cognition Scale, (developed by Cacioppo, Petty, Feinstein, & Jarvis, 1996) that measures the tendency to engage in effortful thinking. Another, proposed by Sa, West & Stanovich (1999) is called the Belief Identification Scale and asks people to rate the degree to which they agree with statements such as “Certain beliefs are just too important to abandon no matter how good a case can be made against them”.

In our case, participants completed the AOT (Actively Open-Minded Thinking Scale) (Stanovich & West, 1997; Sa et al. 1999). We applied the current version of this scale as it is used in Stanovich & West (2007) by not calculating subscales for this instrument, but treating it as a single 41-item scale. We also adhered to Stanovich & West’s method with respect to items that needed to be reflected when scoring. Student teachers responded to each question using a 5-point Likert
scale: “strongly agree”, “agree”, “undecided”, “disagree”, and “strongly disagree”. We used these five points of the Likert-type scale and not the one with the six points that Stanovich & West (2007) proposed, neither the one with the four points that Deniz, et al., (2008) used in their study, in order to be in agreement with the way that the MATE scale was structured and applied by Rutledge and Warden (1999, 2000).

Thinking dispositions measure was applied only to post-course test. The acceptance of evolutionary theory and thinking dispositions measures were translated and adapted into Greek by the first author of this study.

**Frequency of Religious Practices**: Students’ and their parents’ frequency of attending religious activities was recorded using three questions. We used the expression “frequency of participating in religious activities” and we described it as: (attending religious activities, individual prayer, confession, meetings with a spiritual father and so on). Religious orientation was measured using six possible options: “Daily”, “Once a week”, “1-3 times per month”, “sometimes per year”, “maximum once per year”, “Rarely or Never”. We calculated a total score of frequency of religious practices (by adding students’ and her father and mother frequency of religious practices) and in consequent analysis we used individual students’ score.

About the reliability and the validity of assessments

Acceptance of evolution theory (MATE scale): Rutledge and Warden (1999) reported that content-validity of the instrument was established by a committee of five university professors who have expertise in the fields of evolutionary biology, science education, and the philosophy of science. The same researchers reported that factor analysis was utilized to assess the construct validity of the scale. In this study,
reliability of the acceptance scale and its subscales, in both pre course and post course surveys, was determined through measures of internal consistency which are reported in table 3.

Knowledge: In a previous paragraph (page 12) we discuss about the reasons we do not use one of the known scales unchanged. Instead of, we adopted some of the items of a knowledge scale modified and used before (Rutledge and Warden 2007), we modified others and we developed new ones. Item analysis was accomplished by a group of biologists (with expertise in Evolutionary Biology, in Biology Education and one with a long teaching experience in secondary schools) in order to establish the face validity of the items. The estimations of the reliability of this measurement (pre and post course survey) presented in table 3. The values of Cronbach’s alpha are lower than the widely accepted levels in social sciences (>0.70).

Thinking disposition (AOT scale): Stanovich & West, (1997) reported that the subscales of the AOT scale have moderate intercorrelations and that the creation of the composite score and validity of the instrument were justified by factor analysis. They also reported that the split – half reliability of the composite scale was 0.90 and Cronbach’s alpha was 0.88. Reliability estimation of AOT scale in our survey equals to 0.78, value that falls in accepted limits.

Data analysis

Means, standard deviations, and maximum and minimum of surveys responses were calculated and presented in Table 2. Internal consistency estimates of the MATE, the AOT, knowledge and religious orientation instruments are listed in Table 3. All the estimations of internal consistency fell into the acceptable limits (George & Mallery, 2003, p. 231) with one exception; that of understanding evolution scale. As a preparatory step to regression analysis, we estimated intercorrelations between
variables investigated in this study. To explore relationships between the variables, the statistical technique of Pearson-product-moment correlation was used. These correlations are presented in Table 4.

Our research question concerned how the understanding of evolution, thinking dispositions, parental educational level and students’ frequency of religious practices would explain the acceptance of evolutionary theory among student-teachers of Early Education. Multiple regression analysis was used for this purpose. To answer our research question we performed a hierarchical multiple regression. The hierarchical (or sequential) multiple regression started with a single independent variable (in our case thinking disposition, variable with the higher correlation to dependent variable, Table 5) and we then added to the regression model, on a step-by-step basis, other independent variables such as students’ frequency of religious practices and parents’ educational level to the regression model, to determine whether the variance explained increased significantly with the addition of each independent variable.

In order to estimate how much teaching focused on evolution influences acceptance of evolution theory we compared the pre- and post-survey scores of these variables. We used paired sample Student’s t-test, a statistical technique that is used to compare two population means in the case of two samples that are correlated. Paired sample t-test is used when the samples are the matched pairs, or the case is a control study or in “before - after studies”. The last case befits the design of our study for evolution acceptance, with respect to pre-course and after-course measurements. We worked out 112 cases. They were participants they took part in both pre- and post-
Results

Intercorrelations among Independent Variables

Intercorrelations among acceptance of evolutionary theory, thinking dispositions, parental education level, students’ frequency of religious practices are presented in Table 5.

Acceptance and Thinking Dispositions

Thinking dispositions were significantly correlated with acceptance of evolution (post-course survey, $r=0.46$, $p<0.01$) (table 4. This indicates that participants with cognitive flexibility and openness to belief change are more likely to accept evolutionary theory. At this point, it might be of some interest to point out the differences in thinking disposition between the students in our sample and some with USA studies. For instance, Alexander and Dochy (1995) in their study with American undergraduates found that it was (for them) “a sign of a moral character for an individual to resist information or experiences that would challenge their beliefs”. A relevant question was an element of the AOT questionnaire that was applied to Greek undergraduates of the present study, (“It is important to persevere in your beliefs even when evidence is brought to bear against them”). It is not accidental that the vast majority of them, (almost 65%), answered that disagreed (42.5%) or totally disagreed (22.5%) with that claim. Considering the findings of Sinatra et al. (2003) and Deniz et al. (2008), it is important to note that students’ thinking dispositions are related to acceptance of evolutionary theory in a similar fashion in American, Turkish and Greek sociocultural contexts.
Acceptance and Parents’ Education Level and Frequency of Religious Practices

No significant correlation between parental education level and participants’ acceptance of evolution was found, neither in pre- nor in the post-course survey (Table 4. In this case it was not possible to duplicate the findings of Deniz, Donnelly, & Yilmaz, 2008) that parental educational sophistication is positively correlated with participants’ acceptance of evolutionary theory. In this study we record a high educational level (Table 2), as 50% of the students have at least one parent with a university (or technological college) level of education.

Frequency of Religious Practices

We found a significant negative correlation between students’ frequency of religious practices and acceptance of evolution theory score, in both pre- and post-course surveys (pre-test: \( r=-0.20, p<0.05 \), post-test: \( r=-0.26, p<0.01 \)) (Table 4. Negative correlation in our case means that as a student’s frequency of religious practices increases in its values, acceptance of evolution decreases in its values. Significant negative correlation between parents’ frequencies of religious practices and students’ acceptance of evolution theory score, was found in the pre-course survey. (mother’s: \( r=0.25, p<0.01 \), father’s: \( r=0.20, p<0.05 \), parents: \( r=0.26, p<0.01 \))

In our study, Early Education students could be considered as religious according to international standards: more specifically, in the post-course research 30% of them stated that they are following religious practices ranging from daily to three per month.

Multiple regression results
Thinking dispositions and students’ frequency of religious practices were found to be correlated among themselves (Table 5). Therefore, variance explained by each of these factors in the acceptance of evolutionary theory was unique. The addition of students’ frequency of religious practices to the regression model increased the variance explained. Students’ thinking dispositions accounted for 24.80% of the variance ($F (1.84) = 28.73, p<0.01$). Thinking dispositions and students’ frequency of religious practices together accounted for 28.80% of the variance, ($F (2.84) = 18.03, p<0.01$). In other words, thinking dispositions and students’ frequency of religious practices together explained 28.80% of the variance of independent variable, (see Table 7). Students’ frequency of religious practices explains only 4% more of the variance, a rather small but significant amount and consists a factor of acceptance’s conceptual ecology. In any case students’ frequency of religious practices seems to influence acceptance more than parents’ education level reported in other studies (3.3% of the variance, Deniz et al. 2008). Parents’ frequency of attendance religious practices seemed not to contribute significantly to the model and they are removed.

Situating acceptance of evolutionary theory within the context of conceptual ecology and examining the relationships between acceptance of evolutionary theory and other components of the conceptual ecology using multiple regression analysis was informative. We were able to account for only 28.80% of the variance in the acceptance of evolutionary theory among student teachers of Early Childhood Education, but this proportion is still bigger than other similar estimations and explains more of the variance in the acceptance of evolution theory in respect with other similar studies (Deniz et al, 2008). Specifically in our case, the multiple regression equation can be written as follows:

\[ Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \epsilon \]
Acceptance = $\beta_0 + 0.33$ thinking dispositions -1.42 frequency of religious practices.

Based on this equation we can state that thinking dispositions has more explanatory power than student’s frequency of religious practices in accounting for the variance in acceptance of evolutionary theory.

*Pre-, Post- course estimations of acceptance*

We found a significant influence of teaching biology with the theory of evolution as a frame of the course on the acceptance of the theory ($t=3.53, p<0.0$, table 6). We reject null hypothesis and accept the alternative, that there is a significant difference between the means in pre- and post- course tests. In other words we found a significant improvement of the acceptance of evolution after teaching (see table 2 & 6). We were recorded a low or medium size effect, in total acceptance score or in partial concepts’ score.

**Discussion**

The present study is an empirical study that may be considered part of various attempts to test theoretical assumptions that seek linking affective and cognitive domains. It has been suggested, that affective factors such as epistemological beliefs and thinking dispositions, as well as factors that are strictly related to the cognitive domain, should be taken into consideration simultaneously when explaining the learning process (Pintrich et al. 1993; Deniz, Donnelly, & Yilmaz, 2008). Theoretically, it makes sense that these affective factors can mediate the cognitive process. Furthermore, it is theoretically possible that the contextual factors can also play important roles in the cognitive learning process through their connection to mediator variables in the affective domain.
Our study has being conducted in a country that is characterized, up to this date, by almost a total absence in the teaching of evolution and one of the lowest levels of its acceptance. These qualities are combined with a (declared) high religiosity of the population that differs in its characteristics from the ones depicted among students and teacher groups in some previous studies, (i.e. Greek-orthodox vs. Catholic, Protestant and Muslim populations). Our study combines, therefore, studies on the contribution of parameters of the cognitive domain, like the improvement of knowledge due to teaching or the familiarity with the NOS, to affective factors such as epistemological beliefs, thinking dispositions and degree and type of religiosity.

In our case, teaching of a biology course with evolution as theoretical framework, helped to increase students’ acceptance of evolution theory, in a statistically significant way. As seen in Table 2, the level of MATE score, although increased significantly from an original mean value of 70.95 to a mean value of 74.72, remained in the same range of medium acceptance (mean 65-76), as previously estimated by Rutledge and Warden, (2000). A careful study of the MATE sections that are indicated in Table 6 shows that this “withholding of beliefs” might be attributed to two concepts that remained without any change: the evolution of humans and the views of several of the students about what the scientific community accepts about the theory of evolution; i.e. an element of the nature of science (NOS). Knowing the NOS includes, among others, knowledge of how a theory is built up and the meaning of the term “Theory” in Science. When someone has understood the NOS she knows that a theory is a “…confirmed hypothesis that is accepted by the scientific community”. In our case, the short involvement of the students with the NOS was not enough to convince them to change their ideas about what is the meaning of the term “Theory” in Science.
This is in agreement with the proposition by Schwab (1978), according to which the total make up of a subject or domain is composed of both substantive and syntactic elements. Included in the substantive structure are the concepts and propositions of a domain and their organizational framework. The syntactic structure consists of the means by which knowledge is generated within a given domain. In the case of evolution, substantive knowledge entails knowledge of the evolutionary theory while syntactic knowledge entails knowledge of the nature of science. In our case, the teaching intervention was not successful in increasing the syntactic knowledge (Rutledge & Warden, 2000). Our results on the NOS teaching seem to be related to the nature of the teaching strategy applied. It was a typical lecturing procedure that was enriched with instructive means associated with ICT (Information and Computer Technology) and thorough discussion with the students. And while a serious part of it was devoted to teaching the NOS and the meaning of the term “Theory” in science, it did not succeed in helping students change their opinion on what the scientific community believes about the evolutionary theory and in consequence, the level of knowledge and its acceptance. A finding that is strengthening previous suggestions on the importance of teaching the NOS in ways that will include alternative pedagogical skills and practices (Morrison, Raab & Dale, 2009; Smith & Scharmann, 1999). Indeed, although understanding the nature of science seems to be an overly ambitious goal for science instruction, a variety of educators offer specific suggestions for achieving this goal (Duveen & Solomon, 1994; Scharmann, 1990). The key to these instructional approaches is the portrayal of science as a powerful but restricted human enterprise. In NOS instruction, teachers must explicitly address the beliefs and knowledge students bring into the classroom. Note here that the goal of such instruction is not to change students’ religious beliefs.
or persuade them to accept evolutionary theory. Instead, the goal of such instruction should be to help students understand how science does not provide the only answers important in their lives. This concept that science is not the only source of answers, may lessen potential aversion to concepts related to evolution (Sinatra, Southerland, McConaughy & Demastes, 2003). Through what Dole and Sinatra (1998) called high engagement required by activities such as conducting inquiries, writing personal reflection and justifying one’s reasoning, the learner can examine her own beliefs and compare them with the content of evolution. If students are allowed the opportunity to juxtapose their beliefs against those ideas presented by the teacher, this can evoke relevant dispositions, such as the willingness to think deeply about a complex problem and question one’s own beliefs.

We also examined the effects of the family background on students’ conceptual ecology of the evolution education and acceptance, in two ways: on the one hand, we examined the level of parents’ education level, and on the other hand, their degree of religiosity in relation to students’ degree of acceptance of evolution. In their work, Deniz et al. (2008) had hypothesized that students whose parents achieved a higher education would more often support scientific views than their peers whose parents had a lower education. While their results supported their hypothesis, we did not find similar correlation. It seems, though feasible to suggest, that in our case we had to do with a population of students with parents that had altogether a higher degree of education (table 2), something that did not leave room for smooth distribution and correlations. On the other hand, the fact that we found significant negative correlation score between parents’ frequencies of religious practices and students’ acceptance of evolution theory in the pre-course survey comes to support their hypothesis, that family background is part of the conceptual ecology of the
learner. And, as Costa (1995) indicates, the successful transition of students from their own world to school science depends on the compatibility of family and school cultures. While learning a subject, such as evolution, does not have much leverage within the social and cultural milieu it requires a major shift in conceptual ecology or in the worldview (Cobern, 1994). In our case, it appears that the impact of the family and cultural milieu was modified to a certain degree when the participants came in contact with new ideas and evidence.

Our findings with regard to the relationship between thinking dispositions and acceptance of evolutionary theory are in line with findings by Sinatra et al. (2003). That is, participants whose thinking disposition scores reflected more open-minded thinking were more likely to accept evolutionary theory. Considering our findings and the findings of Sinatra et al. (2003), it seems reasonable to consider that dispositions should be included in the conceptual ecology for biological evolution. Pintrich et al. (1993) also suggested that thinking dispositions should be considered when explaining learning as conceptual change.

An interesting point that was seen in this research has to do with the individual characters of religious background or the type of fundamentalism seen in certain members of this society and its contribution to the conceptual ecology of the evolution education. Paradoxically, although they are part of one of the most religious societies, according to the European Barometer (2005), Greek students showed a high degree of AOT (mean=142) compared to other studies: in Deniz’ case, for example, the AOT was found to be 112. It seems reasonable to accept that the kind of religiosity and the substance of religious fundamentalism seen in a specific society should also be taken into account when making out its conceptual ecology in connection to the acceptance of the evolutionary theory. In their paper, Deniz et al.
(2008) discuss the type of fundamentalism in Islam, while Scott (2000), refers to the situation in the USA as follows: “...perhaps the most important reason modern antievolutionism developed here (in USA) rather than in, say, Europe, was the founding in 1910-1915 of Fundamentalism, a Protestant view that stresses the inerrancy of the Bible. Fundamentalism was not successfully exported to Europe or Great Britain, but it formed the basis in the United States for the antievolutionism of the 1920s Scopes trial era, as well as the present day...”.

This kind of fundamentalism can be contrasted to the one occurring in countries with Catholic and Greek-Orthodox backgrounds: the latter are sharing a characteristic in common, while they are differentiated in others, in reference to their type of antievolutionism. Their common characteristic is that the Scriptures are always seen within the context of Holy Tradition, which gave birth to the Scripture. Eastern Orthodoxy and Catholicism maintain that belief in a doctrine of *sola scriptura* would mostly lead to error since the truth of Scripture cannot be separated from the traditions from which it arose. Orthodox and Catholic Christians therefore believe that the only way to correctly understand the Bible is within the Church, a view that leaves room for reading the book of Genesis in a less literal way. On the other hand, Eastern Orthodoxy and Catholicism, distinguish themselves from each other insofar as the catholic world accepts a single centre of guidance, i.e. Vatican and Pope. On the contrary, Eastern Orthodoxy only recognizes an Ecumenical Patriarch, whose role is more symbolic and “ornamental”. Thus, the fact that there does not exist an Orthodox centre to declare something similar to what the Pope John Paul II said in his speech to the Pontifical Academy of Sciences about evolution, (Collins, 1996), “… *new findings lead us toward the recognition of evolution as more than a hypothesis*...”, has left Eastern Orthodox societies, like the Greek one, attached to the dogma of Evolution...
rejection, albeit in a relatively superficial or trivial way. This probably can give some explanations to both, the evolution acceptance increase seen among Greek students in accordance to knowledge acquiring and to the high degree of their thinking disposition, as recorded in their high AOT score recording.

The latter is more interesting if we think of the type of students we addressed in our study, compared to let’s say analogous studies in the USA or Turkey, where similar studies have been conducted with students that had long engagement with the evolutionary theory in their role as prospective biology teachers (Rutledge & Warden 1999, 2000; Deniz et al. 2008). Contrary to that, we addressed students of education that previously had little or no engagement with the theory of evolution. Thus, it seems reasonable to say that their high thinking disposition, contributed substantially to the appeal that the evolution teaching had on them.

We are coming now to the fact that a certain body of students in our study, although ready to some degree to change their views on evolution, in general, did not shift at all from their views on human evolution (Table 2). This is totally understandable, according to Lemke (2001), from the sociocultural perspectives point of view. For a creationist, for example, to adopt an evolutionist view of human origins is not just a matter of changing their minds about the facts or about what constitutes a rational explanation of the facts. It would mean changing a core element of their identity as Bible-believing Christians or breaking essential bonds with their community. It would probably also, mean social ostracism and the ruin of someone’s business or job prospects. It could complicate their family life or their marital situation. The point here is that beliefs about the natural and social world have coevolved in cultures along with the entire complex network of social practices that bind a community together.
Oftentimes, in our well-intentioned efforts, we do not take into account that learning is not just a matter of whether we can understand a scientific account, but also of whether our social and cultural options in life make it in our interest to do so (Lemke, 2001). Thus, student interest in, attitudes with respect to and motivation toward science and student willingness to entertain particular conceptual accounts of phenomena heavily depend on community beliefs, acceptable identities, and the consequences to a student’s life outside the classroom in spite of our well-intentioned efforts.

Conclusions

Our study was an effort to explore the factors that are related to the acceptance of evolutionary theory among prospective Greek educators using conceptual ecology for biological evolution as a theoretical lens. We employed a correlational research approach, in a large group of students describing the relationships between the various constructs. As independent variants we used students’ thinking dispositions, their understandings of the evolutionary theory and improvement in knowledge, their epistemological beliefs, thinking dispositions, their parents’ educational level and their own, and finally, their parents’ frequency of religious practices and general religiosity.

One of our findings comes to support the suggestion that although teaching and learning evolution in a biology class is more than a cognitive-only process, its proper placement in the general structure of the Biology course and teaching may result in the increase of its acceptance. One such case may be a biology course organized around evolution as its teaching framework. Of course, conceptual ecologies have influence on the process of teaching and learning. For that reason, our understanding process may show substantial progress if we are ready to explore
relationships between cognitive and affective domains. This is more obvious when we
deal with topics like biological evolution that exhibit strong sociocultural effects. In
our case, the type of religiosity of the specific society was found to be related to their
thinking dispositions and this in turn seemed to be part of their conceptual ecology,
two parameters directly affecting the acceptance of and readiness to embrace a better
understanding of the evolution theory.

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Table 1: Measures, instrumentation and participants.

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<th>Pre-course survey</th>
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<td>Parents’</td>
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<tr>
<td>educational level</td>
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<tr>
<td>Evolution</td>
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<td>Theory</td>
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<tr>
<td>Knowledge Measure</td>
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<tr>
<td>Measure of</td>
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<td>Acceptance of the</td>
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<tr>
<td>Theory of Evolution</td>
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<tr>
<td>(MATE)</td>
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<tr>
<td>Frequency of</td>
<td></td>
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<tr>
<td>Religious</td>
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<tr>
<td>Practices</td>
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<table>
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<td>Demographics:</td>
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<td>educational level</td>
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<td>Evolution</td>
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<tr>
<td>Theory</td>
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<td>Knowledge Measure</td>
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<td>Measure of</td>
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<td>Acceptance of the</td>
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<td>Theory of Evolution</td>
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<tr>
<td>(MATE)</td>
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<tr>
<td>Frequency of</td>
<td></td>
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<tr>
<td>Religious Practices</td>
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<tr>
<td>Thinking dispositions</td>
<td></td>
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<tr>
<td>measure: Actively</td>
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<tr>
<td>Open-Minded</td>
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<tr>
<td>Thinking Scale (AOT)</td>
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Table 2: Means, standard deviations, with maximum and minimum scores of surveys’ responses.

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<th>SD</th>
<th>Maximum</th>
<th>Minimum</th>
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<td>71.92</td>
<td>7.49</td>
<td>90</td>
<td>41</td>
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<td>Understanding of evolution</td>
<td>5.04</td>
<td>1.56</td>
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<tr>
<td>Subscale 1</td>
<td>3.38</td>
<td>1.24</td>
<td>7</td>
<td>1</td>
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<tr>
<td><strong>Subscale 2</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>(procedures and practices on the evolution of populations)</td>
<td>1.71</td>
<td>0.90</td>
<td>4</td>
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<td>Parents’ education level</td>
<td>3.47</td>
<td>0.82</td>
<td>5</td>
<td>0</td>
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<tr>
<td>Student’s frequency of religious practices</td>
<td>6.25</td>
<td>2.78</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td><strong>Post-course survey (N=112)</strong></td>
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<td></td>
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<tr>
<td>Acceptance of evolution (MATE)</td>
<td>74.72</td>
<td>9.75</td>
<td>100</td>
<td>45</td>
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<tr>
<td>Understanding of evolution</td>
<td>9.10</td>
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<td>13</td>
<td>4</td>
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<td>Subscale 1</td>
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<td><strong>Subscale 2</strong></td>
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<td>1.25</td>
<td>5</td>
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<td>0.99</td>
<td>5</td>
<td>1</td>
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<td>Student’s Frequency of Religious Practices</td>
<td>6.82</td>
<td>3.43</td>
<td>15</td>
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<td>Thinking dispositions (AOT)</td>
<td>144.23</td>
<td>13.68</td>
<td>174</td>
<td>110</td>
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<tr>
<td><em>(possible min=41, max=205)</em></td>
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<td>Table 3: Internal consistency estimates for each scale.</td>
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<td>-------------------------------------------------------</td>
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<tr>
<td>Cronbach's Alpha</td>
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<tr>
<td>Pre-course survey</td>
<td>Post-course survey</td>
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<td></td>
<td></td>
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<tr>
<td>Acceptance of evolution (MATE)</td>
<td>0.79</td>
<td>0.87</td>
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<td>Subscales: Scientific validity of evolution theory</td>
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<td>The processes of evolution</td>
<td>0.75</td>
<td>0.73</td>
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<tr>
<td>The evolution of humans</td>
<td>0.71</td>
<td>0.75</td>
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<tr>
<td>Evidence of evolution</td>
<td>0.69</td>
<td>0.63</td>
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<td>The age of the earth</td>
<td>0.83</td>
<td>0.76</td>
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<tr>
<td>The current status of evolutionary theory within the scientific community</td>
<td>0.65</td>
<td>0.72</td>
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<tr>
<td>Understanding of evolution</td>
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<td>0.55</td>
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<td>Parents' Frequency of Religious Practices</td>
<td>0.76</td>
<td>-</td>
<td>0.70</td>
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<tr>
<td>Thinking dispositions (AOT)</td>
<td>-</td>
<td>0.78</td>
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Table 4:
Intercorrelations among acceptance of evolution, thinking dispositions, parents’ education, and students’ frequency of religious practices.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>5</th>
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<tr>
<td>1. Acceptance of evolution</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Students Frequency of Religious Practices</td>
<td>-0.20*</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>4. Parental Education Level</td>
<td>0.01</td>
<td>0.05</td>
<td>0.10</td>
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<tr>
<td><strong>Post-course survey</strong></td>
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<td></td>
</tr>
<tr>
<td>1. Acceptance of evolution</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Students Frequency of Religious Practices</td>
<td>-0.26**</td>
<td>1</td>
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<td></td>
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<tr>
<td>3. Parental Education Level</td>
<td>-0.07</td>
<td>-0.17</td>
<td>1</td>
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<tr>
<td>4. Thinking dispositions</td>
<td>0.46**</td>
<td>-0.22*</td>
<td>0.14</td>
<td>1</td>
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</table>

*Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)
Table 5:
Summary of hierarchical (or sequential) regression analyses for variables explaining acceptance of evolutionary theory (post-test survey).

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE of B</th>
<th>beta</th>
<th>Adjusted R²</th>
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<tr>
<td>Step 1</td>
<td></td>
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<td></td>
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<tr>
<td>Thinking Dispositions</td>
<td>0.329⁰</td>
<td>0.06</td>
<td>0.51</td>
<td>0.248</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thinking Dispositions</td>
<td>0.300⁰</td>
<td></td>
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</tr>
<tr>
<td>Students frequency of religious practices</td>
<td>-1.423⁰</td>
<td>0.60</td>
<td>-0.223</td>
<td>0.288</td>
</tr>
</tbody>
</table>

R² = 0.257 for Step 1; ∆R² = 0.048 for step 2; B= unstandardized regression coefficient; SE of B= standard error of B; β = standardized regression coefficient. ⁰ p<0.01, ⁰ p<0.05.
Table 6: Acceptance of Evolution Theory: Teaching influence.

<table>
<thead>
<tr>
<th></th>
<th>Pre-course Mean</th>
<th>Post-course Mean</th>
<th>t</th>
<th>df</th>
<th>Sig (2-tailed)</th>
<th>Mean difference</th>
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<td>Scientific validity of evolution theory</td>
<td>21.45</td>
<td>22.72</td>
<td>-3.18</td>
<td>273</td>
<td>.002</td>
<td>-1.27</td>
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<tr>
<td>The processes of evolution</td>
<td>15.11</td>
<td>15.93</td>
<td>-3.01</td>
<td>276</td>
<td>.003</td>
<td>-0.82</td>
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<tr>
<td>The evolution of humans</td>
<td>7.54</td>
<td>7.87</td>
<td>-1.54</td>
<td>276</td>
<td>.124</td>
<td>-0.33</td>
</tr>
<tr>
<td>Evidence of evolution</td>
<td>13.55</td>
<td>14.25</td>
<td>-2.75</td>
<td>272</td>
<td>.006</td>
<td>-0.69</td>
</tr>
<tr>
<td>The age of the earth</td>
<td>6.95</td>
<td>7.42</td>
<td>-2.68</td>
<td>277</td>
<td>.008</td>
<td>-0.47</td>
</tr>
<tr>
<td>The current status of evolutionary theory within the scientific community</td>
<td>6.30</td>
<td>6.49</td>
<td>-1.22</td>
<td>273</td>
<td>.221</td>
<td>-0.19</td>
</tr>
<tr>
<td>Total Acceptance Score</td>
<td>70.95</td>
<td>74.71</td>
<td>-3.53</td>
<td>263</td>
<td>.000</td>
<td>-3.76</td>
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