

Evolution Theory Teaching and Learning: What Conclusions Can We Get From Comparisons of Teachers' and Students' Conceptual Ecologies in Greece and Turkey?

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In this study, we make an effort to compare studies that explore the factors related to acceptance of evolutionary theory among Greek and Turkish students-future teachers, using conceptual ecology for biological evolution as the theoretical framework. We aimed to look into the acceptance and the understanding of evolutionary theory and also to look into the relationship of the acceptance with understanding of evolutionary theory, parents' educational level, thinking dispositions and frequency of religious practising as independent variables by the use of studies conducted in both countries. Both studies found a correlation between students' understanding of evolutionary theory with acceptance of evolutionary theory, the same was recorded for religious practising and acceptance of evolution. A difference was observed in the case of contribution of parents' educational level and acceptance of evolution, where, we did not find any significant positive correlation between parents' educational level and acceptance of evolution, while that was true for Turkish society. Our findings with the comparative study of this type 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 from society to society and how sociocultural factors such as the type of religion as part of the conceptual ecology influence acceptance of evolution and have strong influence on evolution education.

Keywords: Evolution teaching, acceptance, conceptual ecology, Turkish students, Greek students

THEORETICAL FRAMEWORK

Conceptual change has now been improved as being both an affective and intentional process. Intentional

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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

State of the literature

- Mathematics is one of the core subjects in school curriculum. Performance in the subject is crucial for students' admission to scientific and technological professions. However, students often find mathematics too abstract, especially topics like geometry. This result in poor performance and ultimately decline in interest in mathematics.
- The aim of this study is to examine the impact of using the free educational software program, 'GeoGebra' on 9th grade student's mathematics achievement in learning geometry.
- Developing countries like India, resources for integration of technology in school education are very limited.

Contribution of this paper to the literature

- The literature of this paper is divided into four sections: Problem-solving and multiple representations, Information and Communication Technology (ICT) and multiple representations, GeoGebra, Status of ICT in schools in India.
- In the previous studies, researchers used software like Geometer' sketch pad, but this software is not able to provide multiple representations. On the other hand, GeoGebra provides multiple representations (both algebraic and geometric).
- In the previous studies, there were no evidences about status of ICT in schools in India. In the present paper, authors attempted to present an overview of availability of technology in India.

concepts the learner encounters. According to Posner's views on conceptual change (Posner et al. 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 in which one conception is completely abandoned for use of 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 and 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 importance. 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) believe 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. This means that there are instances, where the conceptual ecology of the learner must be taken in consideration before the teaching strategy is to be organized and applied (Demastes-Southerland, Good & Peebles, 1995).

An apparent assumption of conceptual change perspectives in science education, 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, is, according to Lemke (2001), in contrast 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, Good, & Peebles, (1995), described, originally, 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 evolution—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. Other factors that seem to influence one's acceptance of the evolutionary theory is thinking dispositions and her epistemological beliefs.

More recently, Deniz, Donnelly, & Yilmaz, (2008), based on the evolution education literature suggest four other components in someone's conceptual ecology for biological education, namely his/her reasoning level, their perceptions of the impact of the evolutionary

theory, their epistemological beliefs and thinking dispositions. Thinking dispositions 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 would be more likely to accept evolutionary theory. Furthermore, Deniz, Donnelly, & Yilmaz, (2008) collected data from Turkish students with regard to parents' educational level because of the suspected relation to acceptance of evolutionary theory. They hypothesized, considering previous findings (Costa, 1995), that participants whose parents achieved higher educational degrees would be more likely to accept evolutionary theory. That was found to be true, at least for the Turkish society. Based on these and other findings we made an attempt to find some of the factors that contribute in making out the conceptual ecology of the Greek students, in connection to the acceptance of the evolutionary theory. At the same time, we tried to find out if we can make any contribution towards the hypothesis that it is not only the religion, in general, that affects someone's acceptance of the theory of evolution, but the type of religion and its qualitative characters, as well, something that it may be included among the factors that constitute someone's conceptual ecology of the evolution theory (Athanasiou, and Papadopoulou, 2012). Greek and Turkish societies and their educational systems are interesting from the biological evolution point of view: both societies might be characterized as two of the least "evolutionary" educated societies in the modern world. Indeed, those societies are possessing two of the lower positions on the evolutionary acceptance scale proposed by Miller, Scott, & Okamoto, (2006). It seemed feasible to us, that elaborating data and making comparisons from studies on student or/and teacher populations, which come of such societies with low knowledge and acceptance of evolution, can be a useful tool for following the effects of the acquisition and/or the increase of knowledge on evolution. Greece and Turkey, as two neighboring countries that have many similarities and many differences, at the same time, we felt that lend themselves to such comparisons, especially when there are studies that deal with the same subject, as is in this case the factors affecting the acceptance of evolution and the factors that influence the process, as well.

Greek and Turkish societies: Some Characteristics

Contextual Background of the Study

According to Deniz, et al. (2008), Turkey is a secular and democratic state founded in 1923 after the collapse of the Ottoman Empire. Turkey's population is

estimated to be about 70 million and 99% of the population is believed to be Muslim. Turkey's candidacy for membership in the European Union was officially recognized in 1999. Turkey started negotiations for its future accession to the European Union in 2005.

As for Greece, a European Union member state of about 11 million people, that has been recognized as a fully independent state in 1832. The Greek Orthodox Church, a member of the Eastern Orthodox Communion, is accorded the status of "prevailing religion" in Greece's constitution, and Greece is the only country in the world where an Eastern Orthodox Church is clearly recognized as a state religion. Its members comprise between 95% and 98% of the population, although recent surveys on the religiosity of Greek citizens seem to contradict these numbers (Eurobarometer, Special, 2010).

Education System in Greece and Turkey

The education system seems to be quite similar in both countries, with some minor differences, like the fact that in Turkey, basic education is compulsory for 8 years while in Greece is 9. Both countries have a centralized education system, the Ministry of Education determining the curriculum and setting the standards in elementary and secondary schools. The Ministry of Education is responsible for all educational services including hiring teachers, paying their monthly salaries, and maintenance of elementary and secondary schools. University education in both countries is regarded highly and students have to take the university qualification exam at the same time on a predetermined date, in order to enter the University. Students are placed in a program of their choice according to their exam scores.

Religion and Evolution in Turkey

In Turkey, the Qur'an and its interpretations heavily influence public understanding of how the Universe, the Earth, and living things came into existence. The evolution and creationism issue is hotly debated in Turkey, and teaching evolution in schools generates much public controversy (Sayin & Kence, 1999, Deniz et al., 2008).

The Qur'an mentions the creation of the Universe, the Earth, and living things. The Qur'an reminds Muslims that there is no natural event that happens without the permission of Allah (God). Noah's Flood was mentioned in the Qur'an, but Islamic scholars do not insist on the global extent of the flood. The concept of time in the Qur'an is relative. This means that a day should not be interpreted literally as 24 hours. As opposed to the "young Earth" creationists who believe that the Earth is less 10,000 years old, the "old Earth"

creationists accept the relativity of time. In this respect, it can be stated the concept of time adopted by the old Earth creationists and Muslims is similar. The fact that there is no specific process available to Muslims, according to the Qur'an, through which living things have come into existence, it may be believed that most Muslims would not have any problems with theistic evolution. However, this way of thinking is riddled with teleological problems. The Qur'an clearly states that there is a goal or aim in the creation of the Universe, the Earth, and living things. The teleological clash between Darwinian evolution and the Qur'anic verses is a major obstacle that causes many religious people to reject evolution as a scientifically valid theory (Deniz et al., 2008).

Religion and Evolution in Greece

Religion

The kind of fundamentalism existing in Greece seems to be different from the one in USA. Scott (2000), refers to the situation in USA as follows: "...But 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 viewed in opposition with 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 the make 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 most 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 grounds for reading the book of Genesis not in a literal way. On the other hand, Eastern Orthodoxy and Catholicism, they distinguish from each other in the make that in the catholic world exist a single centre of guidance, i.e. Vatican and Pope. On the contrary, in Eastern Orthodoxy even if it is reported an Ecumenical Patriarch, his role is more symbolic and decorative. 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, (Pope John Paul II (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, but in a relatively, superficial or trivial way.

Evolution

Greek society and its' educational system is interesting from the biological evolution point of view: the public educational system is very successful in totally exiling evolution education from all its "territory" without any profound prosecution or any other similar action, for many years. This has been "succeeded" by two simple steps: a) the chapter(s) of evolution has been always last in rank in all biology textbooks and b) it was not included in the teaching curriculum, in both, high school classes and in the university entrance exams. The latter might be related to the situation that the Greek society might be characterized as one of the least "evolutionary" educated societies in the modern world. Of course, there are some bright exceptions, especially with some private schools, where evolution is not only taught, but its' teaching is cultivated and research is made systematically on its' teaching (Kampourakis & Zogza, 2007, 2009). [Here, we must mention that the situation tends to change, and evolution teaching has been included in the University Entrance Exam for the last two years]. Thus, it seems very probable, that this lack of proper education may be related to the fact that this society is possessing one of the lower positions on the evolutionary acceptance scale proposed by Miller, Scott, & Okamoto, (2006) being only a few positions above the last two in rank countries, i.e. USA and Turkey.

Evolution acceptance and Thinking Disposition - AOT (Actively Open-minded Thinking).

Before we present our data on Thinking Disposition of the Greek students, in relation to Evolution acceptance, we thought it might be useful if we present some historical items for this society that may be of help in understating some of the findings of our study. When one looks into the recent history of the Greek society, they can realize that it has been very much marked by the establishment between the years 1967-1974 of a dictatorship that has influenced the whole Greek history and mentality of the newer era. In addition to any deprivation of freedom and severe persecution of the opponents, especially the leftists, the dictatorship regime of that time tried to pass and ideological lines, as well, through the triptych «Country, Religion, Family ". Of course, during this period, it was impossible for any occupation of the educational system with evolution,

and prevailed in Greek society religious terrorism of most preservatives cycles. It was during this period that in a visiting of the very Theodosios Dobshansky, (a person with a Greek-Orthodox background), to release a speech in a conference organized in Delphi by one of his students Prof. Kostas Krimbas, he received severe attack for his evolutionary ideas by some of the very eminent Greek-Orthodox theologians and scholars, a fact that affected Dobshansky very much (Krimbas, 2012). The fall of the dictatorship has been accompanied by major changes in the Greek society expressed by political radicalization and social and ideological changes that permeated the whole spectrum of social life. Special effect occurred in thinking of people and especially young people at universities, something that has been expressed by the way of conduct, the way of expression, policies and general ideas of the society. It is within this context in which one conducting research on Thinking Dispositions that should consider their findings, when it comes to this society, as it is the case with the findings of the present study.

The present study

Here are some of the questions that we had in mind and tried to focus in our research for some answers: What is the conceptual ecology of evolution of students in Greece? Is it different from the ones of some groups of Turkish students? We hypothesized that there should be differences among people from different cultures, because different sociocultural backgrounds and the 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 relation between individual religious orientations with acceptance of evolution? Do someone's family's religiosity and/or educational level, may affect his/hers evolutionary acceptance, as it was the case in the study of Deniz et al. (2008) with the Turkish society?

Are there relations 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, et al. (2003), before the beginning of their study, that there should be such correlation. In that case, why these and others, they did not find such a correlation, while this was found to be so 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

believe, are at the very heart of science education teaching and research, with the researchers having different views, according to their philosophical and epistemological beliefs and ways of thought (Southerland, Sinatra and Matthews, 2001).

And, finally, can the structure of a biology course, be a factor that can affect conceptual change on evolution, when the course is organized and structured having evolution as its central framework and theme? What is the effect of the attempt to make students familiar with the scientific method and the fact that evolution is not "just a theory" but a Theory in scientific terms?

In order to have some answers in our questions we reviewed a number of studies, took place in a Turkish context, related with the acceptance of the evolutionary theory (Table 1). Our main criteria to select studies for reviewing was to include a kind of measurement related to attitude towards evolutionary theory, acceptance or else and to be written in English.

From all studies, mentioned in table 1, only the fifth one (Deniz et al. 2008) - and partly the second (Deniz et al. 2011) fit well with our research in evolution conceptual ecology in the Greek context. That is because theoretical framework, measures and research instrumentation is almost the same. Consequently, we precede in direct comparisons of our research findings only with the findings of the two aforementioned Turkish studies. The other studies are of great importance in the discussion section.

METHODOLOGY

Turkish study: (Source, Deniz, et al., 2008)

Participants

A total of 132 Turkish pre-service biology teachers (95 women, 37 men) with a mean age of 19.8 years who were enrolled in a biology education program in the School of Education at the university.

Data Collection

Demographics: Items, concerning years spent in the biology education program and parents' educational level recorded using six possible options (elementary—1; middle school—2; high school—3; college—4; masters—5; and doctorate—6). The highest educational level achieved by either of the parents was used in the analysis.

Table 1. Synopsis of Turkish Research Related to the Acceptance of Evolution Theory

Study	Theoretical Framework	Variables or Factors – Research Instruments	Sample
1. Akyol, G., Tekkaya C. & Sungur, S. (2012).	N/A	Content knowledge. Acceptance – MATE. Demographics: family income, parent’s education level & employment status. Rate of perceived level of interest, self-perceived knowledge, prior experience in evolution and perceived necessity of introducing evolution in elementary science classes Acceptance – MATE	415 pre-service science teachers
2. Deniz, H., Hetin, F. & Yilmaz I. (2011).	N/A	Content knowledge Religious orientation question: <i>to what extent participants feel religious and to what extent religion plays an important role in their lives</i> Preference for teaching evolution Acceptance - MATE. Adaptation to the Turkish context.	147 Turkish preservice secondary biology teachers from 3 universities in Western Turkey
3. Peker D., Comert , G. G., Kence, A. (2010).	N/A	Understanding Type of high school	1,098 undergraduate students of biology education, and elementary science education in 11 public universities in Turkey.
4. Akyol, G., Tekkaya C. & Sungur, S. (2010).	N/A	Acceptance – MATE Content Understanding of NOS – NSAAQ Acceptance – MATE	136 pre-service science teachers
5. Deniz, H., Donnelly, L. & Yilmaz, I. (2008).	Conc. Ecology	Parents’ educational level Content knowledge Epistemological beliefs Thinking dispositions – AOT	132 Turkish preservice biology teachers

Table 2. Internal Consistency Estimates for Each Scale in Turkish Study

	Cronbach's Alpha
Acceptance of evolution (MATE)	0.92
Understanding of evolution	0.98
Thinking dispositions (AOT)	0.72

Content knowledge measure: A modified version of a scale developed by Johnson (1985) and used by Rutledge and Warden (2000). This scale consists of 21 multiple-choice questions that were). 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, whereas a score of 0 indicated no understanding of evolutionary theory.

Acceptance measure: Preservice biology teachers’ acceptance of evolution was assessed by the measure of acceptance of the theory of evolution (MATE), developed by Rutledge and Warden (1999). This measure consists of 20 items that employ a 4-point Likert scale (4¼“strongly agree,” 3¼“agree,” 2¼“disagree,” 1¼“strongly disagree”). High ratings reflected a higher acceptance of the theory of evolution.

Epistemological beliefs measure: Participants completed a 38-item epistemological beliefs scale developed by Wood and Kardash (2002). Preservice teachers responded to each question using a 4-point Likert scale (4¼“strongly agree,” 3¼“agree,” 2¼“disagree,” 1¼“strongly disagree”).

Thinking dispositions measure: Participants also completed the AOT scale (Stanovich & West, 1997; Sa’ et al., 1999).

Internal consistency estimates for each scale in the Turkish study are presented in table 2 whereas the descriptive statistics concerning all the measurements in the Turkish study are presented in table 4.

Table 3. Internal Consistency Estimates for Each Scale in Greek Study in Both Pre, Post Survey

	Cronbach's Alpha	
	Pre-course survey	Post-course survey
Acceptance of evolution (MATE)	0.84	0.86
Understanding of evolution	0.51	0.81
Religious orientation	0.67	0.74
Thinking dispositions (AOI)	-	0.71

Table 4. Means, standard deviations, and maximum and minimum scores of surveys' responses in Turkish study.

	Mean	SD	Max	Min
Acceptance of evolution (MATE)	50.95	9.76	71	23
Understanding of evolution	9.29	2.40	17	4
Thinking dispositions (AOI)	111.93	8.95	130	82
Parents' education level	2.43	1.16	5	1
Religious orientation	6,82	3,43	15	0

Table 5. Means, Standard Deviations, and Maximum and Minimum Scores of Surveys' Responses in Greek Study.

	Mean	SD	Maximum	Minimum
Pre-course survey (N=112)				
Acceptance of evolution (MATE)	71.89	7.81	91	40
Understanding of evolution	5.04	1.59	9	1
Parents' education level	3.36	0.84	4	0
Religious orientation	6.37	2.81	12	0
Post-course survey (N=112)				
Acceptance of evolution (MATE)	74.98	9.99	113	45
Understanding of evolution	9.10	2.17	13	4
Thinking dispositions (AOI)	144.82	13.69	174	110
Parents' education level	3.51	0.99	5	1
Religious orientation	6.82	3.43	15	0

Greek Study

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. Students in Early Childhood Education Department have the same educational background in evolution theory with the average educated people in Greece, with the probable exception of life sciences students and scientists.

The course: Participants, were taught a biology course, that had evolution to be its' central unifying theme and framework (for a detailed description of the course see Athanasiou & Papadopoulou, 2012).

Procedure: We surveyed students on the first day (pre-course survey) and at the end of the course (post-course survey). At pre-course survey we received 168 questionnaires completed, whereas we received 112 at the post course survey. Responses were used in our subsequent analyses and according to the case we used data either from all participants, or only the ones that responded to both questionnaires.

Data Collection

Demographics: Students responded to two demographic questions which were focusing on their parents' educational level. Parents' educational level was measured using six possible options and the highest educational level achieved by either of the parents was used in the analysis.

Knowledge measure and Acceptance of Evolution assessment: Similar to the Turkish study.

Religious orientation: Students' and their parents' frequency of attending ecclesiastic activities was recorded by three questions. It 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 religious orientation (by adding students and hers father and mother religious orientation) and in consequent analysis we used both scores, individual students score and total religious orientation score. There was, also, a question concerning students' opinion about taking or not the writings of Bible literally and another asking their general attitude towards religion.

Table 6. (Adapted from Deniz et al., 2008). Intercorrelations Among Acceptance of Evolution, Understanding of Evolution, Thinking Dispositions, Parents' Education in Turkish Study.

Measure	1.	2.	3.	4.
1. Acceptance of evolution	1			
2. Understanding of evolution	0.31**	1		
3. Thinking dispositions	0.46**	0.23*	0.25*	
4. Parental Education Level	-0.69	-0.05	-0.03	-0.03

*Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

Table 7. Intercorrelations Among Acceptance of Evolution, Understanding of Evolution, Thinking Dispositions, Parents' Education, Students' Religious Orientation and Total Religious Orientation in Greek Study.

	1	2	3	4	5	6
Pre-course survey						
1. Acceptance of evolution	1					
2. Understanding of evolution	0.20*	1				
3. Student's Religious orientation	-0.20*	-0.01	1			
4. Total Religious orientation	-0.25**	-0.07	0.89**	1		
5. Parental Education Level	0.01	0.01	0.05	0.10	1	
Post-course survey						
1. Acceptance of evolution	1					
2. Understanding of evolution	0.31**	1				
3. Student's Religious orientation	-0.26**	0.03	1			
4. Total Religious orientation	-0.13	0.08	0.82**	1		
5. Parental Education Level	-0.69	-0.05	-0.17	-0.06	1	
6. Thinking dispositions	0.46**	0.23*	-0.22*	-0.15	0.14	1

*Correlation is significant at the 0,05 level (2-tailed)

** Correlation is significant at the 0,01 level (2-tailed)

Internal consistency estimates for each scale in the Greek study (pre, post-test) are presented in table 3 whereas the descriptive statistics concerning all the measurements in the Greek study are presented in table 5.

RESULTS

Turkish study (adapted from Deniz, et al., 2008)

Intercorrelations among acceptance of evolutionary theory, understanding of evolutionary theory, thinking disposition, parents' education level, epistemological beliefs subscales, and students' year in biology education program are presented in Table 4. It was found a significant correlation between participants' knowledge of evolution and their acceptance of evolution ($r=0.20$, $p<0.05$). Thinking dispositions were significantly correlated with acceptance of evolution ($r=0.27$, $p<0.01$). A significant correlation between parents' education level and participants' acceptance of evolution ($r=0.19$, $p<0.05$) was found.

Understanding of evolution, thinking dispositions, and parents' educational level were not correlated among themselves. Therefore, variance explained by each of these factors in the acceptance of evolutionary theory was unique. Understanding of evolution

accounted for 3.3% of the variance, $F(1, 131) = 5.43$, $p<0.05$. The addition of thinking dispositions to the regression model increased the variance explained. Understanding of evolution and thinking dispositions together accounted for 8.3% of the variance, $F(2, 130) = 6.9$, $p<0.01$. In step 2, the addition of parents' education level to the previous regression model further increased the variance explained. Understanding of evolution, thinking dispositions, and parents' education level together explained 10.5% of the variance, $F(3, 129) = 6.1$, $p<0.01$. (See Table 6).

Greek study

Intercorrelations among acceptance of evolutionary theory, understanding of evolutionary theory, thinking disposition, parental education level, students' and parents' religious orientation, and total religious orientation are presented in Table 7. We found a significant correlation between participants' knowledge of evolution and their acceptance of evolution both in pre course survey ($r=.20$, $p<0.05$) and post course survey ($r=.31$, $p<0.001$) (table 5). Thinking dispositions were significantly correlated with acceptance of evolution (post course survey, $r=.46$, $p<0.01$). No significant correlation between parental education level and participants' acceptance of evolution was found,

neither in pre- nor in the post-course survey (table 7). In the Greek study we record a high educational level (table 5), as the 50% of the students have at least one parent with a university (or technological college) level of education.

We found a significant negative correlation between students' religion orientation and acceptance of evolution theory score, in both pre and post course surveys (pre-test: $r=-.20$, $p<0,05$, post-test: $r=-.26$, $p<0,01$) (table 7). We also found a significant negative correlation between religious orientation total score and acceptance of evolution only in pre course survey ($r=.25$, $p<0,01$) (table 7). Significant negative correlation between parents' frequencies of church attendance and students' acceptance of evolution theory score, was found in the pre course surveys (mother's: $r=.25$, $p<0,01$, father's: $r=.20$, $p<0,05$) (table 7).

Greek education students could be considered as religious according to international standards: more specifically in the pre-course research, a 25% of them declared attending church mass between 1-4 times per month, while in the post-course research a 30% of them declared applying religious practices from daily to three per month. But despite their high religiosity, they rather believe more in the symbolic nature of biblical creation narrative (table 10). The last is true even for students that are taking frequently part in religious practices, an aspect we discuss latter in the discussion.

Understanding of evolution, thinking dispositions,

and students' religious orientation were not correlated among themselves (table 7). Therefore, students' thinking dispositions accounted for 24,80% of the variance of acceptance score ($F(1,84)=28,730$, $p<0,01$). Thinking dispositions and student's religious orientation together accounted for 28,80% of the variance, ($F(2,84)=18,029$, $p<0,01$) (see Table 9).

Pre-, Post- course estimations of understanding and acceptance

We found a significant influence of teaching biology with theory of evolution as a frame of the course in both acceptance ($t=3.256$, $p<0,01$) and understanding ($t=14,790$, $p<0,01$) of evolution. In both tests we reject null hypothesis and accept the alternative, that there is a significant difference between the means of the two variables, in pre and post course test. In other words we found a significant improvement of understanding and acceptance of evolution after teaching.

DISCUSSION

As it is mentioned in the introduction, while there are several publications listed on the acceptance of Evolution, we chose and do the comparison between the specific two works from Turkey and Greece, due to the fact that both deal with the conceptual ecology of evolutionary theory (CEET), in similar population

Table 8. Summary of Hierarchical (or Sequential) Regression Analyses for Variables Explaining Acceptance of Evolutionary Theory in Turkish Study.

Variable	B	SE of B	β	Adjusted R ²
Step1: Understanding	0.80	0.34	0.20 ^a	0.033
Step 2: Understanding	0.65	0.34	0.16	0.083
Thinking Dispositions	0.26	0.09	0.24 ^b	
Step 3: Understanding	0.70	0.34	0.17 ^a	0.105
Thinking dispositions	0.24	0.09	0.22 ^b	
Parens' education	1.44	0.70	0.17 ^a	

R²= 0,033 for Step 1; $\Delta R^2= 0,05$ for step 2; $\Delta P^2= 0.022$ for step 3. B= unstandardized regression coefficient; SE of B=standard error of B; β =standardized regression coefficient. ^a $p<0,05$, ^b $p<0,01$.

Table 9. Summary of Hierarchical (or Sequential) Regression Analyses for Variables Explaining Acceptance of Evolutionary Theory in the Greek Study (Post Test Survey)

Variable	B	SE of B	β	Adjusted R ²
Step1:				
Thinking Dispositions	0.33 ^a	0.06	0.51	0.248
Step 2:				
Thinking Dispositions	0,30 ^a			
Student's religious orientation	-1.42 ^b	0.60	-0.223	0.288

R²= 0,257 for Step 1; $\Delta R^2= 0,048$ for step 2; B= unstandardized regression coefficient; SE of B=standard error of B; b=standardized regression coefficient. ^a $p<0,01$, ^b $p<0,05$.

Table 10. Greek Students' Frequency of Religious Practices in Relation to Their Belief in the Literal/Symbolic Nature of the Biblical Narrative.

Valid answers=109		Students' Belief in the literal nature of Old Testament narrative about Creation				
		Totally disagree	Disagree	Undecided	Agree	Total
Students' frequency of religious practices	Daily	4	9	9	2	24 (22%)
	Once a week	0	6	1	0	7 (6.4%)
	1-3 times/a month	3	4	7	2	16 (14.7%)
	Sometimes/ year	8	6	6	1	21 (19.3%)
	Maximum once/ year	6	15	8	4	33 (30.3%)
	Rarely or Never	4	4	0	0	8 (7.3%)
Total		25 (22.9%)	44 (40.4%)	31 (28.4%)	9 (8.3%)	109 (100%)

groups (students-perspective teachers), in relatively short periods in two neighboring countries (Turkey and Greece) that hold together with the USA, some of the lower positions in the acceptance scale in the corresponding study of Miller, et al. (2006). Between the two neighboring peoples, there are significant differences in item issues of religion, ethnicity, language, culture. At the same time, there are important similarities, some of which help significantly, in our opinion, in understanding the factors related to the conceptual ecology of the Evolution teaching and learning.

So, a 1st question that may be answered by the comparative study is why it is so low the acceptance of Evolution in these two countries? It seems that this may be related to a number of factors, among which important position may possess the knowledge and the degree of Evolution teaching. In our case, there was a long period of years where the teaching of evolution had been expelled from the Greek educational system, and this in turn, had as a result low knowledge and acceptance. This view is strongly supported by the fact that in all the studies we have done with Greek students, the improvement in knowledge of evolution led to better acceptance (Athanasiou, et al., 2012, Athanasiou and Papadopoulou, 2012). Furthermore, after the introduction of Evolution as a teaching chapter in the Entrance to University Examination in 2010, it seems that has contributed very much to the situation, where our latter students begin their studies now, by reaching scores in the pre-course evolution acceptance scale of higher levels than before, to such degree, as it was the post score rating in previous years (Athanasiou, et al., 2012).

And this, in turn, leads to the discussion of the 2nd finding which is the correlation between knowledge and acceptance. Actually, in both studies, it was found a correlation between acceptance and knowledge, something that comes in agreement to some American or other studies, but in disagreement to others, as well.

Indeed, there seems to be at that point an agreement to some people in the field that find similar results, (Lawson & Worsnop, 1992), while stands in contrast to others' views (Sinatra et al., 2003, Bishop & Anderson, 1990). As a matter of fact, there seems to be cases, where students may have an understanding of evolutionary theory without accepting its validity, while in other cases, it is the content of one's knowledge that serves as a barrier or as a facilitator to acceptance. In our case, teaching a biology course that used evolution as its theoretical framework, contributed in increasing the knowledge of the students and, consequently, their acceptance of the theory of evolution (Alles, 2001). Nonetheless, this increase in knowledge was not to the degree to make them change their level of acceptance (MATE). As it is seen in table 5, while the level of knowledge on evolution almost doubled, the level of MATE score, although increased significantly from an original mean value of 70,95 to a mean value of 74,72, it remained in the same range of medium acceptance (mean 76-65), as it has been estimated by Rutledge and Warden, (2000). A careful study of the MATE sections in Athanasiou & Papadopoulou (2012) shows that this "withholding of beliefs" could be attributed to two concepts that remained without effect: 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. a constituent 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.

A 3rd interesting point that was seen in this study is related to the type of religious background or the type of fundamentalism seen in a certain society and its

contribution to the conceptual ecology of the evolution education. Paradoxically, Greek students, although they are part of one of the most religious societies, according to the Eurobarometer (Wikipedia, 2005), they showed a high degree of AOT (mean=144.82, table 5). The latter should be seen within the context explained in the introduction, and the consequences of the major changes having made in this society during the last few years, (see the AOT section), affecting very much the way of collective thinking and believes. 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 thinking dispositions should be included in the CEET.

We, also, examined the effects of the family background on students' CEET and acceptance, in two ways: we examined, in one hand, the level of parents' education level, and in the other, their degree of religiosity, in relation to students' degree of acceptance of evolution. Denis et al. (2008) in their work had hypothesized, that students whose parents achieved a higher level of education would more often support scientific views than their peers whose parents had less education. While their results supported their hypothesis, we did not found 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, something that did not leave grounds for smooth distribution and correlations (tables 7,9). And, as Costa (1995) stresses out, 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 that does not have much leverage within the social and cultural milieu requires a major shift in conceptual ecology or in the worldview (Cobern, 1994). In our case, it seems 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. These findings, altogether, comprise the 4th contribution of the present paper that has to do with the variety of the factors that constitute the CEET. According to our findings the latter seems not to be sole throughout the world. In some countries, like Turkey, there should be included the parents education level, while in others, like Greece, this might be omitted. What should not be omitted as a vital constituent of the CEET is the Type of Religiosity, a suggestion which constitutes the 5th contribution of the present work.

At this point, we think that it is worthy to mention that both groups of researchers (us and Deniz et. al., 2011) use concomitantly without any previous agreement, and, probably, for the first time in this kind of literature, the term "religiosity" and, both find a negative correlation with knowledge and acceptance of evolution. For example, when Miller et al., (2006) examine this factor in relation to evolution acceptance, they use the term "Religious belief" and they put and set as an indicator that came with it the degree of frequency that someone devotes to praying. The situation is quite different in Greece, (and probably in Turkey), where people do not show their religious feelings, mostly, by frequent preying (as it is the case with typical Protestant believers), but by imparting broad and varied activities that reveal a more general and "looser" type of religiosity: such is the confession, making their cross, fasting, mass following, reading the synopsis or the Quran, etc..

CONCLUSIONS

Our present work is an effort to make a comparative study in order to explore some of the factors that are related to the acceptance of evolutionary theory among Greek and Turkish perspective educators using conceptual ecology for biological evolution as theoretical lens. One of the questions we tried to answer by this approach is whether or not there is a correlation between the acceptance of Evolution in relation to its knowledge. The answer to such questions can be useful when we aim to teach Evolution to students and teachers. The information taken from the studies in the two countries indicate that there is no single answer to this question and that the acceptance of Evolution is correlated to a number of factors, among which key role plays the kind of religiosity a population possesses. When this is not of the kind that can make someone to have proper thinking dispositions, students and teachers find it hard to accept the truth of the theory and this has as result to make the teaching towards knowledge increase to look like a wasted effort. In contrast, when the conceptual ecology propose a proper thinking disposition in the target group, then the knowledge increase may be a feasible goal, it can drive better acceptance, and this all together may lead to a positive feedback between acceptance and knowledge of evolution. We suggest that the teacher of Biology should always be familiar with the Conceptual Ecology of their students, trying to know their religiosity characteristics, their familiarity with NOS, and their epistemological believes, before organizing her teaching strategy on Evolution teaching.

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