Journal of Genetics and Cell Biology
JGCB, 3(2): 158-161
www.scitcentral.com

ISSN: 2639-3360

Short Communication: Open Access

The 'Geological Argument' as an Instrument for the Acceptance of the Theory of Evolution among Greek Science Teachers

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Received February 13, 2020; Accepted February 17, 2020; Published August 16, 2020

ABSTRACT

This paper examines the significance of 'geological argument' (age of earth, geological changes, stromatography, fossils) in the process of accepting the Theory of Evolution by Natural Selection (TENS), by Greek teachers that teach biology. It is a part of a wider research process, examining the conceptual ecology of evolution. That would be the most relevant terminology relating to the TENS (acceptance, understanding, opinions on the nature of science, way of thinking, religiosity) and their interconnectedness. The research was mainly quantitative, and it has been performed by the use of a closed-ended questionnaire. In addition, we used a qualitative methodology through semi-structured interviews, in order to deepen and interpret the findings of the quantitative method. The results show that there appears to occur an especially high acceptance of the TENS amongst geologists that teach biology in secondary education, compare to similar teachers of science. A finding that may lead to the conclusion that the "geological arguments" are especially strong in the process of accepting the TENS and suggest that they might, therefore, be used more often in the teaching of evolution.

Keywords: Theory of Evolution by Natural Selection (TENS), Geology, Conceptual ecology, Acceptance of the TENS, Evolution, Age of the earth, Fossils

INTRODUCTION

The topic of the TENS and its acceptance, both by the general population and by interest groups, comes constantly on the surface since there is an, almost global, emergence of a process of questioning the TENS and an effort to involve it in ideological and religious conflicts. This phenomenon has a history and depth both in Greece, but also globally. It is a well-known fact that the TENS, regardless of its central role in the field of biology but also in the field of epistemology and the wider process of though, has always had a high proportion of reaction by the wide audience and the academic community, mostly from those who are not life scientists.

The issue of accepting or rejecting the TENS is not dealt with independently in modern research. It is fully accepted that the factors that affect the acceptance of the TENS interact and express themselves differently in different environments. That is the main idea of conceptual ecology. Conceptual ecology is a term introduced by Toulmin [1] and used by Posner and his coworkers to describe the conceptual environment, the ecosystem of terms, or alternatively, the sum of terms surrounding an issue and the relations between them. In 1982, Posner and his coworkers introduced the first model of conceptual change. They revised it on 1992 and it was later adopted by several other researchers. In the field of biology and particularly in the TENS, conceptual ecology has been defined and used by many researchers [2-4].

THESIS

The purpose of this paper is to highlight the importance of these 'geological arguments' (age of earth, geological changes, stromatography, fossils) in the process of accepting the TENS by Greek teachers that teach biology.

METHODOLOGY

This research is part of a wider research, on the factors that affect the acceptance of the TENS by Greek teachers and students. These factors were not dealt with individually, but as a sum, in the theoretical framework of conceptual ecology. The main part of the research was quantitative and addressed to all teachers teaching biology in secondary education. It was done through a closed-ended questionnaire.

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Citation: Katakos S & Athanasiou K (2020) The 'Geological Argument' as an Instrument for the Acceptance of the Theory of Evolution among Greek Science Teachers. J Genet Cell Biol, 3(2): 158-161.

More than 306 teachers of relevant specialties fully responded.

The main tool for this research is the questionnaire that was developed specifically for this thesis. The questionnaire was based on pre-existing international scales. It consists of 6 sections, with answers on the five-tier Linkert scale. The first section focuses on demographics. The second section is the basic scale of accepting the TENS. The MATE scale (Measure of Acceptance of the TENS was built on 20 questions. The third section concerns knowledge and understanding of the TENS by teachers. A well-known scale developed by Johnson, and modified by [5] was chosen, which is composed of 21 multiple choice questions that covers the basic sectors of knowledge regarding the TENS; natural selection, convergent evolution, intermediate forms, adaptive radiation, species formation, evolutionary values, fossils, biogeography, environmental changes, genetic diversity and reproductive success.

The fourth section concerns opinions on the nature of science and scientific methodology while the fifth section depicts the way of thinking of the teachers, their predispositions and how dogmatic or open-minded they are. A scale of 41 questions is used, developed by researchers. Lastly, the sixth section examines the religiosity of the teachers through five independent questions that cover a broad range of religious meanings and practices. The five questions about religiosity investigate the frequency of religious practices, the self-definition of religiosity, the interpretation of biblical texts (realistic or symbolic), their opinion on the role of religion and the manner of their upbringing. The data of the quantitative research were statistically processed with the SPSS Software, edition 19 (PASW18).

The qualitative method of research was used here as a tool of completion and expansion of the data the quantitative research supplied. Conceptual ecology interweaves beliefs, opinions, faith and other strong emotional and social factors [6]. This is why we find the qualitative approach necessary in helping to deeply understand the way the TENS is experienced and interpreted, but also in discovering new aspects and dimensions of the topic examined and understanding it more in depth [7-10].

The main tool of the qualitative research was the questionnaire of the semi-structured interview. This questionnaire is based on and compliments the structured questionnaire used for the quantitative part of the research [11-15]. It has the same section structure and it includes exploratory questions that either expand or deepen the meanings, beliefs and opinions expressed and examined in the quantitative research [16-19]. It was clear that during the interview and discussion there was a large degree of freedom regarding expressing opinions and beliefs relevant to the topics discussed, but also on completely new topics. Eight teachers of all of the relevant specialties participated.

RESULTS

Therefore, a specific research on geologist that teach biology in secondary education was designed. This specific research gathered data from 34 geologist in total. The data confirmed the high rate of acceptance of the TENS by biologists **(Table 1)**.

Table 1. Percentage of acceptance of the TENS by specialty.

Specialty	Acceptance
Biologist	83,9167
Physicist	80,6898
Chemist	78,3267
Geologist	89,3571
Naturalist	90,5

The qualitative method included interviews with three of the geologists. During these interviews, the geologists described their educational and personal history, explained how they gained their knowledge, opinions, beliefs and attitudes and interpreted their answers to the questionnaire. The recurring themes throughout the interviews were:

- Knowledge they accumulated during their studies on the age of the earth, geological time and geological changes.
- Experiential knowledge gained through labs on fossils, fossil succession, their similarities and differences.
- Accepting the TENS as a natural and self-evident fact that is in accordance with their empirical and theoretical knowledge, even if they do not know the biological ‘details’.

DISCUSSION & CONCLUSION

From the quantitative and qualitative data of this research, it can be deducted that the geological arguments, but also the

wider manner of explaining the TENS through understandable empirical examples and information regarding the environment and the earth, aid in its acceptance **(Figure 1)** [20-22].

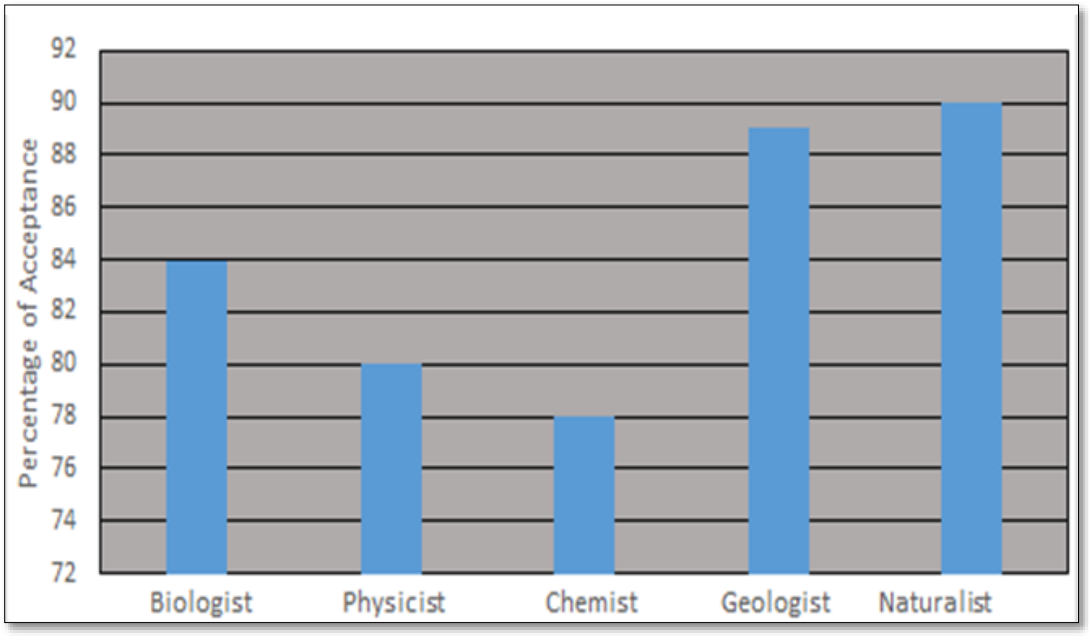

Figure 1. Acceptance of the TENS according to scientific specialty of science teachers.

It is noteworthy that geologists also score highly in the knowledge and understanding of the TENS, despite, as the interviewees admit, their lack of deep and systematic knowledge of the biological processes underlying the whole procedure. A possible explanation could be that the general knowledge on nature that they acquire in university, together with the emphasis on geological and environmental phenomena that they got familiarized, are enough for the level of difficulty this questionnaire exhibits. The latter, is indirectly supported - albeit recognizing their small number - by the fact that the naturalists that responded to the same questionnaire, have also, a general knowledge of how the natural world functions, also achieved a high score. Additionally, at least for one geologist interviewee who was strongly religious, religiosity does not come into conflict with accepting the TENS by a geologist, because it is easier for them to take the sense of Biblical Time not literally, but in a symbolic way. A fact, which in turn, opens ways of mind to accept and understand better a process like that of TENS that needed millions of years to be achieved.

We believe that the above-mentioned results are of interest because: a) it is one of the first times that a comparison has being conducted among science teachers, according to their specialty, in order to assess the degree of their acceptance of the TENS. b) They supply a new perspective about the direction that the teaching of the TENS should take in order to be operative, since, it is a known fact, that many teachers and students around the world reject the TENS, because they accept the biblical description of a "seven days creation" of the Universe. The science of Geology, on the other side, is very absolute about terms and procedures like "Geological timescale", history of earth, formation of fossils, etc.

The possible upshots could concern the addition of elements of geology and ecology in university curricula, but also the construction of educational strategies in secondary education that emphasize the earth and the environment.

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