

“Biology remains platonic in many ways”.
What about Biology Instruction? Effects on Teaching
Variational Evolution

Lucia Prinou, Krystallia Halkia & Constantine Skordoulis
Faculty of Education (PE), University of Athens, Greece
lprinou@primedu.uoa.gr, kxalkia@primedu.uoa.gr & kskordul@primedu.uoa.gr

Framework, Background & Aims

The contemporary evolutionary theory (TE) was founded on the “population thinking, one of the most important concepts in modern biology” (Mayr, 2001) introduced to science by C. Darwin. According to this, in contrast to platonic views:

“What we find among living organisms are not constant classes (types) but variable populations. Every species is composed of numerous local populations. Within a population, in contrast to a class, every individual is uniquely different from every other individual” (Mayr, 2001).

According to Lewontin (2002) this scientific reorientation which was imposed even before the variational mechanism for evolution was defined, is the true revolution of Darwin. It was a change of the object of study from the qualities of the groups in the variation among their individuals. But, as Lewontin believes “biology still remains platonic in many ways”.

As it is known, many researches are concerned with pupils’ difficulties in understanding natural selection. Among the reasons discussed, is the assertion that pupils and students have typological thinking (Greene, 1990, Bishop & Anderson, 1990, Jimenez-Aleixandre, 1994, Rudolph & Stewart, 1998, Andersson & Wallin, 2006).

The aim of our research has been to record the Greek school pupils’ conceptions of the TE and to research whether biology instruction (through curricula and textbooks) contribute to the pupils’ development of population thinking. Research questions were the following:

a) Which are the Greek pupils’ conceptions of evolution? Do they use the concept of natural selection as a mechanism of the evolutionary change or do they adduce other ways of answering and which are they? b) Do curricula and textbooks, which include biology, contribute to the development of the population or the typological thinking?

Methods and Sample

1. Research on pupils’ conceptions: The research instrument was a questionnaire including: a) two open questions through which it was ascertained how pupils explain a change of a population of organisms and the “appearance” of a new species b) sixteen closed questions of a four-grade scale (Strongly Agree, Almost Agree, Strongly Disagree, Almost Disagree, Do not know/Do not answer) recording their conceptions of the TE. Moreover at the end of the questionnaire pupils were called to answer questions asking if they have been taught and understood the TE. The sample consisted of 411, 10th Grade pupils, from 12 different schools in the capital and the provinces, because the 9th grade is the final Grade in Greek school, in the last term of which, pupils are taught the TE. The collection of the questionnaires took place in May 2006. In the processing of the answers of the open and closed questions the content analysis and the statistical program SPSS was used.

2. Research on School Curricula and Textbooks: All curricula and textbooks that include biology, from 1st to 9th grades, were studied and analyzed. The method used is similar to the method used in the study of Jeffery & Roach (1994). According to that, in our research all textbooks were scanned as far as the presence or the absence of concepts contributing to the formation of population thinking.

Results

1. Pupils' conceptions

I. A remarkable percentage of pupils appear to accept the evolutionary conception which is evident from their answers to various closed questions. E.g.: 89.3% of pupils disagree that *"all organisms came into existence at the same time"* and 86.2% disagree with that *"millions of years ago, there existed exactly the same plants and animals as those that exist today"*. 77.6% of pupils recognize that *"the species that exist today are a result of evolutionary procedures that have taken place millions of years ago"*, while *"all species of organisms are descendants of a common distant ancestor"* is accepted by 53.3%.

II. Nevertheless, only 26.8% of pupils agree that *"Evolution refers to changes in populations, not to individuals"*. 46.7% disagree and 26.5% choose the answer "do not know –answer".

- The correlation of the pupils' answers about a) how much *"they have been taught evolution during the preceding classes"* and b) what they think about the conception that *"Evolution refers to changes in populations, not to individuals"* proved to be statistically important with p-value $0,000 < 0,05$ and showed that: 71% of pupils who regard that they have been taught the TE *"Very much"* disagree with the scientific view that *"Evolution refers... .. individuals"*.

- The correlation of the pupils' answers about a) whether *"they have understood the TE"* and b) how they regard the conception *"Evolution refers to changes in populations, not to individuals"* proved to be statistically important with p-value $0,000 < 0,05$ and showed that: Only 32, 3% of pupils who say that they have understood the TE *"Very Much"*, adopt the scientific view.

III. Do pupils use the concept of natural selection to answer biology questions?

The answer is negative.

We present the pupils' answers to one of the two open questions, which was the following:

On a very windy island, there lives a species of insects, which as far as their wings seem to be "non – wing" (wingless), that is to say having small to atrophied wings, not suitable for flying. These features help them, not to drift out to sea by the wind, where they would drown. Can you give an explanation as to how this "non –wing" species of insects originated on this island?

The answers to this question show that pupils think that all organisms, as a whole of identical individuals, have been formed or transformed acquiring a new trait with which they live in the particular environment: either because *"their body formed according to the needs of their survival in their environment, it was made by nature in order to...etc"* (27.6%); either because *"insects adapt in accordance to the environment in order to ...etc"* (22.1%), or because *"their wings atrophied because they stopped using them"* (9.5%).

A percentage (7.4%) answered that *"insects were born like that –insects with wings lived too but they became extinct"* while 33.3% gave answers repeating the statement of the question, etc.

Similar conclusions result from the analysis of the answers to the other open question.

2. Primary & Secondary Education Curricula –Textbooks

The analysis showed that in Greek Primary & Secondary Education Curricula and Textbooks the way of the presentation of the organisms appears typological: Organisms are presented as totally identical to their ancestors. They are classified in various categories which seem to consist of identical members, embodied by only one representative. The concepts of the intra species variation and the existence of differences between the individuals are omitted. Only in the 9th Grade Biology textbook in the (last) chapter entitled "Evolution" is there a reference to particular cases of organisms *"that have resulted from random mutations and are selected e.g. a random mutation gave a long neck to the giraffe"*. References to the existence of variations in the populations are not made. Only in one paragraph entitled "The theory of Darwin and

Wallace” is it said among other statements that: “In each species, there appear to be several differences among individuals”.

Conclusions and Implications

a. Only a typological way of presenting organisms prevails in all Greek biology curricula and textbooks. Thus, while pupils appear to adopt the evolutionary conception, having been nurtured for nine years in school in dealing with types of identical organisms, they explain the appearance of new traits in populations, by adducing explanations similar to the theories of *transmutationism* and *transformationism*, which were based on essentialism and not on population thinking (Mayr, 1991, 2001). Our research showed that pupils’ difficulties in the understanding of the concept of natural selection is a result of the way biology is taught: pupils cannot apply a model of selection to a population of individuals (organisms), if they have already learnt to think from the start of their education in biology, that the members- individuals of the population are totally identical.

b. The unification which is introduced in the field of biology research (Kafatos & Eisner, 2003) points out how important the unifying TE is in biology teaching. For the teaching of the TE to be more effective, the whole instruction of biology should be complemented. Biology cannot be taught, as being typological, with a sudden introduction about population thinking in the last chapter of secondary education biology textbook. Typology of course has helped the organization of our knowledge about the world but pupils should become familiar with the concept of intra species variation as well, throughout their biology education. Keown (1988) gives some examples for teaching the variability. The lack of knowledge in Genetics should not be an obstacle. Neither did Darwin or Wallace have knowledge of Genetics, but they were aware of the variability in populations.

References

- Andersson, B., & Wallin A. (2006). On Developing Content-oriented Theories taking Biological Evolution as an Example, *International Journal of Science Education*, 28(6), 673–695.
- Bishop, B.A., & Anderson, C.W. (1990). Student Conceptions of Natural Selection and its Role in Evolution, *Journal of Research in Science Teaching*, 27(5), 415–427.
- Greene, E. D. (1990). The Logic of University Students’ Misunderstanding of Natural Selection, *Journal of Research in Science Teaching*, 27(9), 875–885.
- Jeffery, K.R., & Roach L.E. (1994). A study of the Presence of Evolutionary Protoconcepts in pre-High School textbooks, *Journal of Research in Science Teaching*, 31, (5), 507-518.
- Kafatos, F.C. & Eisner, T. (2004). Unification in the Century of Biology, *Science*, 303, 1257.
- Keown (1988) . Teaching Evolution. Improved Approaches for Unprepared Students, *The American Biology Teacher*, 50(7), 407-410.
- Jimenez-Aleixandre, M. P. (1994). Teaching evolution and natural selection: A look at textbooks and teachers. *Journal of Research in Science Teaching* 31(5): 519-535.
- Lewontin, R. (2001). *It ain't necessarily so: The Dream of the Human Genome and Other Illusions*, Granta Books.
- Mayr, E. (1991). *One Long Argument: Charles Darwin and the Genesis of Modern Thought*, Harvard University Press.
- Mayr, E. (2001). *What Evolution is*, Basic Books.
- Rudolph, J. L. & Stewart, J. (1998). Evolution and the Nature of Science: On the Historical Discord and its Implications for Education, *Journal of Research in Science Teaching*, 35(10), 1069- 90.