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THE "UNKNOWN" GREEK PALEOENVIRONMENT AND FOSSILS: EVALUATING GEOGRAPHY CURRICULUM PROPOSALS FOR ELEMENTARY SCHOOL

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Abstract

In this study we introduce teaching proposals to "inject" ammonite fossils, in the Geography syllabus, as evidence of Greek paleoenvironment, which at the moment is the only existing geoscience subject of Greek primary curriculum. Paleontology and mainly fossils attract more and more elementary students and teachers. Unfortunately, in Greece, this trend solely concerns about dinosaurs, despite the fact that the most common Greek fossils are not dinosaurs, but ammonites. Ammonites can be found in large population and diversity inside Greek rocks, as these rocks were part of Tethys´ seafloor at their geological time. Apart from the informal sources of education, these geoscience/physical geography topics are excluded from elementary national curriculum, thus leaving out the regional paleogeography and geological history practically "unknown" to students and future citizens of our region. Data collected through a pre-test study among the 5th and 6th grade students confirmed the above belief. A post-test at the original sample, using an open ended questionnaire and students' drawings, evaluated positively the teaching proposals designed.

Keywords: *Physical geography curriculum, ammonites, elementary geoscience education.*

1. INTRODUCTION

Paleontology and mainly fossils tend to attract more elementary students and teachers. In Greece this trend is solely about dinosaurs, despite the fact that the most common Greek fossils are not dinosaurs, but ammonites. In Greece and in many other countries also, formal education's role in geosciences is practically replaced by informal sources, of unknown accuracy and validity. Padian (2000), presents several cases where informal and commercial sources of education provided inaccurate scientific information about dinosaur fossils.

Moreover, apart from the non-formal sources of education, these geoscience/physical geography topics are also excluded from elementary curriculum, and leave the regional paleogeography practically "unknown" to students, a fact in agreement with many geoscience education researchers (Cheek, 2010; Lewis & Baker, 2010; Libarkin, 2006), who note that

Earth sciences are amongst science topics with less attention in terms of curriculum and research. The lack of Earth science information and experience is even recorded among teachers in a degree, a fact that has a negative impact to their professional confidence while teaching these lessons (Harlen & Holroyd, 1997). Despite the fact that ammonites are a significant chapter of Greek geological history and paleontological evolution, they seem to be almost unknown to Greek primary students. The insufficient knowledge about ammonites is probably relevant to their total absence from the Greek teaching textbooks of primary education and is in contrast with the large quantity of information (educational games, movies, books and magazines) about dinosaurs. For the history, a simple reference can be found only in 2002 Geography textbook of 5th grade, which has been though revised. Consequently, a great opportunity for improvement in spatial ability, for an experimental approach of the geological history and physical geography of Greece is lost for Greek primary school students (Orion, et al., 1997). At this point it must be noted that: dinosaur fossils, though they are impressive in kids' eyes, are totally non-Greek fossils.

Though Greece is located in a geologically active region, yet Earth science education is not a major point in the National Curriculum and Geography remains the only existing geoscience subject of Greek elementary curriculum. As pointed out by Klonari and Koutsopoulos (2005), Geography is considered a boring, descriptive subject. Absence of ammonites, the most common Greek fossils in textbooks of any lesson at primary Greek curriculum must also be noted.

Granted all the above, ammonite fossils, the most common Greek fossils, were chosen as the core of this project. This study also provides in service teachers with suggestions and geography curriculum proposals to choose from, as the most suitable to their school class. Geography activities, activities using ammonite fossils and other marine fossils, as learning tools provide students and teachers with the opportunity to connect education with the regional topography and geological history. It is widely accepted that geological and geomorphological sites of each country are important tools for public education. One of their educational advantages, is that they recall that fossils record the evolution of planet Earth and their role as an integral part of the natural world. (Eder & Patzak, 2004). The above physical geography topics are "injected" in the most relevant current subject of Greek elementary school, which is 5th and 6th grade Geography. Burr, et al. (2003) and Dodick & Orion (2003), also suggest the use of fossils as teaching tools for difficult and abstract processes such as geologic time and evolution, as they are a concrete evidence of abstract Earth mechanisms. Towards the same direction, Stanley and Almquist (2008) used fossil findings to help teachers and students to decipher relationships among fossils in time and space.

Considering all the above conditions in primary education, the curriculum proposals, designed for this project, provide the basic scientific knowledge and terminology, about ammonites and their fossils, to primary school students and teachers. Additionally, scientific information about ammonites and fossils could be included in some textbooks of primary education, especially in Geography or Environmental and Physical sciences. Getting kids to learn and being interested in ammonites can be achieved by participating in the following activities, which can be organized during teaching Geography lessons, which are usually conducted twice a week according to the Greek primary school schedule. Advantages of these activities are their interactive character and the simplicity of suggested and used materials. Moreover, the curriculum proposals, are in accordance with most of the principles followed by the authors of the new Geography Curriculum of Greek elementary school (National Gazette B' 2322/3-10-2011; Klonari et al., 2014). Towards that direction, emphasis was given on working in groups, on keeping a student - centered character of the activities and focus on an experimental instead of a verbalistic approach.

2. BRIEF BACKGROUND ON THE AMMONITES

Ammonites were carnivore marine cephalopod mollusks, which dominated prehistoric seas from Ordovician (485-443 mil. years ago) to Cretaceous (145-66 mil. years ago), at the same geological time that dinosaurs dominated land. At present, ammonites are index fossils of the Mesozoic era as they are widespread, they have shown a fast evolution rate and can be easily identified (Shome, *et al.,* 2004; Sabyasachi, et al., 2004). Their name comes from their shape's similarity to the horns of ancient Egyptian god Ammon. (McMenamin, 2007). They had a decorated shell, in a variety of diameter from few centimeters up to 2,5 meters wide. Their shell was divided in to inner chambers by multiple diaphragms and the animal itself lived inside the last chamber. One proven ammonite eater was the large marine reptile, plesiosaur. (Tamaki & Kazushige, 1998)

Ammonites were one of the most dominant species in Earth's prehistoric seas for millions of years, thus very successful in terms of evolution. They went extinct, like dinosaurs, due to the meteorite crash on Earths' surface 65 million years ago, known as the K-T event. Consequently, only their fossils can now reveal some information about them.

According to Aubouin's theory, Greece during Triassic period (200 mil. Years ago) was part of the hypotropic Tethys Sea. Ammonite shells and skeletons were trapped and fossilized during sedimentation. As a result, several marine fossils and especially ammonite fossils can be found in rocks all over Greece, even on the mountains. (Pope, et al. 1998, Raup, 1994). Ammonites are the most commonly found fossils in Greek rocks and reveal the regional geological history and paleoenvironment. The most common Greek ammonites are the Carboniferous Permian ammonites of Parnitha, Hallstatt ammonites at the limestones of Chios, the ammonites of Othrys mountain, Epidaurous ammonites at Peloponnese, and ammonites of Ammonitico Rosso (lower Jurassic) at Corfu, Lefkada, Epirus and Argolida. (Ministry of the Aegean, 2002).

3. METHODOLOGY

3.1 Participating group and ethics

The study group consisted of 376 students ($n_{5th\ grade}$=186, $n_{6th\ grade}$=190) from 18 classes, nine of each 5^{th} and 6^{th} grade. The students were recruited from five middle class urban elementary public schools, in Zografos, Ilioupolis, Pallini and Kessariani (municipalities of Athens major area). All answers were collected during scheduled visits of the researchers to the above schools, after a brief meeting with the class teachers and school administrators. During both pre-test and post-test studies, the researchers used the students' drawings / representations and open-ended questionnaires to access every possible students' conception, by letting them become as analytical as they wished to be.

As the participants were children, thus parts of vulnerable groups, the researchers paid special considerations in ethical issues (Hill, 2005). The objectives of the research and the purpose of each task (i.e. pre-test visit, curriculum proposal application and finally post-test visit) that was taken with the children were communicated with the school's principal, the teachers of the school, and the legal guardians of students. Researchers also got the consent for taking pictures during the activities, informed and got consent of the children themselves to participate in this study. To ensure the anonymity, researchers gave different names to children's work/ illustrations and they used pseudonyms. They also avoided showing children's full faces in photos taken during the project or posting their photos on Internet sites.

3.2 Method

Researchers intended to investigate, if ammonites, marine fossils and Greek paleoenvironment are really unknown to Greek students, which in brief was the first research question. This was also a necessary step in order to access any prior knowledge and possible misconceptions about the specific topics. Any information gained at this step would be taken into consideration while designing the geography curriculum proposals at the following phase. The research tool used at this step was an open-ended questionnaire, with two questions. Open-ended questions were preferred as they would give the students the opportunity to get as analytical as they wished and express any possible alternative idea about the topic. Also, the absence of relevant literature in childrens' alternative ideas about fossils, practically left no other option. The first question "What is an ammonite?" intended to find out if students had any basic information about ammonites and fossils while the second open-ended question "*Have you ever seen an ammonite and if yes, where?*" intended to define the source of any possible knowledge or scientific information, that students might have had about ammonites and fossils. Finally, participating students were asked to draw an ammonite.

The main goal of next research question was to find out if basic content about Greek paleoenvironment can be "injected" in Geography primary curriculum, using regional physical geography, geology, ammonites and other marine fossils as teaching tools in Geography. Five different activities relating the proposed curriculum content were designed and presented to serving teachers. The activities were: (i) Developing of a thematic "Fossils' map of Greece", (ii) Production of clay model replicas of ammonite fossils, (iii) Drawing of layer maps, (iv) Identification of marine fossils and (v) Activity of changes on Earths' surface.

The first activity, "Thematic Fossils' map of Greece" aimed to present to students all the areas of Greece, that fossils and especially marine fossils can be found. This activity, included maps developed by students working individually. Students were asked to use a blank map of Greece as a starting point of their work, and add the fossils found in each area. Brief information about fossil species found per area was given to them through a list from the Greek Ministry of Cultural Affairs. Students were also asked to design and add a map legend with all Greek fossils according to an index, in a form of list, given to them.

The second proposal about model replicas creation, intended to help students recognize ammonite shape and referred to production of marine fossil imprints on clay or models of the living animal, an idea borrowed by Waters & Savage (1971). Students were encouraged to choose the ammonite representation they preferred, either as an animal or as a fossil and create a label with 2-3 sentences of information about their "exhibit", in order to create an in classroom "ammonite museum".

During the third curriculum suggestion, the drawing and layering of three different maps, two of which were printed on fully transparent plastic pages, proved that volcanic and tectonic activity co-exist on specific areas of the planet, like Greece. In this activity, students working individually were asked to match the transparent maps on a third map. As a result they discovered that these areas are also located approximately on the lithospheric plate boundaries and realized the connection between the phenomena.

The fourth geography curriculum proposal aimed to make the students familiar with the Greek marine fossils, which they tried to identify. During this activity, several marine fossils were used, such as fossils of trilobites, ammonites, sea urchins, bivalve mollusks (*pecten*), shark teeth and fish fossils. Students, working in groups of four, were asked to match the name of the fossil with each sample and add the correct information label about each fossil, in order to create an in classroom marine fossils exhibition.

Finally, the fifth curriculum proposal aimed to help students visualize the changes in

Earth's surface. Students working in groups of four, were asked to represent the Earth's surface during past geological periods. In order to do that, they had to place plastic pieces representing the shapes of the continents, in the right place, according to each geological period. No picture, geoscience information, map, fossil or ammonite model was presented prior to geography proposals' application. (Figure 1, Figure 2)

Figure 1. Activity of changes on Earths' surface.

Figure 2. Marine fossils identification

The last phase of this project concerned the effectiveness of the above teaching approaches. How effective was the approach? Were students able to understand such topics? Did they gain stable knowledge after lesson? Did they have erroneous understandings (alternative conceptions or misconceptions**)** on geoscience features they have been taught and investigate? In order to answer these questions, approximately two months after the teaching approach, the researchers visited again the same classrooms and investigated the efficiency of the curriculum proposals using a post-test. The participating students were given at that time an open-ended questionnaire with the two following questions: a) "*What is an ammonite?*" and b) "*Why we find ammonites in the Greek mountains?*" At this phase open-ended questions were preferred also because, they would give the students the opportunity to include as much information and details as they wanted. The first question in this stage would show if students, gained the given basic information about ammonites and fossils while the second one would show their ability to connect the above terms with the regional dynamic geoenvironment. Also, students were asked once again to draw an ammonite, in order to see if they would include correct details in their representations.

3.3 Data analysis

A simplified version of the qualitative content analysis method was used to analyse the data collected from the above research tools. (Mayring, 2000)

In order to analyse the pre-test data obtained from the first open-ended question (What is an ammonite?), two categories were defined, the first "correct answers category" included every answer with at least one correct scientific expression about ammonites and fossils. Every other answer was categorized at the "incorrect answers category". Each phrase or sentence included in the students' answers, was the analytical unit at that point. Further analysis of the incorrect answers was conducted, using the word as the analytical unit at this point. This further analysis resulted in several categories amongst incorrect answers, which are detailed presented in the following results and discussion section. The analytical unit during data analysis of the second pre-test question (Have you ever seen an ammonite and if yes, where?) was the single word and analysis of given answers resulted in two categories, which were: "I have not seen - category", "Goulandri museum of Natural History, Greece - category".

In order to analyse the post-test data obtained from the first open-ended question (What is an ammonite?), two categories were defined, the first "Correct answers category" included every answer with at least one correct scientific expression about ammonites and fossils. Every other answer was categorized at the "Incorrect answers category". Each phrase or sentence included in the students' answers, was the analytical unit at that point. Further analysis of the correct answers was conducted, using the word as the analytical unit at this point. This analysis resulted in several categories amongst correct answers, which are detailed presented in results and discussion section, which follows. The analytical unit during data analysis of the second post-test question (Why we find ammonites in the Greek mountains?) was the phrase or sentence included in the students' answers and the analysis of given answers resulted in categories, presented in the following section of results and discussion.

4. RESULTS & DISCUSSION

As far as the analysis of students' drawings, in both pre-test and post-test is concerned, every representation showing at least the broad approximately round shape of the fossil shell or the living animal was categorized as a correct representation. The rest of the drawings, which included irrelevant shapes, landscapes and figures were counted as incorrect representations.

Pre-test findings were very revealing and prove the students' lack of knowledge about Greek paleoenvironment and marine fossils beyond any doubt. No student mentioned an exact and correct answer, including that ammonites went extinct and can be found as marine fossils. The great majority claimed that had no idea of what an ammonite is, a result which was totally in accordance with the 91.4% of the incorrect representations. Given answers also reveal that the small number of students who had an idea of what is an ammonite, had seen them at the Goulandri Museum of Natural History, the only well-known museum in Athens major area with an ammonite collection. It is of great concern that ammonites, the most common Greek fossils, are practically unknown to Greek students therefore the teaching effort was noteworthy. Students showed great interest in the topic and were very impressed by the fact that Greece at that time was part of a prehistoric sea. A couple of students even wondered and commented: "*Why don't our textbooks mention them*?". (Figure 3)

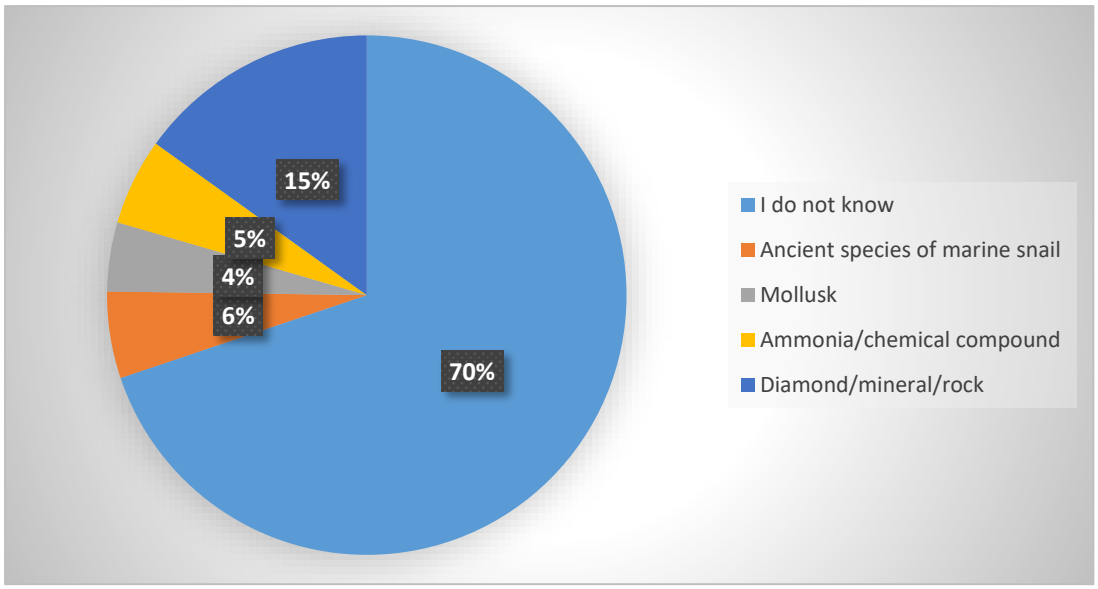

Figure 3. Frequencies of pre-test students' answers about what is an ammonite.

After proposals application, the percentage of students, that knew what an ammonite is, raised up to 83.0%. Correct scientific details appeared in the students' answers and nearly a quarter gave an accurate and fully descriptive answer on what an ammonite is. As seen on Figure 4, the 56% of the students (by adding the percentages of fossilized animal, past geological time animal and sea animal) included one scientific information in their answer, the 31% (by adding the percentages of fossilized animal of past geological time, fossilized marine animal and prehistoric sea animal) included two different scientific details. Finally, the 13% of the students gave the most complete answers, which included three different scientific facts about ammonites.

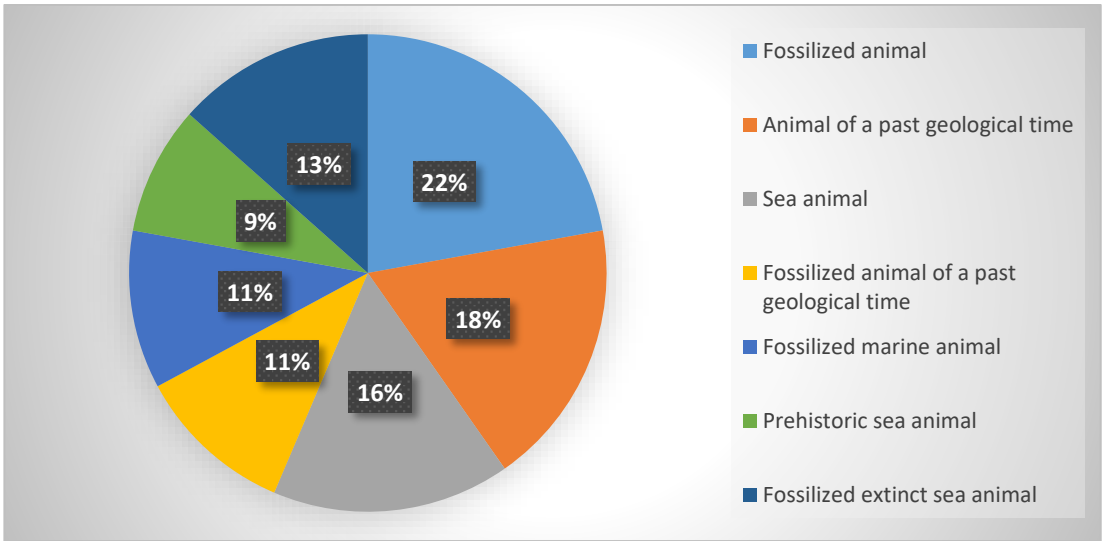

Figure 4. Frequencies of correct post-test students' answers about what is an ammonite.

Students drawings were, once more, very revealing and showed that nearly all of them were able to draw a correct representation of the ammonite, either as an animal, either as a fossil. The 97.3% of the students was able to draw a correct representation, after proposals application. It is remarkable that some students added very explanatory details in their drawings.

The 2nd post-test, open-ended question requested an ability to connect the ammonites with the regional dynamic geoenvironment. Only the 43.9% connected the presence of marine fossils in mountain rocks with the fact that Greece was once the bottom of a prehistoric sea. The incorrect answers revealed misconceptions and use of students' irrelevant experiences and previous frameworks, such as earthquakes, tsunamis, meteorological phenomena, sea withdrawal and appearance of marine fossils on the top of the mountains. Curriculum proposals were not able to replace the alternative ideas, which are often persistent and can be carried into adulthood.

5. CONCLUSIONS

As Greece is an active tectonic area, geoscience and physical geography education shouldn't be absent in the national curriculum. The aforementioned curriculum proposals can partly compensate for this absence, under given circumstances and reality in Greek school. Students gained scientific information about ammonites and realized that these animals dominated their region at the same time when dinosaurs dominated other areas of our planet. Nearly every child represented an ammonite successfully and the misconception that ammonites are marine snails seems eliminated. Many students realized that ammonites have gone extinct and can now be found only as fossils, but only one third of them managed to combine the change to the regional paleoenvironment with the presence of marine fossils in mountain rocks. The curriculum proposals seem sufficient for primary acquisition covering this field, but not suitable for an in depth understanding of the whole Greek geoenvironment and regional physical geography. A possible alternative, aiming this direction would be to extend the application not only in the Geography curriculum, but also in more subjects of the school curriculum such as "Research of the Physical Environment", "Sciences" or activity hours such as "Projects' zone" or "Environmental Education". Besides gaining and applying new knowledge, of equivalent importance was also the motivation and positive attitude of students and teachers, while being cultured towards these "unknown" topics. Scheduled visits to geoscience museums or field trips to relevant geosites could complete the above approach in an effective way and also answer the need for a more "hands on" practical approach.

In terms of Physical Geography teaching research, a worthwhile effort would be to investigate Greek students' views, possible misconceptions in other specific topics (e.g.: geoparks, petrified forests) and furthermore into understand the similarities and differences between relevant geoscience topics, such as rocks and minerals, rocks and fossils. Further research on serving and pre-serving teachers' beliefs in fossils and ammonites would be interesting and helpful in order to produce additional or supplementary teaching material. More and broader suggestions could be a starting point to introduce specific chapters about Greek geoenvironment and geological history, including ammonites and marine fossils in the Greek national curriculum. Pilot application, evaluation and improvements will be necessary in order to enrich the National Curriculum in terms of geoscience education.

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