BGSG

Volume 56

Research Paper

Correspondence to:
George E. Kontokostas
geokon@geol.uoa.gr

DOI number:
http://dx.doi.org/10.12681/bgsg.21002

Keywords:
geological walk trail, urban geology, geological notions, geology teaching, secondary school.

Citation:
Kontokostas G. E., A. Antonarakou, M. Fountopoulou, H. Drinia, S. Lozios (2020), Urban Geology: Educational proposal for Geoscience. A case study from the Inner city of Athens, Greece. Bulletin Geological Society of Greece, 56, 133-146.

Publication History:
Received: 13/08/2019
Accepted: 02/04/2020
Accepted article online: 20/04/2020

The Editor wishes to thank two anonymous reviewers for their work with the scientific reviewing of the manuscript and Ms Erietta Vlachou for editorial assistance.

URBAN GEOLOGY: EDUCATIONAL PROPOSAL FOR GEOSCIENCE.

A CASE STUDY FROM THE INNER CITY OF ATHENS, GREECE.

George E. Kontokostas[1], Assimina Antonarakou[1], Mariza Fountopoulou[2], Hara Drinia[1], Stelios Lozios[1]

[1]**National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Panepistimiopolis, Zografos, Greece,** geokon@geol.uoa.gr aantonar@geol.uoa.gr cntrinia@geol.uoa.gr slozios@geol.uoa.gr

[2]**National and Kapodistrian University of Athens, Faculty of Philosophy, Pedagogy and Psychology Panepistimiopolis, Zografos, Greece,** mafoun@ppp.uoa.gr

Abstract

The limited exploitation and low understanding of geological notions, in modern education in physical sciences, motivated the planning of research procedures about the understanding of rock formations, of recognizing rocks, of informing about geological and hydrographic potential, for students of secondary school of Attica, using techniques entailed in the scientific/educational methodology by inquiry, suggesting educational walking paths through the historical center of Athens. Selected places of the walk trail served our educational aims. Via the educational intervention, students improved their understanding of geological notions, their creativity, their cooperation and their critical thinking. The educational walk trail motivated the students' interest in the science of geology.

Keywords: *geological walk trail, urban geology, geological notions, geology teaching, secondary school.*

Περίληψη

Η περιορισμένη γνώση και η χαμηλή κατανόηση των εννοιών της γεωλογίας των μαθητριών και μαθητών στη σύγχρονη εκπαίδευση στις φυσικές επιστήμες, *μας οδήγησε στη σχεδίαση εκπαιδευτικής διαδικασίας, με στόχο τη βέλτιστη κατανόηση του τρόπου σχηματισμού των πετρωμάτων, της αναγνώρισης του είδους των πετρωμάτων, της ενημέρωσης για το γεωλογικό και υδρογραφικό δυναμικό, σε μαθήτριες και μαθητές της Δευτεροβάθμιας Εκπαίδευσης της Αττικής. Κατά την εκπαιδευτική διαδικασία εφαρμόσαμε τεχνικές ενταγμένες στην επιστημονική / εκπαιδευτική μέθοδο με διερεύνηση, προτείνοντας / χρησιμοποιώντας εκπαιδευτικές γεωλογικές διαδρομές στο ιστορικό κέντρο της Αθήνας. Οι επιλεγμένες τοποθεσίες της διαδρομής εξυπηρέτησαν τους εκπαιδευτικούς μας στόχους. Μετά την εκπαιδευτική παρέμβαση οι μαθήτριες και οι μαθητές βελτίωσαν τις γεωλογικές τους γνώσεις, ανέπτυξαν την κριτική τους σκέψη, την δημιουργικότητα τους και θεώρησαν την επιστήμη της Γεωλογίας ενδιαφέρουσα.*

Λέξεις κλειδιά: *γεωδιαδρομή, αστική γεωλογία, γεωλογικές έννοιες, εκπαίδευση της Γεωλογίας, δευτεροβάθμια εκπαίδευση.*

1. Background and Objectives

Most people think that the urban area is poor for geological study and contains few useful geological data *"With all the constructions, the initial data that could provide the references for the tectonic regime have been lost"* (Chuang Xu et al., 2015). This thought derives from the fact that "In urban areas the initial surface has been shaped due to the rapid growth, in a way that covers the needs of the inhabitants of a region. The land surfaces have been built and sharpened artificially, roads have been constructed, and the hydrographic networks have been changed and shaped, while natural surface have been fragmented and degraded, hence the constructed landscape is "poor" for geological study (Zervopoulou and Pavlides, 2016). In our research we studied the city in the light of geology, the designed geological walk trail is a practical endorsement, where the students will use fieldwork skills to identify a range of rocks and geological materials in the built environment and can also be informed about geological features of the area.

From the geological point of view, the basin of Athens is bound to the east by Mountain Hymettus which is built by metamorphic alpine formations (marbles and schists), constituting the lower tectonic unit, and to the west by the overlying tectonic unit of Mountains Egaleo and Poikilo, which include non-metamorphic formations like limestones, volcano sedimentary sequences and ophiolites (Figure 1). The tectonic contact of these two units includes a low gradient detachment fault. The major part of the basin is covered by Neogene and Quaternary formations (terrestrial, marine and lake deposits of conglomerates, sandstones, marls and pelitic rocks, but also laterally extended debris and scree deposits). Below the Neogene formations, small alpine low-grade metamorphic rock formations (crystalline limestones and phyllites) are emerging forming small individual hills (Turkovounia, Lycabettus, the Acropolis, Philopappus etc.), overlying both the metamorphic formations of Hymettus and the non-metamorphic formations of Egaleo.

In this research the educational aims for the students were: a) to recognize rocks b) to be informed about geological and hydrological potential, and finally, c) to understand the geological notions in time and in space, that means to recognize the geological time and to comprehend the rock cycle (Kali et al., 2003). The educational goals of our proposal were: a) to inform students about the urban environment of Attica, b) to show that geology is an attractive and important science, c) to study geological phenomena with an interdependence procedure with geosciences and d) to view physical phenomena with a holistic approach, improving students' ecological consciousness.

2. Research Methodology

This educational procedure took place in Athens in 2018-2019 and 160 students of 15 years old, from secondary schools of Attica took part. We started with two pilot research studies in Pikrodafni stream, where the students were instructed the geological and hydrological potential of Attica and in Daphni Monastery, where the students learned about mineralogy. Next for our main research, we designed a geological walk trail in the center of Athens which combined our educational objectives : the students to know about the geological and hydrological potential of Attica and mineralogy. We set up two equivalent groups of students, a control group and an experimental group. The control group attended a teacher-centered education and the experimental group followed the geological walk trail. Some 50-minute semi-structured interviews were carried out with pre-test and post-test questionnaires and worksheets containing “control questions precodification” (Bakopoulou et al., 2016) and observers, as assessors, were attended the educational intervention. The triangulation of our data assured the validity of our research, (Cohen and Manion, 2000, p. 321). The pre-test where different from post-test and each one contained ten questions. The questions examined if our didactical intervention contributed in the achievement of our educational objectives and they were about recognizing the three types of rocks (metamorphism, sedimentary, explosive), predicting the rock cycle, explaining the fossil formation, identifying the geological time of the rocks, knowing hydrographic network, explaining the mechanism of orogenesis and mountain formation in the area of Attica and students’ attitude towards geology. These questions checked understanding, creativity, cooperation and critical thinking of the students.

In this work, we attempted to follow research steps, (Kalkanis, 2010) set forth by inquiry-based learning (Dermott, 1996) : a) trigger for interest, b) reminder of basic knowledge/formulation of hypotheses, c) experimentation/trials, d) formulation of conclusions, e) applications/generalization according to learning. A control group of 30 students at the age of 15 years old attended a teacher-centered education in class of a secondary school and an experimental group of other 30 students from the same school participated in the pilot research studies.

3. Pilotic research studies:

1) PIKRODAFNI STREAM

Students walked by the side of the stream (Fig. 2.) and they knew about the hydrographic network of the basin of Athens, for the other 2 main rivers: Ilissos and Kifissos and about 5 mountains which bound the Attica’s basin.

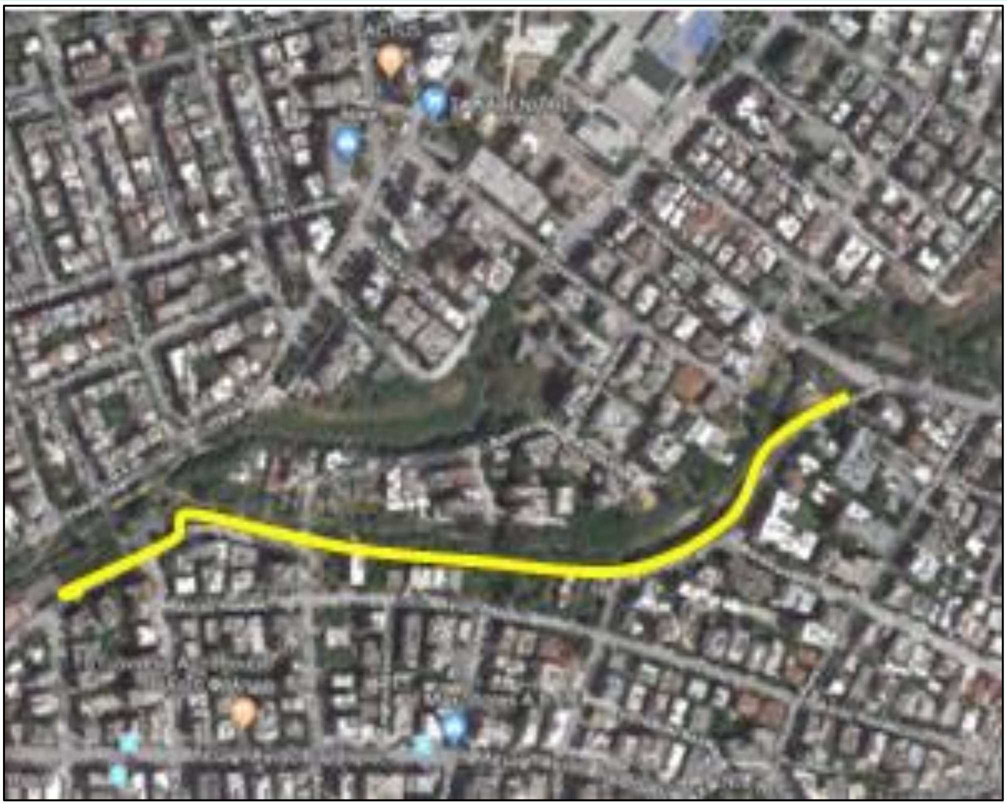


Fig. 1: Geological walk trail alongside the stream.

2) <u>DAPHNI MONASTERY</u>

Second school visited Dafni Monastery. The students recognized: marble, granite, limestone, limestone with fossils and they knew about the geological procedures and the rock cycle and other geological notions.

2a **2b**

Fig. 2: a) Dafni monastery b) Dafni monastery is also constructed by limestone with fossils of the Neogene period and we informed about the time a rock layered deposited**.**

After our educational intervention the following percentages derived: From the control group educated with teacher-center method, only the 45% of them understood the educational aims. From experimental group following the Geological walk trail, the 75% of the students understood the educational aims.

4. Main research study: Walk trail through Monastiraki.

The good results of our pilot research_encouraged us to search and to design a walk trail which will combine our educational aims. For that purpose we selected stops which were very closed to each other, they were in an area with rich geological features (river: Eridanus, hills: Lycabettus, the Acropolis, Philopappus) and they had a wide range of rocks in the built environment. In this specific study: Monastiraki-Kapnikarea-Pantanassa-Library of Hadrian - Roman Market, is the walk trail that was selected, (Figure 4)

Fig. 3: The walk trail: (1) Monastiraki (2) Kapnikarea (3) Pantanassa (4) Library of Hadrian (5) Roman Market.

We first enlisted the aid of 3 small groups of students to help us formulate the approach. An educational proposal with semi-structured interviews was carried out, using the proper equipment and following the necessary rules of safety. Each student had a hand lens ×30, a street map, a small water bottle and a field notebook. Health and safety were considered by a centre before undertaking the work trail. A full risk assessment of any activity was undertaken including the information about the weather broadcast. We continuously assessed the safety of our working environment. The main risks were posed by traffic and we took care crossing roads and stepping back to take photographs. We were respectful and courteous to members of the public. If it was appropriate, we asked permission to take photographs, especially in indoor locations. We asked for permission from security officers and we scheduled our visit at the Metro Station of Monastiraki. The good results from our tools of research became a trigger for pursuing the main research with an experimental group of students from a secondary school of Attica.

4a **4b** **4c**

Fig. 4: We first enlisted the aid of small groups of students from secondary school of Attica, to help us formulate the approach: 4a) Students visited Pantanasa , 4b) Students observed with hands-lens, having a close up view of Hymettus grey marble in Roman Market, 4c) Students noticed fossils in limestone, in Hadrian’s Library.

5. SELECTED SITES

The following sites have been selected as points of this research.

5.1 The River Eridanus

The River Eridanus, is highlighted and the natural bed of the river became visible after the construction of the metro and the repair of the Monastiraki square. It is very interesting that the design of the square is in accordance with the flow of the water in the bed of the river. The water of the rainfall follows the slope and the engraving of the terrain according to the flow of the river. It is a unique picture in a city, because someone cannot see any other hydrographic network in the Centre of Athens.

Fig. 5: The River Eridanus is almost subterraneous, is rising at the foot of Lycabettus and is flowed through the heart of Athens city. Students from secondary school of Attica visited the the Metro Station of Monastiraki.

5.2 Kapnikarea

There are many Byzantine churches in the historical center of Athens. Kapnikarea is located on Ermou street the busiest street of Athens. It was built in the third quarter of the 11th century A.D. For the construction of walls sedimentary rocks with fossils of the Pliocene age were used. Inside the four columns without bases and capitals, from earlier monuments are supporting the dome. Three of them are made from granite and the fourth, from green marble of Karystos (Chipolino), (Bouras, 2017). The quarries, located in Evia, were imperial property.

6a **6b** **6c**

Fig. 6: a) Kapnikarea church. b) Regarding first research step, students were asked to notice the sedimentary rocks with fossils outside the church. c) Inside the church, the northeast column is from green marble of Karystos (Chipolino) and the other three columns are made from granite.

5.3 Pantanasa

Pantanasa is also a byzantine church located in Monastiraki. For the construction of walls limestones with fossils of the Pliocene age were also used.

7a **7b**

Fig. 7: a) Pantanasa church is located on Monastiraki square. b) Regarding 2^{nd} research step, students knew about geological notions.

5.4 Hadrian's Library

When the students entered the library, they came across with Phrygian pink marble with blueish veins. One hundred columns were made of Phrygian stone. The stoas and the walls were made of the same material (pavonazzetto). The quarries, located in Phrygia -today in Turkey- were imperial property.

8a 8b

Fig. 8: a) Regarding third and fourth research steps, students visited Hadrian Library b) when the students entered the library, they came across with many wells. For this reason we cannot reconstruct the church which was there.

5.5 Roman Market

Regarding the fifth research step, the students entered the roman market and they came across with granite, the white marbles of Penteli on the eastern gate and the gray marbles of Hymettus on the western gate of the Agora. The marble of Penteli is metamorphosed during the alpine Orogeny, of late Cretaceous to the late Eocene age. We left the students with the challenge of carrying out similar questions about recognizing Igneous, Metamorphic and Sedimentary rocks and determining their formation.

9 (a) 9 (b)

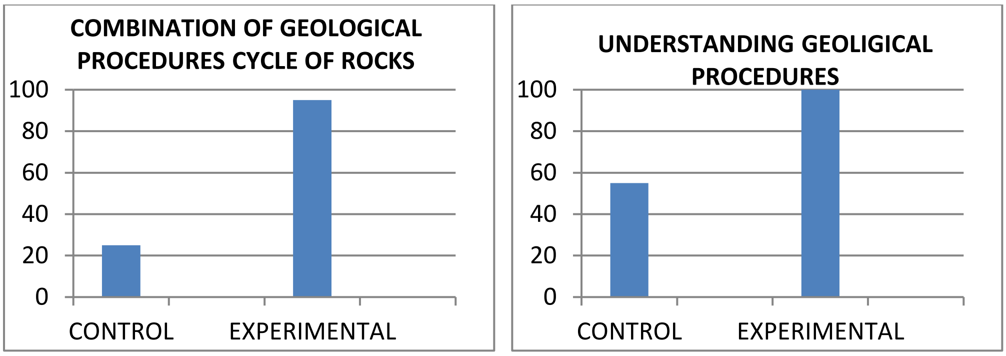
Fig. 9: a) Eastern gate of Roman Market with the white marbles of Penteli. b) Western gate with the gray marbles of Hymettus.

Fig. 10: The students observed with hands-lens, having a close up view, the medium-grained crystalline rock with granular (sugary) texture.

6. Results and Conclusions

The preliminary results of our research involving the experimental group, which were compared with the results of our research involving the control group of students of a secondary school of Attica, who visited our paleontology museum in the Faculty of Geology and Geoenvironment of School of Science of National & Kapodistrian University of Athens. Each one of both groups contained 30 students at the age 15-years old. After evaluating the same questionnaires (the pre-test was different from the post-test), pre-test responses showed that students faced the same difficulty as far as the educational aims are concerned. On the contrary, the post-test responses of the experimental group, following our educational intervention and methodological steps, showed that almost all students had mastered the educational aims. We assessed changes in their understanding of geological notions with a pre-test and a post-test. The students did strikingly better on the experimental group than the control group. On the control group, only 20% of the students could combine geological procedures. This jumped on the experimental group to 95% (Fig. 11a.). Being able to state the rules that govern geological procedures jumped from zero to 100% (Fig. 11b) and they improved their creativity.

Also, all the students of the experimental group learned about geological and hydrological potential (Fig. 12.) getting better their understanding and the 95% of the students of the experimental group could recognize rocks (marbles, granites, limestone and fossils) after the educational geological walk trail and they improved their critical thinking (Fig.13). Almost all the students from experimental group admitted that geology is a very interesting science changing their attitude towards geology (Fig. 14). It is worth mentioned again, that the students of experimental group educated and worked together in small teams of 5 persons, improving their cooperation and communication ability.



11 (a) **11(b)**

Fig. 11: Understanding of geological procedures.

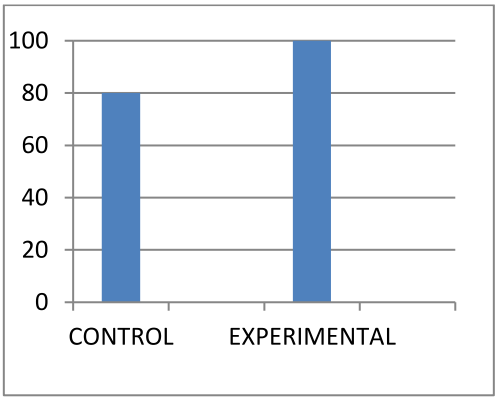


Fig. 12 : Information about geological and hydrological potential.

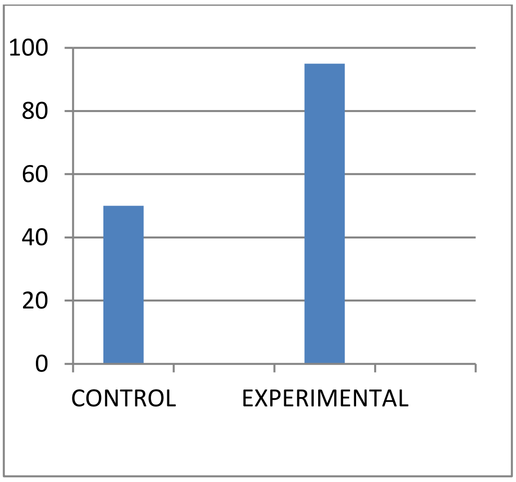


Fig. 13: Recognizing rocks.

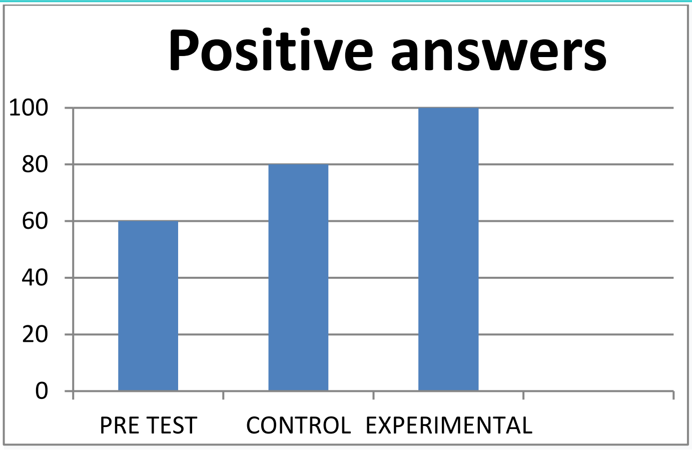


Fig. 14: Students were asked: How interesting is geology?

Students' understanding, creativity, cooperation and critical thinking were spectacularly improved. Such skills are classified in Bloom's taxonomy as belonging to the 'analysis' and the 'synthesis' higher-order cognitive levels (Bloom, 1984). They learned about the river Eridanus, they could recognize white marble of Pendeli, grey Hymettus' marble, green marble of Karystos, granites and limestones with fossils.

The educational geological walk trails seems to have clear value in student motivation and in student learning.

7. Acknowledgements:

The authors would like to thank the Director of Paleontology-Geology Museum, Professor Vassileios Karakitsios.

8. References

Καλκάνης, Γ.Θ., 2010. ΕκΠαιδευτικό ΕΡΓΑΣΤΗΡΙΟ και ΕκΠαιδευτικές ΤΕΧΝΟΛΟΓΙΕΣ, Ι. το Εργαστήριο, ΙΙ. οι Τεχνολογίες, Αθήνα (in Greek).

Bakopoulou, A., Antonarakou, A., Loizos, S., Zambetakis –Lekkas, 2016. Development and precodification of a lithosphere questionnaire as a tool in educational research (Geosciences). *Bulletin of the Geological Society of Greece*, 50(1), 201-208 https://doi.org/10.12681/bgsg.11720

Bloom, B.S. (Ed.), 1984. Taxonomy of educational objectives. 1: Cognitive domain. White Plains, Longman, NY.

Bouras, Ch., 2017, Byzantine Athens. 10th-12th centuries, Routledge – Benaki Museum, Athens.

Chuang, X., Hai-hong, W., Zhi-cai, L., Jin-sheng, N. and Hua-liang, L., 2015. Multilayer stress from gravity and its tectonic implications in urban active fault zone: A case study in Shenzhen, South China, *J. of Applied Geophysics*, 114, 174-182.

Dermott, L.,1996. Physics by Inquiry: Physics Education Group University of Washington, Washington.

Kali, Y., Orion, N. & Eylon, B-S, 2003. The effect of knowledge integration activities on students' perceptions of the Earth's crust as a cyclic system. *Journal of Research in Science Teaching*, 40(6), 545–565.

Manion, L, Cohen, L., and Morrison, K., 2000. Methodologia ekpaideftikis erevnas, publ. Metaixmio, 737 pp. (in Greek), Athens.

Zervopoulou, A., Pavlides, S., 2016. Geological mapping in urban areas. a case study from the inner city of Thessaloniki, Greece. *Bulletin of the Geological Society of Greece*, 50 (2), 1027-1023 https://doi.org/10.12681/bgsg.11807.