

Characterization of minerals based on geological criteria by children in early school years in a non-formal educational setting

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ABSTRACT

This research is related to the design and evaluation of an educational intervention that focuses on classification of minerals based on geological criteria. A sample of 17 children at the age of 6-7 years participated in the intervention, which took place at the Mineralogy Laboratory of the University of Patras. The results demonstrate that the children have made a cognitive progress since they were able to classify minerals on the basis of their physical properties (color, transparency, luminescence) as a consequence of their participation in the intervention.

KEYWORDS

Early childhood education, minerals, non-formal education, educational intervention

RÉSUMÉ

Cette recherche concerne la conception et l'évaluation d'un programme éducatif traitant de la classification des minéraux sur la base de critères géologiques. Le programme a eu lieu dans le Laboratoire de Minéralogie de l'Université de Patras et 17 enfants âgés de 6 à 7 ans y ont participé. Les résultats mettent en évidence un certain progrès cognitif chez les enfants puisqu'après le programme, ils peuvent classer les minéraux en fonction de leurs propriétés physiques (couleur, transparence, luminescence) à la suite de leur participation à l'intervention.

MOTS-CLÉS

Éducation préscolaire, minéraux, éducation non formelle, programme éducatif

INTRODUCTION

It is known that formal education does not constitute the only way for approaching knowledge: Museums of natural sciences as well as other venues that aim to spread of the scientific knowledge, such as university laboratories, take part in the education of wide audiences and students. The museum setting offers the so-called non-formal education (Eshach, 2007; Meunier, 2018), in the pursuit of a cooperation with formal education at school and university level. On the other side, the

formal environment can approach the non-formal educational environment in order to enrich and complete teaching with original material and knowledge offered by the non-formal educational environment (for geological topics see, eg. Clary & Wandersee, 2009). In this context, the Department of Educational Sciences and Early Childhood Education of the University of Patras collaborated with the Mineralogy Laboratory of the Geological Department in order to implement an educational intervention for children at the preschool and early school level, dealing with the characterization of minerals.

The aim of this project is to describe the specifics of the design and the results of the implementation of the educational intervention. More specifically, we attempt to answer the following research question: Can children in the early school level categorize minerals by using as criteria their natural characteristics (color, transparency and luminescence) after their participation in a corresponding educational intervention? The color of a mineral is due to the absorption of certain wavelengths of the wavelengths of white light by the atoms of the crystal. In terms of transparency, minerals are distinguished in transparent, translucent and opaque. With reference to luminescence, the crystals of minerals can absorb ultraviolet radiation and re-emit part of it in the form of visible radiation. This phenomenon is called luminescence. These properties were chosen because it is easier to look at them macroscopically than others who need microscopical analysis.

THEORETICAL FRAMEWORK

Pedagogical Design Principles

The Mineralogy Laboratory as a university laboratory addresses mainly a specialized homogenous audience; at the same time it aims to the cultivation of knowledge and skills of students of all ages. In this context, it offers educational interventions to preschool and elementary school children. The designed interventions take place every year during the spring semester. These interventions, besides dealing with mineralogy matters, also pursue the development in the children of positive attitudes towards a laboratory of Natural Sciences. The intervention analyzed below was designed in the context of a postgraduate course, focusing in the active participation of the students in the specific laboratory environment.

The design was based on grounded pedagogical principles that have already been used extensively in science-related teaching interventions in formal education environments (Zogza & Ergazaki, 2009). From a pedagogical perspective, the constructive approach of teaching and learning guided the design and also the implementation of the several activities. In this context, knowledge is a mental structure that the students create individually. It has been noted that preschool and early school level students, especially in a setting such as the laboratory, are in the position of constructing the so-called precursor explanatory models, which are related to the scientific and technological knowledge. There is a substantial number of research works in Greece and internationally that support this theoretical perspective (Hadzigeorgiou, 2015; Ravanis, 2017). However, just a few of them focus on the necessary educational material concerning the construction of precursor scientific and/or technological models in non-formal educational settings (Sobel & Jipson, 2016).

The starting point of the program suggests a parallel use of both the exhibits of the museum itself and its facilities. The design of this intervention is related to suitable didactic approaches which addresses specific ages, taking into consideration the cognitive peculiarities and needs of the participants (Filippoupoliti & Koliopoulos, 2012; Koliopoulos, Gouskou & Arapaki, 2012). In this context, the intervention is nothing else but an “open research assignment”, within which the

children's alternative conclusions/categorizations are accepted. In this way the specific characteristics of the group have been taken into consideration (age, cognitive background), while at the same time an attempt is made for promoting the participants' self-action and initiative, motivating them to research, but also enabling them to construct personal meanings. The possibility of detecting and choosing the minerals under investigation, on the one hand, intrigues the children's interest and, on the other hand, reinforces their initiative.

This specific intervention is also characterized by teamwork, which leads the participants to pose questions that they process as an outcome of the interaction with the other members of their group.

Misunderstandings-obstacles in the thinking of the children

After reviewing the pertinent literature, it seems that there is just a limited number of researches with a relevant subject matter (Francek, 2013; Rule & Auge, 2005). However, some cognitive obstacles regarding children's thinking have been recorded. More specifically, according to Piaget (Francek, 2013) the pupils attribute the creation of minerals and rocks to supernatural powers or to human activity. According to Francek (2013), difficulty is also acknowledged in regard to the identification of the composition of the rocks. Finally, the children appear to focus on criteria concerning external similarities such as size, shape and color when they attempt to categorize minerals (Francek, 2013).

Dealing with children's difficulties, posing them as teaching targets, is a concern also expressed by Rule & Auge (2005), who tried to investigate the early school level children's knowledge about minerals and rocks, working with pupils from a New York elementary school. To achieve this, comics and related activities were used in a humorous way to teach the concepts of minerals and rocks, as it has been shown that humor increases the attention and motivation of children and contributes to the process of learning. In their research they claim that the use of innovative methods for the teaching of these concepts helps the children to connect their pre-existing knowledge with new information, underlining at the same time the effectiveness of these methods in comparison to the traditional ones.

METHODOLOGY

The outline of the research

This research is a case study (Creswell, 2005), since its main focus is on a) the investigation of the participants' viewpoints on minerals and rocks and b) the cognitive progress that takes place when the participants are involved in an educational intervention on this matter.

The sample of the study consisted of 17 children (9 boys and 8 girls, 6-7 years old) that were students of a Greek public school, with mainly middle socio-economic characteristics, and attended the intervention in January 2018. The students were chosen on the basis of the teacher's willingness to help in our research and they neither had dealt before with the notion of minerals nor had attended other similar educational interventions.

As a tool for the collection of data, the focus group interview was used. The advantage of this method is the interaction among people and the collection of more qualitative and suitable information because of the succeeded collaboration (Creswell, 2005). One more reason is the limited time we have in our disposal for the collection of the necessary data, since this educational intervention should be completed in about an hour (Creswell, 2005).

Finally, in the context of a qualitative analysis of the data, two consecutive processes took place. The first one was the transcription of the dialogues of each group, followed by the constitution of categories under the criterion of the exploited natural property of the minerals for each case.

The educational intervention

Implementation conditions

This intervention was designed with the aim to be implemented at a place where experimentation and exploratory learning are mostly favored, as children have the opportunity to come in immediate contact with the mineral samples and interact with the materials.

The intervention was implemented in two of the classrooms of the laboratory. During the intervention, the children worked in groups of four and each group was named by a distinctive color (red, blue, yellow, green). Each group had two minerals at its disposal and also two rocks, stickers of a specific color, pails, which were used for the categorization of their materials (pail for the minerals, another pail for the rocks). More explicitly, the minerals given to the red group were fluorite and aragonite, to the blue quartz and calcite, to the yellow pink quartz and calcite and finally to the green fluorite and quartz. The mineral samples used in the groups present all the properties mentioned for the design of the intervention (color, transparency and luminescence). The intervention had duration of 80-90 minutes.

Aims and context of the activities

The aim of this educational intervention is to help the children:

- to categorize minerals under the criteria of the natural properties of color, transparency and luminescence,
- to recognize the laboratory as a place of research and collection of information.

In order to intrigue the children's interest, the story of a mole (a mammal living below the earth) was used as a communication context. The mole tries to bring the children into contact with the minerals through his narration for travels under the earth. The intervention started with the detection of the children's initial ideas through the posing of questions such as: "*What do you believe exists beneath the ground?*":

The children's familiarization with the mole presented in the scenario allowed them to face with the problem that they had to solve and the assumptions they had to make for setting appropriate criteria for the requested classification. The children, working in groups, initially were asked to form categories utilizing "spontaneous" criteria. The formed categories were presented as a response to the question "*Why did you divide them in that way?*". In the same activity, aiming to the discovery of information for the various materials that the children had in their disposal, the need for visiting the laboratory arose.

The free tour that took place in the area of the laboratory, lead to the emerging of a new question that the participants have to consider in the second phase of the intervention. More specifically, during the free tour the children detected among the exhibits only the minerals. This action contributed to the normal transition towards the natural properties of the minerals, as a new question arose "*What distinguishes the materials-objects we located in the laboratory from those we did not locate?*", "*Are there differences between our materials? And if yes, which are they?*".

So, in this phase, the utilization of scientific geological criteria is pursued these criteria concern the color, the transparency and the luminescence of the examined samples.

With the completion of the systematic examination of the presented natural properties shown by the “items” that each group had at its disposal, we gave one more mineral which macroscopically looked like a rock, was transparent, and it is intensely luminescent, and then the children are asked to include it in a category.

Conclusively, a discussion was held at the plenary. Each group was asked to present its final categorizations to the other groups, using geological criteria to justify their choices.

The role of the teacher throughout the process is adjuvant and he/she provides information when needed. In this application, the teachers-researchers were the ones who implemented the program. In any other case, the same program could have been implemented by the educator as an animator in collaboration with the staff of the museum.

RESULTS

From the data we concluded that the children initially categorized focusing on the external similarity of the samples with references to shape, the size and the gleam. Indicative answers given to the question “*Why did you divide them in this way?*” are “*Because these are all round*”, “*in one pail we put the big ones and in the other the small ones*”, “*Because these shine whereas these don't*”. One group mentioned that “*we put them randomly*” so they do not categorize based on a specific criterion.

With the completion of the activities, it was noticed a transition from the use of criteria of external similarity to the use of geological criteria that children used during the program. Typical examples of the dialogues among the members of the groups were the following:

Focusing on the property of transparency, during the experimentation with the lenses and while examining a sample of quartz, one group concluded that:

Girl 3 (G3): Light goes through it.

Boy 4 (B4): Yes, it does!

Researcher (R): What do you notice?

G4: We can see beams in it.

G3: The light comes out from the other side.

In regard to the property of luminescence, the dialogue among the members of the other two groups, categorizing with the criterion of the specific property, is interesting.

R: Did this change color?

B1: Yes, it did. It turned to brown.

R: What do the rest of you say? Did it change color?

G1: It turned to white with brown.

B2: Let me see, I see something blue there.

R: Why did you divide them in this way?

B7: These (showing the minerals) changed color.

G8: It was perfect! This one turned to red (referring to the sample of calcite).

A particular interest is represented by the combination of criteria used by one group in order to justify their categorization. The combination of two criteria was not used by the children in the categories made in at the begging of the program (spontaneous criteria).

R: Explain to me, why did you divide them in this way?

G5: Well, because from these (shows the pail with the mineral) the light comes through from the other side.

B5: (with certainty) These (shows the minerals) shine!

G5: They shine a lot!

This particular group justifies its choice to put the minerals in the same pail by making reference to the properties of transparency and luminescence of the specific samples.

DISCUSSION

The results lead us to conclude that it is possible for the educators to design and implement an intervention in a non-formal educational setting, within which cognitive development can be accomplished. This fact is confirmed by Rule & Auge (2005), who suggest that the use of innovative teaching methods contributes to the substantial change in the children's thoughts.

The children initially made classifications by focusing on the external similarity of the samples (size, shape), as Francek notices (2013) in his research. After the completion of the activities we saw how they used the criteria that, in a higher level, approach the scientific model (natural properties of minerals).

Moreover, the children used more than one natural property of the minerals to argue for their categorizations. This fact presents a particular interest, as this assumption might show a different way of composition of the young children's notions, that present larger cognitive complexity in comparison to the linear causative thinking, within which one cause is connected to a specific result, as the kids seem to frequently use at this age.

Concluding, it must be noted that the above results are due to the use of representative mineral samples, which present the three properties under examination at great extent.

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