

ACADEMIA | Letters

A survey to analyze the learning of geology in the Compulsory Secondary Education system of Catalonia (Spain)

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Introduction

The training received during primary and secondary education is crucial for the development of our behavior in adulthood. For this reason, at this early stage, it is important to know our environment and its dynamics to appreciate it. The Spanish Secondary Compulsory Education (SCE) comprises four academic years and is taken by students aged 12-16. The learning of geosciences during this level takes place only in the first, third and fourth year. Biology and geology are part of the same subject, being mandatory in the first and third year and optional in the last year. The students lose their interest in science as they advance from primary to secondary education and cease to see it as a viable option for their future (Zamalloa and Sanz, 2020). Several authors have also detected this lack of interest in science of young people (Ali et al., 2013; Christidou, 2011). This disinterest is manifested in expressions such as “Science does not provide food”, “You have to study hard” or “Science is boring”. To avoid this lack of motivation, educational models should be reoriented towards an educational system in which students are at the center of their learning and not simply focused on the systematic acquisition of memorized concepts to pass an exam.

The discipline of Earth Sciences, or Geosciences, face a more difficult challenge than many other sciences given that students do not learn geology during early stages of their academic life (Adetunji et al., 2012). In many places such as the USA (Lewis, 2008), Australia (Dawborn-Gundlach et al., 2017), some countries of northern Europe (King, 2013), Argentina and other Latin American countries (Lacreu 2017; UNESCO, 2019) and Spain (Pedrinaci, 2012) geoscience subjects are underrepresented and frequently in the optional subjects, it is selected by students who are unmotivated.

Given this context, the present study investigates the structure of geoscience education in the frame of the SCE system from Catalonia and the degree of geological knowledge acquired by the students.

Data collection

An online survey was selected as an appropriate methodology to be used in a quantitative study, which was conducted with 1197 students of the SCE system from Catalonia (an au-

onomous region of Spain). Most of the answers correspond to students of 1st (426), 3rd (256) and 4th (424) year. The survey included 23 items. It was divided into five blocks named (1) students profile, (2) academic factors, (3) perception of geosciences, (4) personal interest and curiosity in geosciences and (5) linkage with outdoor activities. The answers were anonymous. The 85,3% of the high schools that participated in the survey were public, whereas 14,0% were partially state-subsidised and 0,7% were private.

Students responded most of the multiple-choice questions and items on a 5-point rating scale from 1 to 5, where 1 means that they do not agree at all and 5 when they totally agree. In addition, they also responded to open questions and others with semantic differential scales. Moreover, specific questions were raised to know the usefulness or professional future value of geology.

Results and discussion

Perception of geoscience

To analyze the perception of geology by SCE students a question with semantic differential scales was formulated in order to know the positive and negative aspects. Students were able to choose a word to describe her/his perception about geoscience: illusion, interest, ignorance, indifference, boring. The less appreciated perception of geoscience was illusion (2,7%) and the most appreciated was interest (45%). However, 12% of the students found geosciences boring and 17% showed indifference. It is important to note that the 23% of the students surveyed recognize that they have a significant lack of knowledge on fundamental and basic geological concepts and processes. In addition, the 70% of the students who responded the questionnaire do not believe that geology can be useful for their further studies. This result agrees with the lack of information about the professional job opportunities in geology highlighted by the 85% of the survey participants.

A great number of students perceived geology as a destructive discipline. They believe that geology is predominantly an economic discipline, supplying raw materials needed for economic development. Moreover, geology only comes to the fore and is visible by society when a catastrophic phenomenon associated with geological hazards (volcanoes, earthquakes, floods, landslides) or anthropogenic pollution occurs. However not always the students have a negative perception on geology. Other survey (Almeida et al. 2013) reported that some of the respondents acknowledge the role of geology against the destruction of the nature and emphasizing the importance of this science in the sustainable management of mineral resources.

Personal interest in geosciences

Although the large majority of the surveyed students (85%) answered that they had learned geology topics in CSE, the 59% of them did it only during the first year. The main topics covered were: 1) the Universe and the Solar System (70%); 2) crystals and minerals (58%); 3) plate tectonics (56%); 4) fluid envelopes of the Earth (55%); and 5) the rock cycle (50%). The 2% of the students do not remember having learned any of the proposed topics. When they are asked to specify further geological concepts learned, a confusion with other subject areas such as biology (47%) was observed, especially in 1st course students (12-13 years).

Despite these results, the students consider that they have a medium or medium-high level of geological knowledge (2.99, in the range from 0 to 5). This acquired knowledge is concentrated in some part of the geology, such as fossil recognition (85%). However other issues are less known, such as the origin of the raw materials for making the objects we use daily. Even, most of them (55%) do not know or have only a little knowledge that a large amount of minerals is needed to make a cell phone or that we use the minerals regularly every day, e.g. in the toothpaste or medicines. When asking Do you know what rock is used to make cement? 75% of student responses were that they do not know. However, more than a half of the surveyed participants (50%) affirmed that they know what mineral we eat each day. These results show that the study of raw materials for the manufacture of most every day items is undervalued in the secondary education. Also, the geosphere is one of the less studied topics, only 19% of the students indicated that they know the chemical composition of the Earth's crust.

Moreover, students, and society in general, tend to have a passive attitude towards acquiring new knowledge. Nowadays, it is more attractive to watch a film or a YouTube video or in another digital platform, than to read a book. Along these lines, the survey asked about if they had watched videos or documentaries related to geology either at school or at home, and 79% of them gave an affirmative answer. These results prove that interest in geology topics exists among the student community.

Linkage with outdoor activities

Nearly half of the surveyed students, 45%, affirm that they have carried out outdoor activities related to the geology, such as field trips, it occurs mainly during the 1st year of CSE (54%). During the following years of CSE this activity drops significantly, and only 18% of the students surveyed participated in a field trip during the 4th year, for example. When evaluating these results, however, it is important to consider the mess that students made between geology and any other subjects related to outdoor didactic activities e.g., the biological part of

the ecosystems, archaeology, visits to a planetarium. Accordingly, it would be advisable to teach on the different aspects before and after a field trip with high school students to fix the concepts and to promote the mainstreaming of the activity.

In general, field trips and fieldwork are a good strategy in teaching geosciences. For example, Esteves et al. (2013) show in their study the efficiency of field trips in the transmission of geological knowledge and environmental issues. Evidence suggests that contact with nature contributes to the learning and development process (Kuo et al., 2019). Outdoor activities also facilitate the socialisation of students, because they can interact with each other more easily while directly developing the scientific method (observe, propose, experiment and discuss). However, there are noticeable differences in the time spent outdoors between children and teenagers. Children aged 13-19 displayed lower levels of participation in outdoor activities compared to children aged 6-12 (Larson et al., 2011). Esteves et al. (2013) insist on the need to increase outdoor activities in the SCE and the Baccalaureate.

Conclusions

Geological learning on the CSE system of Catalonia mainly occurs during the 1st academic year, when students are not yet aware of the geological implications in both the natural and anthropogenic environment. The CSE students show a significant lack of knowledge of the most applied aspects of geology, such as the use of minerals in daily objects. Field geological practices, which have the potential to act as a motivation factor among students, are also only performed, for the most part, in the 1st year of CSE.

Although CSE students show enthusiasm for geosciences and they consider that they have a medium or medium-high level of geological knowledge, the survey results highlight a significant unfamiliarity with fundamental geological concepts and processes. Furthermore, the fact that students do not perceive geology as useful for their future aggravates the poor state of Geoscience schooling in CSE.

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References

- Adetunji, O. O., Ba, J. C. M., Ghebream, W., Joseph, J. F., Mayer, L. P., & Levine, R. (2012). Geosciences awareness program: A program for broadening participation of students in geosciences. *Journal of Geoscience Education*, 60(3), 234-240.
- Ali, M. M., Yager, R., Hacieminoglu, E., & Caliskan, I. (2013). Changes in student attitudes regarding science when taught by teachers without experiences with a model professional development program. *School Science and Mathematics*, 113(3), 109-119.
- Almeida, A., Vasconcelos, C., Pereira, C., Torres, J., & Moutinho, S. (2013). The role of geology in a sustainable society: perceptions of University students. ICERI2013.
- Christidou, V. (2011). Interest, Attitudes and Images Related to Science: Combining Students' Voices with the Voices of School Science, Teachers, and Popular Science. *International Journal of Environmental and Science Education*, 6(2), 141-159.
- Dawborn-Gundlach, L. M., Pesina, J., Rochette, E., Hubber, P., Gaff, P., Henry, D.,...& Redman, C. (2017). Enhancing pre-service teachers' concept of Earth Science through an immersive, conceptual museum learning program (Reconceptualising Rocks). *Teaching and Teacher Education*, 67, 214-226.
- Esteves, H., Ferreira, P., Vasconcelos, C., & Fernandes, I. (2013). Geological fieldwork: A study carried out with Portuguese secondary school students. *Journal of Geoscience Education*, 61(3), 318-325.
- King, C. (2008). Geoscience education: An overview. *Studies in Science Education*, 44(2), 187-222.
- Kuo, M., Barnes, M., & Jordan, C. (2019). Do experiences with nature promote learning? Converging evidence of a cause-and-effect relationship. *Frontiers in psychology*, 10, 305.
- Lacreu, H. L. (2017). The social sense of geological literacy. *Annals of Geophysics*, 60.
- Larson, L. R., Green, G. T., & Cordell, H. K. (2011). Children's time outdoors: Results and implications of the National Kids Survey. *Journal of Park and Recreation Administration* 29 (2): 1-20, 29(2), 1-20.
- Lewis, E. B. (2008). Content is not enough: A history of secondary earth science teacher preparation with recommendations for today. *Journal of Geoscience Education*, 56(5),

445-455.

Pedrinaci, E. (2012). Alfabetización en Ciencias de la Tierra, una propuesta necesaria. *Enseñanza de las Ciencias de la Tierra*, 20(2), 133-133.

Pedrinaci, E. (2014). La geología en la educación secundaria: situación actual y perspectivas. *Macla, Revista de la Sociedad Española de Mineralogía*, 14, 32-37.

UNESCO (2019). *Geoscience in primary and secondary education, volume 1. Realities and opportunities in Latin America and the Caribbean. International Geoscience and Geoparks programme.* <https://unesdoc.unesco.org/ark:/48223/pf0000371312>. Accessed 22 Nov 2021

Zamalloa, T., & Sanz, J. (2020). Attitudes of secondary school students towards geology in Spain. *Research in Science & Technological Education*, 1-24.