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Short communication

Volcanologists for a day: an experience with Canarian students

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Abstract: Geology, as a basic science within the natural sciences, is one of the key areas of knowledge for students in both primary and secondary education. However, when teaching the areas related to geology, many doubts arise both, for teachers and students. In the case of students from the Canary Islands, who live literally on volcanic islands, geology becomes even more important and its teaching becomes mandatory. Geological concepts and processes form part of their environment, their heritage and it is also relevant in terms of the exploitation of natural resources and ecosystems around them.

During the 2021-2022 academic year, and within the educational project "Ciencia a lo grande" (Science in a big way), a number of practical workshops on volcanoes have been developed in 9 primary schools in Tenerife, with the target audience being students and teachers, who also received specific training to continue the activities on their own in the following years. The workshops were very successful, and the results were very positive, partly due to the interest around all the information surrounding the last eruption that took place in the Canary Islands archipelago, Tajogaite volcano in the neighbouring island of La Palma. For this reason, there was great motivation between teachers and students. The workshops have been focused on the activation of perception and awareness of our environment, highlighting the volcanic structures that each school has around it and their morphological characteristics, differentiating them from other prominent volcanoes in the Canary Islands and all around the world.

Keywords: Viscosity, volcanoes, volcanic structures, geology education, hands-on, active learning, volcanic risk, Canary Islands.

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1. Introduction

Taking advantage of the natural resources offered by the environment allows pupils to learn useful lessons for life (Pedrinaci, 2012), which are essential in the new legislative change (LOMLOE, 2020). In this sense, the Canary Islands are an incomparable setting for the study of the processes and results of volcanic activity. Being eminently volcanic in origin (Anguita and Hernán, 2000), volcanic dynamics and their main products can be studied directly on the islands, and this knowledge indirectly affects the perception of volcanic risk. Physical and energetic terms such as viscosity and explosiveness are sometimes difficult to understand for secondary school pupils (Pedrinaci, 1996), so if these scientific concepts are introduced in elementary education using low-cost science, we will attract pupils' interest to scientific areas and, at the same time, we will be able to avoid the emergence of misconceptions or alternative ideas (Perales-Palacios, 2021).

Knowledge of the natural environment at elementary school level is an area of knowledge that has undergone various changes in the educational laws of the past few years. These changes can be seen both in the didactics and objectives of the stage, as well as in the content and knowledge included in the curriculum. In fact, in the new guidelines established by Educational organisation and curriculum of Primary Education in Spain (LOMLOE, 2020), the areas of Experimental Sciences and Social Sciences are combined again in order to promote more multidisciplinary learning at this stage, and to educate children who are more curious, attentive, social and critical of the world around them, giving greater relevance to knowledge of and respect for heritage. Regarding this, it is intended that in the design of learning situations a more active and competent learning is promoted with activities focused on the basic knowledge of initiation to scientific activity: "scientific culture" where through active methodologies such as inquiry-based learning or discovery, they manage to develop scientific thinking skills and strategies, as well as develop creativity, curiosity through observations and measurements, and the use of scientific vocabulary.

Previous studies focused on volcanology and education try to understand, from a "passive" perspective, how students perceive the complexity of a volcano, and what perceptions or knowledges they have about its forms, their related products and about the volcanic risk (Vilchez-González et al., 2014). There are very few studies that propose the acquisition of knowledge, skills and attitudes in a practical way. In this line, primary school teachers need to have resources that allow them to move away from the textbook, and invite them to use more active and hands-on methodologies in the classroom. These teachers also need training initiatives in science and didactics of experimental sciences, which provide them with theoretical support and curricular anchoring for more practical or laboratory activities. These needs are not new, and are even recognized by UNESCO (Soussan, 2003).

During the 2021-2022 school year, the first edition of the " Ciencia a lo Grande" (Science in a big way) project took place, with the participation of 9 schools of the island of Tenerife in Canary Islands. The teachers received theoretical and practical training on volcanology concepts and experimental activities to improve their lessons. Later, the science educators of the project carried out the workshops in the schools, where the teachers could learn from the experience and give feedback to the project and their results with their students. In this way, both primary school students and their teachers can take advantage of the experience. This type of training for teachers serves also to certify a number of hours of learning courses that they are required to achieve every year by the Spanish Education System.

In this study, we present a collection of three workshops oriented to the study of volcanology and natural sciences in the primary education stage, which serves as a guide and inspiration for teachers who want to use active and participatory methodologies, introducing the scientific method, using accessible, manipulative, low-cost materials, and that does not require a laboratory to be carried out.

2. Materials and methods

This project has designed and carried out a didactic training in experimental sciences focused on earth sciences and volcanology for primary school teachers, afterwards taking the practical workshop to the classrooms of the participating teachers to put it into practice with their students. This practical workshop was planned to last one hour and consisted of four experiences, which will be detailed below. The activities were designed so that students could carry them out in a manipulative way, following in part the instructional design proposed by Merrill (Merrill, M. D., 2007). All the resources created use everyday materials that students recognise and use. In this way, students are brought closer to science and can better understand natural processes by linking them to their everyday experience, while at the same time acquiring a vision of science as something close, interesting and relevant to life.

The first part of the workshop started with an introduction in which previous ideas and personal experience with volcanoes in the Canary Islands are activated in order to connect them with simple scientific vocabulary, in this way we manage to enrich the students' knowledge of the Canary Islands' natural environment of volcanic origin with scientific vocabulary and concepts, building on their previous knowledge.

The second part of the activity was a classroom experiment to work on the viscosity of volcanic materials in a practical and visual way. To do this, we used a smooth surface as a sloping plane and a viscous polymeric fluid (slime) as materials. Mixtures with different polymer concentrations were prepared to achieve different degrees of viscosity. Using deductive methodology, the aim is for students to understand what a non-Newtonian fluid (such as lava) is and how the viscosity of the material in the magmatic chamber is an important factor in explaining the behaviour of geological characteristics such as the explosiveness of a volcano or the expansive capacity of lavas.

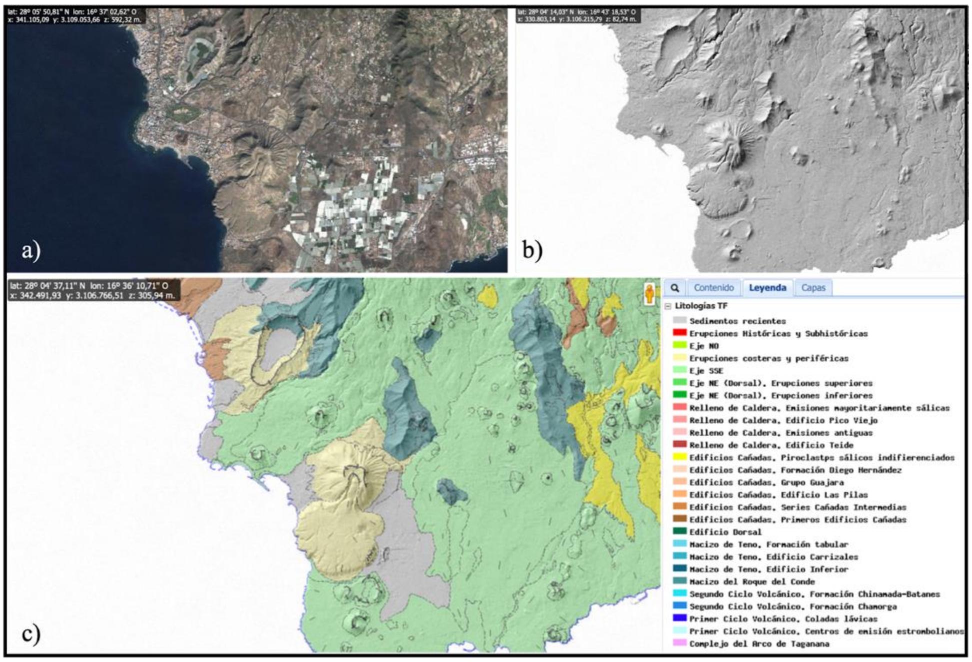

Figure 1. Tenerife South transect maps used for the teaching sheets (**a**) Ortophoto, (**b**) Hillshade image and (**c**) Geological map. Source: Visor Grafcan-IDECanarias (https://visor.grafcan.es/visorweb/).

The third step was a topographic study using satellite images to identify volcanic buildings on the islands of Tenerife and Lanzarote. These images were taken from the Canary Islands Government's software IDE Canarias (Infrastructure of Space Data of the Canary Islands). Three space images were provided: an orthophoto without legends in which volcanic buildings predominate; in the case of Tenerife, cuts were made in the southern and central areas of the island, and in the case of Lanzarote, a cut of the Timanfaya National Park was selected. The second image offered to the students was the geological map of these sections, including the legend. The third map was a shadow model image. Together with these images, according to the maturity level or academic level, the activity was completed with cards on types of volcanoes in the world. These cards included different types of volcanoes according to their morphology and behaviour and were created by the authors using the software Google Earth. The methodology used was problem-based learning, as the activity consisted of trying to identify the morphology of the buildings by comparing the different types of images with the cards and the information presented on them. Figure 2 shows an example of the space images with which the students carried out the activity. In addition to the images and cards, we provide the students with a field notebook to record the results of their research, the number of volcanoes detected, and the types of volcanoes observed on the maps.

The fourth activity consisted of simulating a volcanic chamber and a live eruption, to bring the students a demonstration of the influence of gas accumulation and magma viscosity as key factors that determine the explosiveness of a volcano. Materials used to make this experiment were slime, syringes, water and effervescent pills. Deductive methodology will be employed.

As a final activity, students were asked to interpret what they observed in the slime experiments to determine the influence of viscosity on the destructive power of a volcano. The students deduced that more fluid lavas can cover larger areas, while more viscous lavas can be associated with more violent eruptions. Finally, the pupils were given some safety advice on how to act in the event of a volcanic eruption near their place of residence.

3. Results and discussion

This is a pilot project and we have obtained qualitative results; in the next year we will carry out these activities with a complex structure and quantitative results. The results of these workshops have been obtained through teacher satisfaction questionnaires (who have collected the experience of their students), delivered both at the end of the theoretical-practical training of teachers and at the end of the workshops in schools with the students.

The theoretical and practical training on geology and volcanology for primary school teachers was very well received. However, the teachers stated that, given the complexity of the concepts and processes explained, they found it very difficult to independently use the resources provided by the trainers. For this reason, a series of workshops were held at the teachers' schools to consolidate the practical experiences provided by the trainers through hands-on experience in their own classrooms. The geology and volcanology workshops were conducted in 9 primary schools on the island of Tenerife, with students from first to sixth year of Primary School (6 to 12 years old), as our proposals do not require the use of a laboratory or special classroom to carry them out. The reception and participation of the students in them has been very high and the teachers have shown their satisfaction with the results obtained, the methodology applied and with the curricular anchoring in the subject of Natural Sciences.

3.1. Activating volcanologist

During the activation part of the workshop, we found that most of the students already knew some terms related to volcanoes (mainly related to volcanic products such as lava, lapilli, etc.) and many of them commented that they had followed the recent eruption of Tajogaite volcano on the neighboring island of La Palma. This fact has undoubtedly meant that the activation of the workshop has directly connected with the pupils' previous knowledge.

3.2. Slime race

To connect these prior ideas with scientific concepts and vocabulary, the students are introduced to the relationship between a more or less explosive eruption and the morphology, types of materials deposited, color, etc. We use slime (viscous polymeric fluid) to simulate volcanic lava. If the lava is more liquid (less viscous), the eruption produces a larger volume of material that generally moves faster than more viscous lava. To see this property visually, we place three samples of fluid of different viscosity on a sloping surface at the same height in a race, to see which one moves faster, analogous to what would happen with lava flows (see Figure 2 (b)). Students hypothesize about which one will arrive first and then observe how they behave in the experiment and draw conclusions about the degree of destructiveness of each type of lava, dependent on the speed at which they reach the base of the valley.

Figure 2. Workshop evidence: (**a**) Production of polymeric fluids (slime) with different viscosities, (**b**) Slime race experience in the classroom.

The students' preconceptions about viscosity were quite accurate. Whilst their assumptions about how a fluid will behave as a function of viscosity in a volcanic eruption were confusing, when shown the example material (slime) they were able to predict without failure that the more viscous fluid would take longer to slide. This indicates that practice with real materials is much more illustrative for understanding the process. Also, the use of common material such as slime made the activity more attractive. The students showed great interest in observing the progress of the fluids along the slope.

When asked about what they observed, the pupils responded that they found a volcano with fluid magma much more dangerous than a viscous one, as they observed a greater destructive capacity as it reached a larger surface area. This is the reason why the authors believe that the second part of the workshop, which shows the relationship between the violence of an eruption and viscosity, is essential to provide students with a complete picture of the influence of this factor on volcanic eruptions.

3.3. Analysis of Canary Islands volcanic surface

The aim of the activity is to distinguish on the maps the materials that make up each of the areas of the terrain, as the magma comes to the surface in three forms: liquid (lava), gases and projection of solid fragments (pyroclasts, pyro-fire and clastic fragments) and this results in different morphologies and volcanic structures depending on the type of volcano. This type of activity helps us to continue to base the children on the concept of danger or the probability of a volcano erupting and causing material and human damage. Therefore, the analysis of satellite orthophotos and materials gives us an idea of the eruptive history of a volcano, which is an important factor in determining its volcanic danger, as it allows us to define approximately its current or more recent state and to predict its behavior in the future.

For the analysis of images, space photographs and orthophotos of the Canary Islands, where the pupils live, were used to foster knowledge of their own environment and use it to stimulate curiosity and motivate learning. These images were also chosen because they present a learning curve very suitable for a one-hour session, where students can point out and even identify most of the volcanic buildings present without the need for prior training or guidance from the teacher. We were able to verify that the material was suitable and that the timing of the workshop is perfectly adapted to the different educational levels, and the resources generated allow us to make the activity more or less complex, depending on the level of maturity or skills of the class or working group.

The identification of volcanic buildings by comparing them with images of volcanoes around the world was only offered to those groups of pupils who showed the greatest interest. These pupils needed help with the first examples and then quickly acquired the ability to recognize the structures. We believe that a longer activity would allow them to go more deeply into this part of the activity.

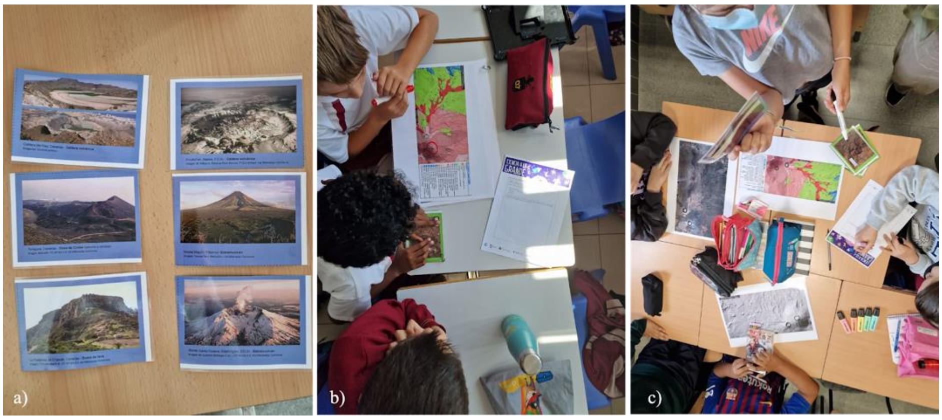

Figure 3. Workshop evidence: (**a**) Cards of volcanic buildings of volcanoes of the world (own production). (**b** and **c**) Primary school students working with the cards, maps and field notebook.

3.4. The role of gases in a volcanic eruption

To get a better understanding about the explosiveness of a volcano, a simple experiment was carried out. With this intention, the eruptive process was simplified by using the phenomenon of effervescence, which allows a rapid accumulation of gases inside a container. In this case, the container was a 5 ml syringe filled with slime and water, to which an effervescent vitamin tablet was added. The syringe represents the magmatic chamber in which the gases produced by the effervescent tablet accumulate. The outlet of the syringe was plugged with 1 ml of slime, which prevented the gases from escaping. The more liquid mixtures emerged from the syringe in a fluid form, while the more viscous mixtures clogged the hole until they reached a pressure that caused them to come out explosively. Finally, a highly explosive volcano was simulated using a film canister, where the lid represented the highly viscous magma. This experiment amazed both, pupils or teachers.

Figure 4. Workshop evidence. Experiment with effervescent tablets and Slime to simulate a volcanic eruption in the classroom: (**a**) Set-up of the experiment. (**b**) Result after the low-viscosity experiment.

3.4. Evaluation of the workshops by the scientific trainers and teachers

As mentioned in other sections, the perception of the teacher trainers who went to the schools to run the workshops was that the pupils had a positive reception of the workshops. Despite having carried out the workshop with different groups of students, between 1st and 6th grade of primary school (6-12 years old) and having to adapt the complexity and depth of the activities, even the youngest students were able to use deductive reasoning during the sessions.

As for the assessment of the teaching staff participating in the educational project, some of them stated that they lacked training in the experimental sciences area and, therefore, in geology. In spite of this, their attitude has been proactive, and they have even admitted that they too have learned from the training and the experiential workshop.

The teachers evaluated the activity via a questionnaire that included questions on satisfaction, applicability of the resources presented and suggestions or improvements to the workshop activities. The most significant results are shown here. For the degree of understanding, 80% of the respondents admitted that the activity was well understood and 20% said that the students had some difficulty at the beginning (prior to the experiments). Some teachers also said that they had learned about the volcanic processes in the Canary Islands.

Most of the teachers surveyed emphasized that the activities were enjoyable and captured the students' attention, being very easy and fun to carry out in the classroom. They highlight the experiments carried out in the classroom using local and manipulative material (Slime Race and Volcanic Eruption experiment). Finally, regarding the use of materials, some teachers stressed that they would use ICT tools such as digital whiteboards in addition to what was proposed. However, all of them welcomed the selection of materials because of their links with pupils' everyday lives and their simplicity (printable maps and worksheets, slime, syringes, water, effervescent tablets, etc.).

4. Conclusions

A pilot project has been carried out to bring volcanology to elementary school classrooms and the qualitative results obtained in the 9 schools where it has been implemented have been very positive. The three educational workshops carried out within the framework of the project have used accessible resources and didactic materials of their own elaboration, which work both with elementary school pupils (6 to 12 years old) and with the teaching staff. Theoretical and practical training has been given to these teachers, reaching 17 teachers from these 9 schools. Therefore, it can be concluded that the objective of providing primary school teachers with accessible didactic tools and strategies to incorporate hands-on science experiments in their classes has been satisfactorily achieved and we hope to see some results in the next educational year. It is important to highlight the importance of carrying out this type of training with primary school teachers, as giving a purely competence-based approach to the teaching of experimental sciences in general, and geology in particular, encourages the intrinsic motivation of teachers. This happens thanks to the eminently active methodologies used, in which both teachers and students have been the actors in their own learning process.

Moreover, an added value to this training is that the workshop leaders and educators made their academic training known in the classroom, serving as role models of women scientists, in line with the strategies to promote scientific vocations in girls and to include the work of Canarian women scientists in the imagination or perception of both boys and girls.

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References

References must be numbered in order of appearance in the text (including citations in tables and legends) and listed individually at the end of the manuscript. We recommend preparing the references with a bibliography software package, such as EndNote, ReferenceManager or Zotero to avoid typing mistakes and duplicated references. Include the digital object identifier (DOI) for all references where available.

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1. Anguita, Francisco; Hernán, Francisco. «Origen de las Islas Canarias: Un modelo de síntesis. *Enseñanza de las Ciencias de la Tierra,* **1999**, Vol. 7, Núm. 3, (pp. 254-261).
2. Merrill, M. D. First principles of instruction: A synthesis. In R. A. Reiser & J. V. Dempsey (Eds.). *Trends and issues in instructional design and technology* **2007** (2nd ed., pp. 62-71). Upper Saddle River, NJ: Merrill/Prentice-Hall.
3. Pedrinaci, E. Sobre la persistencia o no de las ideas del alumnado en geología, *Alambique. Didáctica de las Ciencias Experimentales*, **1996**, 7 (pp. 27-36).
4. Pedrinaci, E. Trabajo de campo y aprendizaje de las Ciencias, *Alambique. Didáctica de las Ciencias Experimentales*, **2012**, 71, (pp. 81-89).
5. Perales-Palacios, F.J. Los volcanes: algunas perspectivas para un conocimiento científico y didáctico. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias* **2021**, 18(3), 3105.
6. Ley Orgánica 3/2020, de 29 de diciembre (BOE núm. 340, de 30 de diciembre de 2020, páginas 122868 a 122953), por la que se modifica la Ley Orgánica 2/2006 de Educación (LOMLOE).
7. Soussan, G. Enseñar las ciencias experimentales: didáctica y formación. *UNESCO Office Santiago and Regional Bureau for Education in Latin America and the Caribbean*. **2003**, ISBN: 956-8302-05-0.
8. Vílchez-González, José Miguel & Prudencio, Janire & Urbano-Rodríguez, Lucía & Ibáñez, Jesús & Carrillo-Rosua, Javier. El conocimiento sobre volcanes en educación primaria, *Vivencias innovadoras en las aulas de Primaria.* **2014**, ISBN 978-84-697-1190-3, (pp. 455-468).