

PAPER VOLCANOES LAB: ENGAGING YOUNG CHILDREN WITH EARTH SCIENCE IN KENYA. WHAT WE HAVE ACCOMPLISHED SO FAR

S. Amici¹, A. Bertoli², J.T. Ng'asike³, M. Tesar², R. Sulpizio⁴, S. Eleman⁵,
P. Emase⁶

¹INGV (ITALY)

²The University of Auckland (NEW ZEALAND)

³Turkana University College (KENYA)

⁴Università di Bari (ITALY)

⁵Middlesex University (UNITED KINGDOM)

⁶University of Nairobi (KENYA)

Abstract

Although most of East Africa's volcanoes are currently dormant they could erupt in the future, while 25% of Africa's volcanoes had eruptions in the last 100 years. How to be prepared and respond to natural hazards such as volcanoes, need to be communicated to young children, learning settings and communities. The project presented here has been funded by IUGG and supported by IAVCEI within the priority area Geoscience Education and Outreach in Developing Countries. It aims to present the Paper Volcanoes toolkit and create a dialogue between science and the indigenous knowledge to communicate natural hazards to children considering their identity and context. The Paper Volcanoes Laboratory toolkit is an experience based activity enriched with pedagogical elements, created within the INGV Educational Group, to help early childhood children to familiarize themselves with natural hazards including volcanoes.

The project focuses on the Turkana rural setting in Kenya where the regional volcanism is known by geologists or indigenous people through their traditional stories. Here we present the methodology used, the preparatory pilot involving four universities students and Turkana early childhood teachers to experience the Paper volcano toolkit and the extended pilot. The pilot was run in September 2022 in Lodwar and consisted of four themed workshops involving stakeholders, teachers (40) and elders. The pilot enabled teachers to hear the stories about the Turkana mountains, experience the paper toolkit, to share ideas, to connect with geoscience specialists and sociologists.

Keywords: geoscience, volcanoes, preschooler, primary school, object play.

1 INTRODUCTION

Natural hazards such as volcanic eruptions, earthquakes, flooding, tornados are fascinating and appeal to young children while at the same time providing an educational opportunity and teachable moments. However, limited activities are designed for early childhood children on geoscience natural hazards [1, 2]. In order to cover this gap we have been exploring playful approaches to help young children familiarize with them starting with volcanoes. In fact, learning theory suggests that we need to incorporate a wide range of skills and competencies in the learning process, not just cognitive skills, and development is dependent upon such interactions [1]. In addition, play transforms behaviors and is acknowledged as the main way children learn, it creates iterative connection with environments and local communities.

Paper Volcanoes Laboratory is an experience-based activity enriched with pedagogical elements [2] created within the INGV Educational Group. Between 2016-2019, the activity has been successfully realized in six INGV open days and three preschool centres in Italy [3] and three in New Zealand [4] resulting in a highly engaging experience for children and in the realization of a paper volcanoes toolkit for educators. The toolkit comprises of an infographic, the instructions for realizing the paper volcano, three templates of coloring volcanoes scenes (two of them depicting two active volcanoes in Italy), 3 sheets of origami paper and lots of resources to widen knowledge about volcanoes. In addition, the kit provides the purposes, the particulars, the room layout suggestions and instructions on how to realize the paper volcano laboratory, the motivation and the variations synthesized can be found in a handy 2-page sheet.

The PAPER VOLCANOES LAB: A way to engage early childhood and primary school children on Earth Science Project (2020-2023) here presented, is funded by IUGG and supported by IAVCEI within the priority area Geoscience Education and Outreach in Developing Countries. It aims to present the paper volcanoes toolkit to teachers and children in Kenya and to create a dialogue between science and the indigenous knowledge to communicate natural hazards to children in a way respectful of their sense of identity and cultural background.

Although most of East Africa's volcanoes are currently dormant, they could erupt in the future. This highlights the need for communicating preparedness, resilience and response with a focus on preparedness of young children, learning settings and communities. Firstly, this project offers the opportunity to enhance the educational experiences of pre-school children and school-aged children through connecting them with knowledge about volcanoes as well as their cultural significance. Secondly, it aims to create a dialogue between science and indigenous culture to communicate natural hazards to children in a way respectful of their sense of identity and cultural background. For example, rural communities and native culture hold in its history and stories the knowledge of volcanism and from those stories the link with geoscience can be found. Thirdly, through the project we aim to increase educators' scientific content knowledge and pedagogical skills by presenting a set of learning activities that are highly engaging the Paper Volcanoes toolkit. Finally, there is an opportunity to connect educators with scientific and geological experts to craft rich learning opportunities.

The communication of geoscience natural hazards to K6 and K12 children can play a role in enhancing people's knowledge of volcanoes and their preparedness to respond to possible volcanic activity or other geophysical phenomena such earthquakes. In this framework, the communication of geohazards is critical.

The research questions of the project are summarized as follow:

- Can the PVL laboratory be used in the frame of the African education system?
- Can the PVL lab be used in a primary school context as well? How do we need to adapt the activities?
- Can the PVL lab play a role by linking researchers and teachers to raise awareness of the impact of geoscience knowledge in developing countries?
- Can the PVL lab be used to increase the learning area of geoscience?

2 METHODOLOGY

2.1 Geological setting of the region

Kenya's volcanism allowed the country to put in place a mature geothermal energy program utilizing heat from volcanoes. However, the knowledge of volcanism of the region is limited to specialists. The project area of interest is Turkana County found in the great Gregory Rift valley in Northern part of Kenya. The Rift Valley of Kenya has numerous features associated with its volcanism. The four most popular are Namarunu Mount, Mount Silali, Barrier Volcano and the famous Mount Kulal. Amongst these Mount Silali has the highest peak with an elevation of 2355m. This mountain is a dormant volcano that is found near the Kapedo region. It was created during the formation of the rift when the ridges were sinking. The action of volcanism caused the magma to erupt forming this feature which has since remained dormant with no signs of recent or future volcanic activities. The Barrier Volcano is a large body of basaltic shield which with time has eroded. It has a caldera that subsided during the time of eruption some 92,000 years ago. This barrier however, has had some subsequent eruptions in the recent times of the Holocene. The Barrier Volcano has a series of complex volcanoes namely the Teleki Volcano, the Likaiu Volcano and the Andrew's Volcano which is the most recent one to erupt in this complex. Lake Turkana is a special volcanic area in this county and in the entire Rift Valley with at least four active volcanoes. Volcanic activity is thought to be spreading downwards to the southern side where there is real proof of it [5]. The northern island of Lake Turkana consists of volcanic tuffs which are thought to have been ejected from tuff cones that were composed of trachyandesite rocks. These tuff cones are of different ages. This island is an active volcano with predictions of a future eruption. The central island also known as the Crocodile Island is another island with active volcanism. The island shows that there is evidence of water and magma interaction. It has many craters scattered across the entire island. There is a varying composition of lavas from basalt to trachydacite. It is believed that an eruption occurred here during the Holocene Era. In the early 20th century in the 1930's however, the island was very active and produced steam and sulphuric gasses and in 1974, some molten sulfur erupted from one of the craters. The Southern Island, also known as the Hohnel Island is a different type of volcano with different lava composition from the Northern and

the Central Islands. The lava found in this island is of the phono-tephrite and trachyandesite. This island has no signs of recent volcanic activity [6].

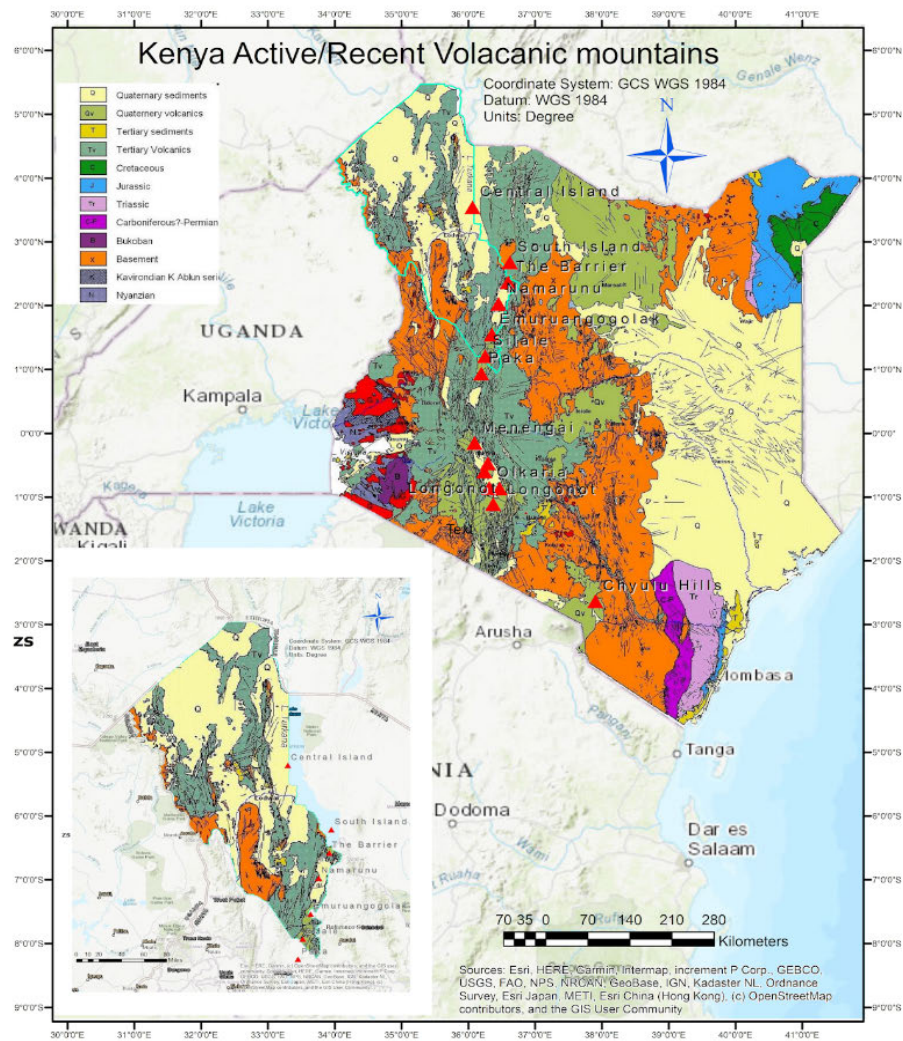


Figure 1. Kenya Geology volcanism. The inset shows Turkana geology and volcanoes location. Map realized by Simon Eleman.

2.2 Preparatory pilot: PVL toolkit test

The aim of the pilot was to engage with the next generation of teachers in Turkana. On 6th April 2022 a preparatory pilot was carried out at the Turkana University College involving a cohort of four teacher students. The leader of the course introduced the Paper Volcanoes Toolkit to the students, who studied the content, accessed the resources and experimented with the activities. A feedback questionnaire was given to the students. The survey consisted of 14 questions (8 closed questions and 4 open questions).



Figure 2. Students experiencing the Paper Volcanoes Toolkit, in Turkana 6 April 2022.

2.3 The pilot: the workshops

2.3.1 Pilot preparation

A more extended pilot consisting of four workshops involving stakeholders, teachers, and elders was organized in September 2022. In order to represent different backgrounds and learning methods, teachers from both urban and rural schools were invited. A letter of invitation was sent to the teachers explaining the aim of the project and the benefits for their learning, teaching and children. For the teachers traveling from a large distance a travel reimbursement was provided.

Since the stories from Turkana elders play an important role within the project. An elder was also invited to the workshops. Due to the relevance of the topic, the local and national authorities in the educational field were also invited to attend. The purpose for involving the education officials in the project, was to create awareness in them about the project. We wanted the officials to appreciate the content of science as it relates to volcanic activities and cultural background.

Two early career geologists from the University of Nairobi were engaged to help during the workshops and bring their geological setting knowledge of Turkana to the teachers. A trip to the Turkana Lake, relevant from a geological point of view, was organized.

The workshops were anticipated by an introduction of the project to the officials. The relevance of awareness about natural hazards and volcanic activity for the safety of the population was discussed during the meeting. Although Kenya does not have volcanoes with active eruptions, it has active geothermal volcanic areas and is prone to some seismic activity. Positive feedback was received from the officials who perceived the awakening of volcanic activity and natural hazards as a relevant topic. The feedback was positive and the importance of communicating the risks of natural hazards was valued.

2.3.2 The workshops

The workshops were conducted on the 13th and 14th of September, aiming to initiate a dialogue between local community knowledge that has the potential to be linked to geoscience knowledge, to present the Volcano Laboratory Toolkit to the Turkana community. The workshops were introduced by a questionnaire (Paper Volcanoes Lab. introductory survey) made accessible by a printed QR code that teachers could scan from their mobiles. The survey included both open and closed questions. It was designed to understand teachers' expectations for the day and their hoped outcome. Also, there were additional questions regarding the size of teachers' classes and the distance traveled to attend the workshop.

Workshop 1 "*A dialogue with teachers and stakeholders of the Turkana community*" aims to comprehend Turkana's knowledge of what are called mountains of fire/spiritual mountains, or volcanoes through story-telling. The workshop is introduced with a questionnaire to understand the expectations of the teachers. The Turkana Mountains of Fires are identified through the help of the geologists and locals and written in Turkana with an English translation on an A3 sheet of paper. The teachers are divided into groups. Each group works on a specific mountain. The leader of each group (volcano) presents the results of their discussion and knowledge about the mountain they have explored, integrating scientific information and traditions. Dialogue is encouraged. At the end the elder tells the Turkana stories related to the mountains of fire.

Workshop 2 "*The encounter between Turkana and science knowledge*" aims to create a dialogue between Turkana knowledge and the information about volcanoes in the Paper Volcano Laboratory Toolkit. In this way, we create new ways to understand volcanoes and avoid separating Turkana's cultural identity and Turkana's views on science. An introduction of the volcanoes and associated risks from a science perspective and presentation of the pedagogy and concept of Volcanoes Laboratory is presented. Small discussion groups to discuss on how we can, as teachers, integrate Turkana and Western Knowledge are created. The group members discuss how to create a dialogue between Mountains of Fire/Spiritual Mountains and the volcanoes to be part of the Paper Volcano Lab Toolkit. They write or draw their answers on a board and dialogue is initiated.

Workshop 3 "*The way to know*" aims to open a discussion with the teachers to understand the best way to present the Volcano Laboratory (PVL) Toolkit to children and the way to produce their knowledge. We present the PVL Toolkit activities as an opportunity for children to know what other children do in different parts of the world. Each teacher receives a copy of the paper Volcano Toolkit. They are given time to read the content and play with the activities themselves. Moreover, we invite the teachers to integrate the PVL Toolkit with activities that are connected to the context of the Turkana community. For

example, using traditional games, art and/or materials from their own culture. Feedback survey was used to allow their feedback on the toolkit experience.

Workshop 4 “*the children’s voice*” aims to find shared strategies with teachers allowing children to be active learners, that can express their opinions and their points of view about this project. Small discussion groups are created and members discuss the question and write/draw on a paper the different answers to the question, “What is a child? What is childhood?”

3 RESULTS

3.1 Results of the preparatory pilot

The activity was well received by the students who were highly engaged as confirmed by the teacher in charge and by the score in the questionnaire Figure 3 [6]. After receiving the activity, they formed a group and gathered the required materials. They used paper to make material look like mountains and cut paper into long-thin pieces and placed them on the top of mountain paper and colored with orange color to represent magma and black color to represent smoke.

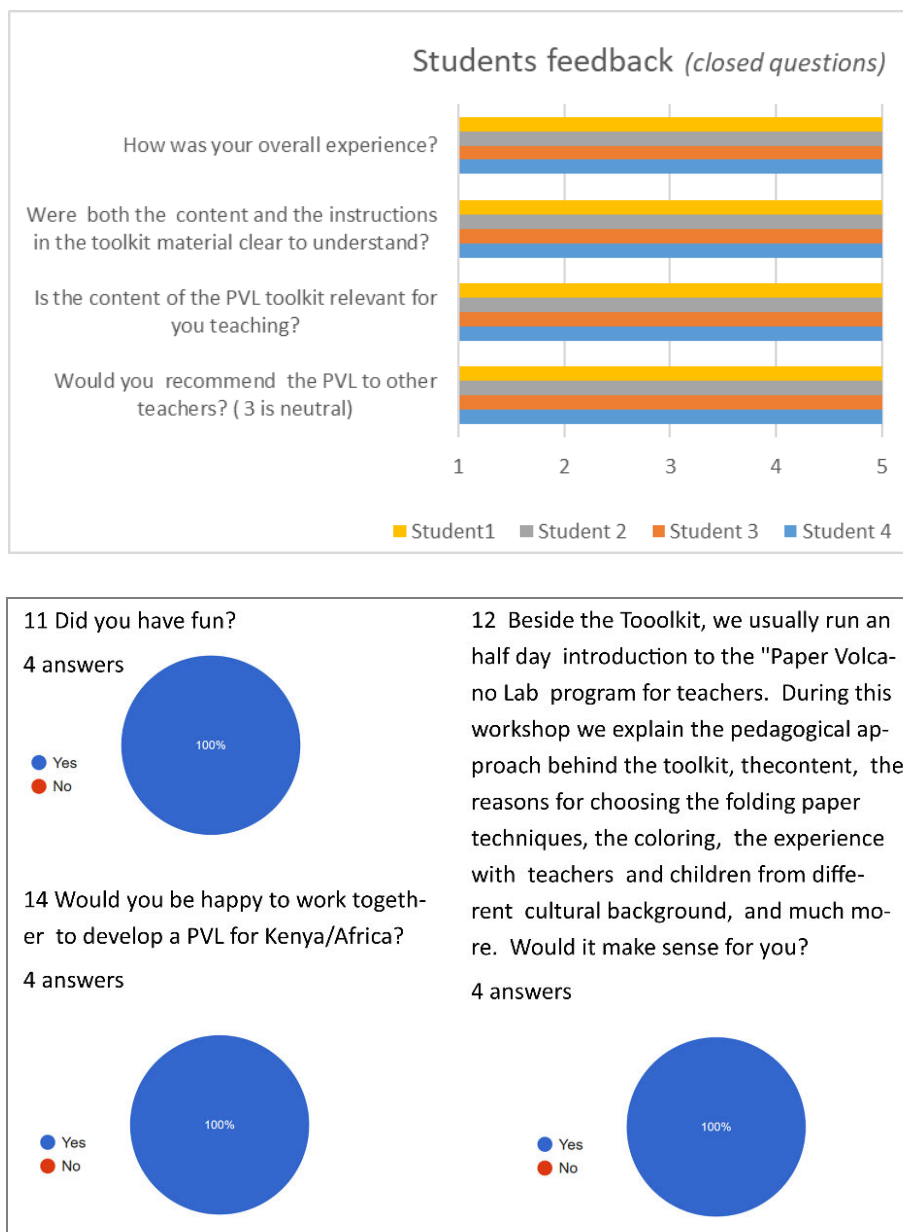


Figure 3 Closed questions rating score.

The toolkit was evaluated in a positive way: the scientific content was appreciated and the description of the passages to realize the volcanoes was clear. They had good fun as well (Figure 3).

The analysis of the open questions emphasized the appreciation for the clarity of the material, the organization of the experience. They felt the group was very cooperative and felt motivated to carry the process forward. When the reasons for their scores was asked the answers included different aspects such as: “*by understanding vulcanicity theoretically it was easy for us make into practical work using paper and colors*”, “The results of the activity according to our observation and response from the teachers were brilliant, because the results of volcano paperwork were amazing”.

About how the toolkit could fit in the Turkana curricula, the motivation was found in the geology of Turkana which includes the volcano Hills, such as “Pelekech Hills and Lodwar Hills which is possible to use paper to make it representing extinct volcanoes found in Turkana and hence, it will be used for learning in Turkana county.”

New acquired skills included both scientific knowledge and artistic skills. Finally, an introduction to the toolkit and the use of coloring scenes depicting Kenyan volcanoes emerged as valuable.

3.2 Results from the pilot

3.2.1 The two days' workshop

The workshops enable the teachers to share ideas and face challenges. For example, the introductory questionnaire accessible by a mobile through a QRcode, was challenging for some of the teachers but, with the help of both the researcher, the geologists and other teachers, they all had access to it. At the end the feedback was positive, and the challenge turned into being a good IT skill beneficial for the teachers. From the introductory questionnaire it emerged that their expectations were related to the acquisition of knowledge about volcanoes and new learning skills. A remarkable 65.9% of them had travelled far more than 30km away demonstrating the great level of interest and commitment in attending the workshops. The size of their classroom (Figure) highlighted that more that 61% of the classes had more than 60 children. This result made clear now how having sufficient material for the children and how to involve them all is a challenge.

In the class I teach there are:

41 answers

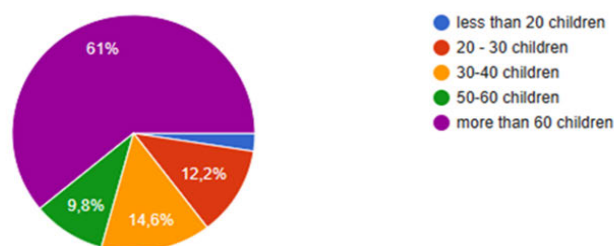


Figure 4 Closed questions rating score.

The dialogue around the Turkana Mountain explored geological-sociological aspects and with the support of the elders the Turkana stories related to the Mountain of fire or the Mountain of smoke (were shared). For example, the name Lodwar Hill comes from the word Edwar (bitter). The story behind it is that white man visited the area and found a lady cooking food, (Edung/wild fruit). The man asked the lady if she could give him some. Due to language differences the white man replied by saying "lodwar". The people around him started laughing at the way he pronounced the word and that is why, they name the area and the Hill Lodwar.



Figure 5 a) the elders introducing traditional Turkana stories. b) introduction to workshop c) the names of the mountains on the board and information retrieved for each one by the teachers;

The workshop lasted longer than expected as they were deeply involved in the conversation. The following day was re-planned to fit in workshops 2 and 3. This is something that didn't surprise us as it can occur in these kinds of activities. The workshop 2 started with an introduction of the Paper Volcanoes Laboratory and the pedagogy elements in it. A copy of the paper volcanoes toolkit was given to each teacher before starting the experience. The Paper Volcanoes Laboratory usually starts by using a volcanic rock to be shown to the children. In this case the geologists collected a volcanic rock from the Turkana Volcanic Area to be used. To bridge the geological background to the cultural knowledge a scientific introduction about volcanoes and how we can observe them was given by the team and followed by an introduction of the Turkana geological setting, delivered by the geologists. They started to introduce themselves explaining about their passion for geology and what geology means to them. They provided additional information related to the volcanic rock. The teachers had the opportunity to touch the rock (which usually it is done by children during the Paper Volcanoes Laboratory) and discovered more about volcanoes by touching and observing like a geologist. The dialogue was started by using questions such as, What is this? What do you know about this? Have you seen something similar in your area? Where?

Their answers included "Yes I know", "It is a volcanic rock", and others.



Figure 6 a) the volcanic rock sampled at the Kawalase Bridge. b) Simon and Peter discussing the volcanic rock before presenting to the teachers. c) teachers experiencing the paper volcanoes Toolkit. d) the paper volcano made by a teacher's daughter.

The geological setting of Turkana County was introduced, explaining that it is found in the Great Gregory Rift Valley and the state of the Great Rift Valley to the northern part of Kenya. The four major volcanic features of the Turkana Rift and volcanoes (Namarunu Shield Volcano; at the southern tapering end of lake Turkana, Mount Silali, Mount Kulal and the Kailongol Range of mountains) were introduced to the teachers. The scientific introduction was followed by the time to play with the toolkit. They had some time to go through the content, experiment with the volcanoes realization and play with the coloring. New forms and shapes were created, and a lot of discussion and experience exchange were shared. Finally, a discussion about how to integrate the paper volcanoes laboratory and the challenges of the laboratory were made. For example, using the volcanic rock to introduce the laboratory as suggested in the toolkit, could be easily integrated in their classes. In fact, the children might have seen those rocks and the teachers would be able to connect the geological knowledge and to make sense of the volcanic

topic with the children by relating with something, for example the rock, that they are familiar with. A relevant challenge, instead, can be the material; in fact, for many schools in the area, paper and colored pencils may be very limited or not available to be used by the children. The teachers proposed materials such as clay, charcoal and suggested alternative material such as sand, stoners, sticks, etc. On the completion of the workshops the teachers received an attendance certificate.



Figure 7. a) Teachers receiving the certificate. b) Group picture of the team and the teachers attending the workshops. c) The children of Locher Esekon Preschool). d) Uniform distribution to the children.

3.2.2 Feedback questionnaire

In Figure 8 are reported four graphs in relation to the closed questions following the workshops 1 and 2. The survey was filled in by 33 teachers. In relation to the question, what are the three most useful things of the workshop's answers given included: *Myths and conception about physical feature formation in Turkana County. Physical feature characteristics i. e. mountains, lakes. Formation of Turkana mountains History of different Turkana mountains Geographical locations and Communities surrounding mountains, Formation of Turkana mountains History of different Turkana mountains Geographical locations and Communities surrounding mountains, Storytelling, Moru-Anayeche story, mountains in Turkana, storytelling, chopper story on lake Turkana, Kori anayeche story.*

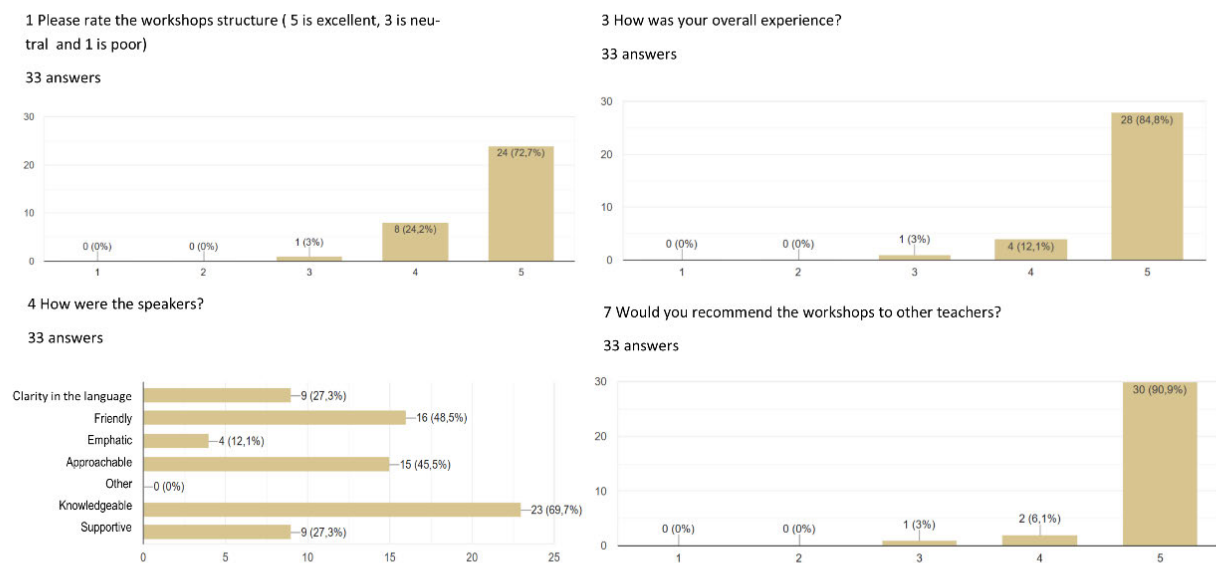
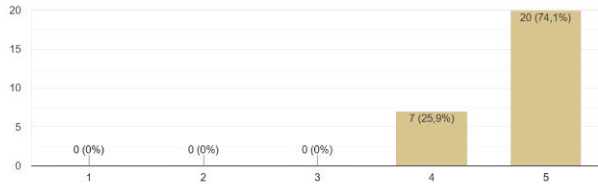


Figure 8. Workshops 1 and 2 teachers' feedback closed questions score

In Figure 9 are reported four graph in relation of the closed questions following the workshop 3 The survey was filled by 27 teachers.

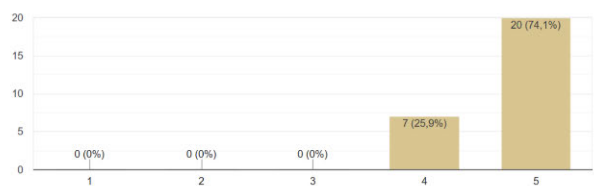
1 Please rate the workshops structure (5 is excellent, 3 is neutral and 1 is poor)

27 answers



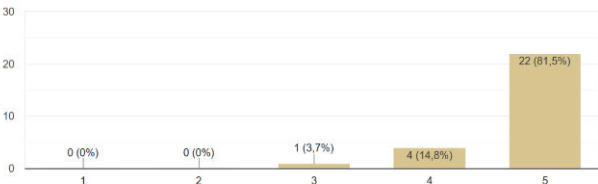
2 Were both the content and the instructions in the toolkit material clear to understand? (5 is excellent, 3 is neutral and 1 is poor)

27 answers



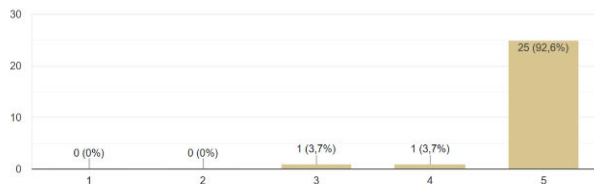
6 Is the content of the Paper Volcanoes Toolkit relevant for your teaching? Please rate the workshops structure (5 is excellent, 3 is neutral and 1 is poor)

27 answers



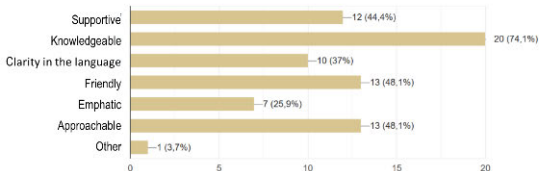
3 How was your overall experience?

27 answers



4 How were the speakers?

27 answers



9 Would you recommend the workshops to other teachers?

27 answers

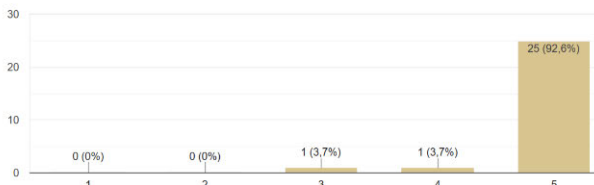


Figure 9 Workshops 3 teachers' feedback closed questions score

Some of the motivations for the high scores regarding the Paper Volcanoes activity were: *the workshop has brought about new ideas and ways of passing knowledge to the learners; acquire practical skills that I will use in my class to support my children; the workshop provided very impressive guidance and gave opportunities for participants to ask questions; it has been so enjoyable because of doing it practically; the content of making paper volcanoes was really amazing; the coloring of structures on paper work was interesting because colors were provided; I was able to colour the volcano's original structure; the workshop work participant based was very interesting enough and inspiring, the speakers were supportive and they inspired me to do so in my pre-school children.*

4 CONCLUSIONS

Both Preparatory pilot and pilot provided different perspectives in relation to the Paper Volcanoes Laboratory toolkit. New generations of teachers appreciated the educational material and carried the process forward. They also set up a volcanoes WhatsApp group to exchange information and news on volcanoes.

The extended pilot involving 40 teachers from rural and urban schools, highlights the positives and the challenges in relation to poor areas where paper and pencils may be not available for children to use. However, alternative materials were suggested (i.e. clay). The use of a volcanic rock, which children can touch and teachers describe, has resulted in a valuable element of the paper volcanoes toolkit for the Turkana children as well. The toolkit will help the teachers to break down the curricula with ideas that they can discuss with children, for example the infographic designed for the Italian volcano will incorporate local volcanoes instead. The follow up from the workshops will help to rework the toolkit incorporating elements of Turkana tradition.

In relation to the research questions presented within the project. The PVL laboratory can be used in the frame of the African Education System with appropriate adaptation which links with the indigenous knowledge as well.

PVL would probably work better in a primary school context. The paper volcanoes project has resulted in linking researchers, teachers and officers to raise awareness of natural hazards and the impact of

geoscience knowledge. Teachers underlined in their feedback, the enrichment received in terms of a wider knowledge of geoscience concepts in relation to volcanoes.

A conceptual paper exploring the decolonization theme in relation to western science and natural hazards, was realized within the project during the pandemic [8].

The project was successfully closed on 31 December 2023 and we are looking for collaborative work and aim to find new funding to bring forward the creation of a Paper Volcanoes Toolkit for Africa.

ACKNOWLEDGEMENTS

Dr. Abisaki Loo is thanked for facilitating the engagement of the cohort of students to the preparatory pilot.

Mr. Philip Narebon is thanked for his contribution in relation to the traditional Turkana stories connected with the mountains of Fires.

IUGG and IAVCEI are thanked for funding the project within the priority area *Geoscience education and outreach in developing countries*.

Mrs. Nina Rizzo is thanked for the English proof review.

REFERENCES

- [1] I. Schoon, B. N., Rukmen S Cook and R.Cook. "*The Impact of Early Life Skills on Later Outcomes*", Report for the OECD (Early Childhood Education and Care). EDU/EDPC(2015)26 JT03384682.
- [2] S. Amici and B. Castello, "Paper volcanoes Laboratory", ICERI2018, Seville, Spain, proceeding paper, 12-14 November 2018
- [3] B. Castello, S. Amici and G. D'Addezio, "Geoscientists at pre-school in the framework of Testing Volcanoes and Earthquakes" an educational project to engage kids in natural hazards, eLighting poster ID ED12C-04AGU fall meeting 2019.
- [4] K. Bone and S. Amici, "The wonderment of volcanoes from a pre-schoolers' perspective",- eLighting poster ID ED12C-03, AGU fall meeting 2019
- [5] Feibel S.C. "A geological history of the Turkana Basin", *Evolutionary Anthropology; issue news and reviews* 20(6), 206-216, 2011.
- [6] Tyrone R., James M., Paul W., Brandon C., Alex S., and Guillaume G., "Strain Localization in the Turkana Depression of the East African Rift Magmatic Evidence from South Island". *AGU fall meeting abstracts*. T53C-02, 2021.
- [7] S. Amici, M. Tesar., Paper "'Volcanoes Lab: engaging young children with earth science" *13th annual International Conference of Education, Research and Innovation*, Dates: 9-11 November, 2020, ISBN: 978-84-09-24232-0, ISSN: 2340-1095, doi:10.21125/iceri.2020.1507
- [8] A. Bertoli, J. T. Ng'asike, S.Amici, A. Madjar and M. Tesar, "Decolonizing western science education and knowledge in early childhood: Rethinking natural hazards and disasters framework through indigenous 'ecology of knowledges' in Kenya", *Global Studies of Childhood*, Sage Journals, 2023.