

Article

The Museums of Geology and Paleontology as Geoeducational Learning Environments for Raising Climate Change Awareness

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Abstract: Museums are called to respond to contemporary challenges and contribute to the formation of more progressive societies. One of the major challenges of our time is climate change and sustainability, and museums could construct cocreated narratives around climate and implement targeted actions for the audiences through their sensorial and affective experiences. More specifically, Geology and Paleontology museums are repositories of knowledge on geoheritage and geoconservation, recognized for their scientific, pedagogical, cultural, and recreational values. The educational potential of geological and paleontological exhibits could be used in informal education activities regarding the climate emergency and the need for sustainability. Taking the above into consideration, this study focuses on both the creation and the evaluation of an educational program for the Natural History Museum of Arsakeio Campus in Psychicko. According to our findings, students really enjoyed their experience in the Museum, gained knowledge regarding mass extinctions driven by climate change, and suggested ways to tackle the current problems and promote our planet's sustainability.

Keywords: climate change; museum education; AR in museums; geoconservation; sustainability



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1. Introduction

In the last decade, the academic community has focused its research on geoconservation and geological heritage issues [1]. The term “geological heritage” is systematically linked to the broader concept of natural heritage [2]. Paleontological heritage is classified as a subcategory of geological heritage [3]. Geological heritage, or geoheritage, is divided into two categories: in situ and ex situ elements. Geosites are an example of in situ elements that contribute to geodiversity and have high scientific value. Ex situ elements are also part of geodiversity, albeit not in situ; they retain their high scientific value, as demonstrated by university collections [4].

Natural History museums and in particular Geology and Paleontology museums are repositories of knowledge on natural heritage, providing important information about the evolution of life on earth through their collections. Geological collections are notoriously recognized for their scientific, pedagogical, cultural, and recreational values. It is true that any science museum has a great potential to communicate scientific knowledge to a broad audience [5]. According to [6], the educational potential of geological and paleontological exhibits could be used in informal education activities to promote sustainability. Consequently, they could play an important role in public awareness regarding the protection of the environment. The sensorial and affective experiences provided by the museums could construct cocreated narratives around climate and implement targeted actions for the audiences through their sensorial and affective experiences [7].

Taking the above into consideration, this article attempts to underline the role of museums in raising awareness and inspiring action about climate change. It is of utmost

importance to adopt behaviors that secure a sustainable future for our planet, without compromising the ability of the next generations to meet their needs. Since museums are social learning spaces and spaces of transformation, they are called to respond to contemporary challenges and contribute to the formation of more democratic and progressive societies [8] by creating educational experiences [9]. More specifically, the study focuses on both the creation and the evaluation of an educational program for the Natural History Museum of Arsakeio Campus in Psychicko. The program is for students in the final years of primary school and endeavors to point out the correlation between climate change and mass extinctions throughout the long history of Earth [10,11]. In addition, it seeks to understand the root of the problem called climate change nowadays and simultaneously make the younger generations reconsider their attitude and perception about the harmonious coexistence of man and nature.

The specific educational program was effectively developed overcoming the difficulties that arose from the limited number of exhibits and interpretative material, while taking the objectives, opportunities, and limitations of the museum into account. The development of the program was based on the use of several interactive methods and tools such as AR applications as well as targeted educational material. Immersive technologies contribute to the creation of a communication bridge between visitors and the museum that facilitates the process of imparting knowledge [12]. The whole process created the basis for a unique museum experience, expanding the possibilities of learning and entertainment.

Furthermore, a pilot implementation and a formative evaluation by postgraduate students of the master's program "Museum Studies" contributed significantly to the final format of the educational program. The conclusions drawn confirmed the intended objectives and choices and contributed to the modification of certain aspects of the program. Lastly, the program was presented to and evaluated by the targeted recipients, i.e., school children between the ages of 10 and 11 years, of Arsakeio Campus.

To conclude, this study contributes to the broader discussion involving museums around the world about the urgent need to build future citizens' environmental awareness and highlights the role of non-formal learning and museum education to promote sustainability.

2. Materials and Methods

The educational program at the Natural History Museum of Arsakeio Campus in Psychicko was designed in three parts. The first part concerned the selection of the topic and the exhibits based on a literature review. The second part involved the program development and addressed learning theories and techniques as well as the activities and the tools included. The third part focused on the implementation of the program and its evaluation.

2.1. Topic and Exhibits: Selection

The main goal of this program was to talk about climate change and how exhibits from a museum collection could create a learning space, thus stimulating a discussion about the current situation and environmental conditions of planet Earth. The initial thought was to investigate some of the major natural disasters during the geological time and connect this information to the consequent climate change that led to mass extinctions.

The title of the program is "To live and how to live? Mass extinctions!". Its structure is based on two displayed trilobite (Figure 1) and ammonite (Figure 2) museum fossils as well as one representation of Meganeura (Figure 3) that was created to serve the objectives of the program due to the limited number of exhibits.



Figure 1. A trilobite fossil.



Figure 2. An ammonite fossil.



Figure 3. A Meganeura representation.

All of the above exhibits are related to a major catastrophic event on Earth, and each one concerns a certain geological era. More specifically, they were animals that went extinct due to the climate change that followed natural disasters such as volcanic eruptions or an asteroid impact.

The age of the target group of students was taken into consideration before deciding on the topic. Mass extinctions are a favorite topic for 9–11-year-old children, and according to Piaget's stages of development [13], the youngsters have the ability of "Concrete operations", such as abstract reasoning, based on personal experiences.

2.2. Program Development: Activities and Tools

The educational program that was developed consists of two parts where climate change is presented as a natural change (past) and as a result of human actions and habits (present). For this purpose, several interactive methods and tools, as well as targeted educational materials, were used.

Several learning theories were employed to design the activities, mainly theories about discovery learning [14,15] and experiential learning [16]. In addition, Gardner's theory of Multiple Intelligences [17] was taken into consideration when designing the program, as well as Bloom's taxonomy [18].

A few pictures were employed, along with short videos and texts. The innovative part of this program is that an AR application, called ARTutor [19], was used so that the participants were able to scan the specific exhibits of the museum and have access to information compiled for certain activities. A game-based approach was used to lead the students from one clue to another with the use of their mobile phones through this AR application. Finally, a cooperative approach was used throughout the program.

2.3. Implementation and Evaluation

The program was first evaluated, during its development phase, by a group of students of the master's program in Museum Studies at the Museum of Geology and Paleontology of the University of Athens, as it has similar exhibits (ammonites, trilobites) as the Natural History Museum of Arsakeio Campus. The purpose of implementing the educational program at this stage of the research was to formally evaluate it in order to ascertain the students' view of the overall experience and to identify any problems in the flow and structure of the program. After this evaluation, the modified program was implemented for and evaluated by students in the fifth grade of Arsakeio Campus and their teachers who also attended the program at the Natural History Museum of the campus. The evaluation was accomplished through evaluation sheets that consisted of close-ended (Likert scale) and open-ended questions and were distributed to the participants after the completion of the program, as well as through the observation of their attitudes and reactions during the whole procedure.

2.4. An Overview of The Educational Program

While designing the program, a connection between learning and having fun was attempted. The activities sought to motivate the students and actively engage them in discovering the importance and meaning of the exhibits as well as finding some personal relevance. Since all the activities were carried out in groups of 7–8 participants, social interaction was promoted. Initially, the students were encouraged to wander around the museum, examine the exhibits, and locate the specific exhibits that were employed for the program. The educator acted as a mentor, supporting the learning process but not dominating it. Such an approach can result in realizing the importance of guided discovery and the freedom of the students to participate in the co-construction of knowledge [20].

To achieve this, extra focus was placed on the interaction with the exhibits as well as among the students. The students were engaged in multiple ways with the materials developed for this program through teamwork, a situation that favors a three-dimensional museum experience that is physical, intellectual, and social-emotional [21].

All the activities aim at achieving a quality experience that will keep the participants motivated throughout the educational program, with no signs of fatigue or boredom, so that the “flow” can be maintained, a fact that will ultimately lead to their cognitive and emotional development [9].

3. Program Description

The educational program entitled “Climate and change: To live and how to live?” was developed for the Natural History Museum of Arsakeio Campus in Psychicko. As it was mentioned, it is for students in the final years of primary school and aims to highlight the correlation between climate change and mass extinctions throughout the geological history of Earth. In addition, it sets out to comprehend the root of the present climate change and simultaneously encourage the youngsters to change their attitude and perceptions and envision a harmonious interaction between man and nature.

The main objectives of the program are the following:

- To learn about extinct or endangered species due to climate change throughout the long history of Earth.
- To understand the causes and effects of climate change on Earth’s life.
- To understand the correlation between humans and the natural environment.
- To develop environmental attitudes, behaviors, and responsibility.
- To develop critical thinking, problem-solving, and research skills.
- To promote teamwork and cooperation.
- To have fun and express one’s thoughts.

The program consists of the following parts.

3.1. Introduction: Introductory Question

The introductory question serves the purpose of connecting the students with the content of the museum and the program. In this activity, the students are encouraged to share their ideas on the topic “extinct species” by being asked the question “What extinct animals would you like to meet?”. This activity focuses on introducing the issue of species’ extinction, while establishing the students’ dynamic and encouraging their participation and the expression of their ideas at the same time [22]. However, the topic of the educational program is not revealed from the beginning, as it is intended to be discovered by the students themselves through the activities that will follow.

3.2. Part I—Climate Change and Big Mass Extinctions: Augmented Reality

During this part of the program, the students have the mission to discover not only the geoenvironment and geodiversity in the past but also the root cause of the big mass extinctions on Earth. A mass extinction event is a widespread and abrupt reduction in biodiversity on Earth. Paleontological data point out five major extinction events, which are known as the “big five mass extinctions” and include the mass extinction at the end of the Ordovician period (Ordovician period), about 440 million years ago, when 85% of the species became extinct, the mass extinction of the Late Devonian (Devonian period), about 375 million years ago, when 75% of the species became extinct, the mass extinction of the late Permian (Permian period), about 250 million years ago, when 95% of the marine species and 70% of the land species became extinct, the mass extinction of the end of the Triassic (Triassic period), about 200 million years ago, when 70–80% of the species became extinct, and the mass extinction of the end of the Cretaceous (Cretaceous period), about 66 million years ago, when 75% of the species became extinct.

The mass extinctions were the result of various natural disasters combined with intense and abrupt climate changes, such as extreme temperature changes, rising or falling sea levels, and catastrophic, one-off events like a huge volcano erupting or an asteroid hitting the Earth [10,11,23]. Unlike the previous extinction events, many scientists today warn about a sixth mass extinction driven by humankind activities that have caused mass extinctions of plant and animal species, pollution of the oceans, and alteration of

the atmosphere, during the so-called Anthropocene era, leading to the anthropogenic greenhouse effect [10,24,25].

Taking the limited number of exhibits and interpretative material of the museum into account, this part of the program is based on the use of several interactive methods and tools such as an Augmented Reality application and targeted educational material (Figure 4). The students discover three exhibits of the museum in small groups and gather information about the environment they lived, their species characteristics, and the causes of the natural disasters that led to their extinction.



Figure 4. Steps for proceeding from a fossil to information with the use of augmentations.

Each group's tools are a smartphone/tablet with the ARTutor application, where the information is presented through texts, images, and videos, along with a worksheet, a picture of the fossil exhibit that the students have to approach, and printed pictures that are gradually distributed to the children in order to gather all the necessary information (Figures 5–7).

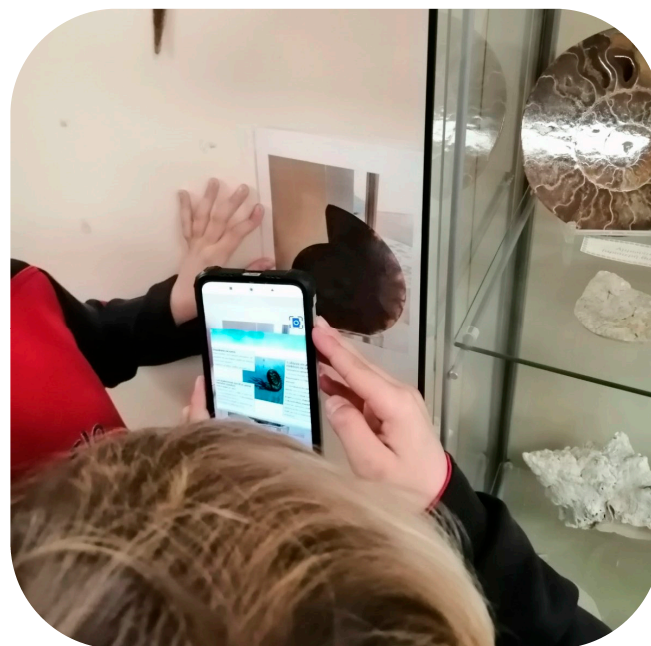


Figure 5. Providing information through augmentations regarding the ammonites.



Figure 6. Augmentation regarding Meaganeura.

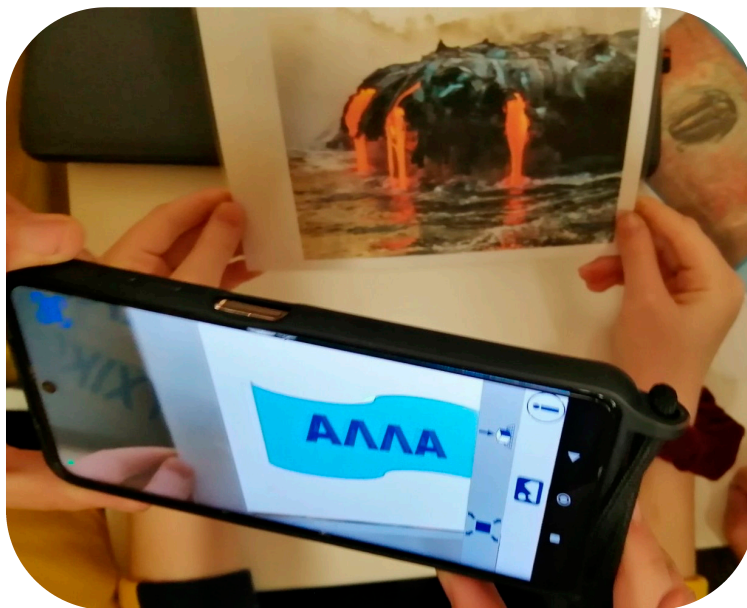


Figure 7. Collecting clues for final synthesis through AR.

ARTutor is a free-of-cost, augmented reality educational platform developed by Advanced Educational Technologies and Mobile Applications (AETMA) Research Lab of the International Hellenic University in 2016. It consists of a web-based authoring environment (administration page) and a mobile application. In museums, it can maximize audience engagement and experience using AR experiences built with ARTutor. The users can upload a document file that they wish to augment, select the image or the part of the page that will act as a marker for the augmentation, and then upload the digital material they want, which can be in different formats (images, sounds, videos, YouTube videos, 3D objects, and URL links; <http://artutor.ihu.gr/home/>, accessed on 16 April 2024).

Once the groups stand in front of the exhibits, they are encouraged to observe the elements of the museum space (authentic objects, constructed exhibits, interpretive material) and answer the questions on the worksheet by using the ARTutor app and the printed pictures, developing skills of observation, collaboration, and communication [26].

The exploration is completed when a clue (syllable) appears on the phone's/tablet's screen of each group. After presenting all the gathered information to each other, the groups join the clues together and reveal the phrase "Climate Change", as it is the main cause of mass extinction in Earth's history. Then, the mission comes to an end. Through this activity, the children gain an interactive experience and collaborate with each other. The use of the ARTutor application requires communication/discussion and interaction of the children in each group, thus highlighting the social dimension of the museum experience [26]. Furthermore, the children learn to listen and respect all the opinions through their presentations [27]. Therefore, it becomes clear that the intended goal of this activity is not only to transmit information, but also to activate the participants.

3.3. Part II—Human Climate Change and the Threat to the Environment and Species: Sorting Activity and Discussion

The second part of the program aims to identify the real and threatening effects of climate change nowadays not only to animal species but also to the environment and humans. It also aims to highlight that the human modification of the environment contributes to the contemporary form of climate change, the so-called anthropogenic climate change, and that it is of great importance to change actions and habits. This part of the program seeks to create a "continuity" between children's everyday life and new knowledge, as defined through Dewey's pedagogical theory. According to Kolb's theory of "virtuous and vicious cycle", when children can relate a topic to their life and personal experience, then a "virtuous cycle" is achieved, leading to effective learning, as it is easier for them to make associations and connections, to apply what they have experienced, and to show more enthusiasm for further learning [9].

To begin with, the educator proposes some questions in order for the students to identify the role of human actions in climate change and the need to take certain actions. More specifically, the tools that are used in the first activity, entitled "The animals speak!", are cards with endangered species, along with cards where each animal describes the ways in which its environment is threatened. These cards are distributed to the groups so as to match each "animal under threat" card with the "climate change threats to/impacts on their environment" card (Figure 8). Finally, the groups discuss and present their choices in order to understand that the consequences of climate change are real and threatening. The transition to the second activity comes with several questions regarding climate change today (e.g., "Who is considered to be responsible for climate change today? In what way are humans affecting the climate today? What can we do to help reduce climate change?"). Through the second activity called "The die is cast!", the students actively reinforce the idea that climate change today is not a natural change but is mainly the result of human actions and daily habits. The aim of this activity is to make them understand that we are all part of the problem, so as to propose alternatives and changes that will help protect the planet. The tool used in this activity is a paper cube with pictures that depict human activities related to climate change (e.g., carbon dioxide emissions from cars and factories, deforestation and fires, landfills with waste, junk food). Each group throws the cube on the ground, and then the children decide on a solution to the problem by communicating and interacting with each other [28]. Then, they share their views in order to understand the importance of changing everyday habits to protect the planet, the ecosystem, and themselves (Figure 9).



Figure 8. Students collaborating during the activity “The animals speak”.



Figure 9. Students collaborating during the activity “The die is cast”.

3.4. Part III—Evaluation

The program is completed with evaluation sheets for both teachers and students. For this purpose, questionnaires were formulated. Teachers’ evaluation is necessary because they can understand to what extent the pedagogical and learning objectives of the program are achieved and whether the methods and the activities implemented work. Furthermore, it is easy to determine the students’ interest or lack of it, record the strengths and weaknesses of the program, and make suggestions for its improvement. The evaluation process by the students attending the program is of great importance too, because they are the main participants who can provide feedback on their overall experience.

4. Implementation and Evaluation

Nowadays, museums are displaying an avid interest in matters regarding their exhibits as well as the services they provide as places for conserving and promoting our heritage. This is the main reason why museum experts and policy makers are interested in the evaluation of their projects even before these are put into practice, so it can be determined if they meet the visitors' expectations and accommodate people's current needs.

Evaluating museums consists in the "systematic collection of information which can be used to provide answers to specific questions regarding a certain display, collection or educational programme" [29]. The evaluation focuses not only on "what makes a good display" but also on "how visitors perceive this display and in which way they can construct their own meaning affected by it" [30].

A combination of evaluating methods can be applied to this process, all of which are based on experiential methodologies as well as interpretation approaches. Reaching valid conclusions means that qualitative and quantitative data need to be extracted and analyzed [27,31].

The effectiveness of an educational program at a museum is a combination of different factors. One program can be considered successful when it meets certain standards, such as the perception of the visit as a pleasant recreational experience, the achievement of cognitive, emotional, and kinesthetic goals, as well as the enthusiastic response of the youngsters during its implementation [32]. It is vital that a program be evaluated from its conception to its implementation by everyone participating in it in any way.

4.1. Aims and Objectives of the Evaluation

The aim of this educational project, as mentioned above, was to implement it during a visit to the Museum, in order to evaluate it and ascertain the participants' (students and teachers) view of the overall experience. Their perspective was a very important source of feedback, as it was possible to test the functionality and effectiveness of the program and the choices made in terms of the scenario, exhibit activities, supervisory material, methods, and teaching aids [27,31].

4.2. Research Tools

The main method of evaluating a program, which is the most common method for collecting data and information, is the use of questionnaires that are filled in after the completion of the program. The questionnaires were formulated in light of the Generic Learning Outcomes (GLOs), which are divided into five main categories:

- Knowledge and understanding (assimilation of new information, associations, deepening of understanding).
- Skills (the possibility of developing emotional and cognitive, communication, and physical skills).
- Attitudes and values (changing attitudes towards life, oneself, and the others).
- Enjoyment, inspiration, and creativity (recreation, new contacts and experiences, originality of thought and action).
- Action, behavior, and learning (change in the way one manages one's life and in one's observed actions) [9,33].

The GLOs were developed in the early 2000s by an interdisciplinary team of researchers led by the Centre for Research on Museums and Art Galleries of the University of Leicester and by Professor E. Hooper-Greenhill, following specific U.K. government policies that highlighted the need to develop a robust methodology for describing, measuring, and demonstrating the role of museums, libraries, and archives in lifelong learning. They focus on all the dimensions that learning in informal learning environments can have, such as knowledge, understanding, utilization and development of skills, and development of a learning identity. They can be used in planning and at all stages of an assessment process [33].

More specifically, in our program, questionnaires were created for both the students and the teachers that took part in the educational program. Through these, quantitative and qualitative data were gathered [31,34]. Thus, the teachers' questionnaire consists of two closed-ended, Likert-scale questions in order to collect quantitative data and measure the extent to which the respondents agree or disagree with a particular statement, as well as two open-ended questions that allow the respondents to share their thoughts and opinions (for more information on the Likert scale, see [35]). The first questions focus on evaluating the content and techniques of the program. More specifically, the first question aims to highlight the extent to which the educational program meets the learning and age-related expectations, while the second one aims to canvass its contribution to the development of the kids' cognitive–intellectual, social, and communication skills, and its recreational value as well. As for the open-ended questions, these focus on the teachers' opinion about the strengths and weaknesses of the program and the parts that need improvement, reflecting their overall feeling about it.

The students' questionnaire consists of three closed-ended questions, in order to understand whether (i) the cognitive objectives of the program were achieved; (ii) the use of the augmented reality application was an enjoyable experience; (iii) the students enjoyed the program's activities. These questions are multiple-choice questions (Yes, No, I do not know) with the answers presented as "happy", "neutral", and "sad" emojis in order to make the evaluation process more enjoyable. At the end of the process, the students are asked to indicate what impressed them most and least in the program. Thus, they are offered the opportunity to express themselves and provide additional valuable information about their experience.

Finally, it is suggested that the students create a poster or comic in class, addressing the threatening impact of climate change on the environment and ecosystems throughout the history of the planet. This activity will serve multiple purposes, as it is a linkage between the museum and the school, allowing the school groups to continue their experience and evaluation through a sensory activity.

In addition to the use of the questionnaires, throughout the program, the attitudes and reactions of the participants to the evaluation are observed for the overall data collection. The combination of qualitative and quantitative data contributes to the deduction of more accurate and tangible results.

4.3. Implementation and Evaluation of the Program

The implementation of the project took place during three school days at the Natural History Museum of Arsakeio Campus. The program took place on 14, 15, and 28 February 2024 with four different fifth grade classes, and the total time of completion was approximately one hour.

Initially, the students were welcomed and informed about the reason for their participation in conducting an evaluation of an educational program addressed to students of grades 5 and 6 of primary school. They were then encouraged to form a circle in order to become acquainted with the group and the Museum, which was followed by an introduction to the topic. In the initial introductory question, which asked them to name an animal that went extinct in the past and they would like to meet, most responded that they would like to meet a dinosaur or a mammoth. These responses justify and reinforce the choice to use animals that have disappeared and are unknown to the public in the educational program. The students seemed to show curiosity about the activities that would follow later.

At the end of this process, they set out to explore the three different animals that disappeared many millions years ago and are now part of the Museum's exhibits. Although each group, guided by the questions and the information on the worksheets, gathered the necessary information on their own, the educator and teacher had a supporting and assisting role in the process. This suggests that when implementing the project, the presence and collaboration with the teacher is important for the smooth flow of the project. To gather information about the species, their environment, and the causes of their extinction,

each team needed a mobile phone which had the ARTutor augmented reality application installed beforehand. The combination of the real and the virtual world sparked interest and created feelings of fascination in the participants, who saw the Museum's exhibits come to life in front of them. Then, during the presentation process, each group watched the others carefully, even expressing a desire to watch the videos of the animals that the other groups watched and presented. In the end, when they received and displayed the envelope with the syllables, they showed intense curiosity and desire to put the syllables in the right order to discover the hidden word, and once this was achieved, their enthusiasm was evident through some exclamations they made.

The formation of the phrase "Climate Change" was the trigger for the connection to the present day and the effects of climate change on the living organisms today. This part of the program included two different activities that were based on collaboration and communication between the groups. Firstly, the groups were asked to match the images of animals with the effects of climate change on them, as presented by the animals themselves, and describe them. After that, they tried to highlight the role of humans in climate change today in order to discuss the changes we can make as individuals in our daily lives that will help reduce our impact. This process contributed to the interaction of the students, both within their group and with the other groups, as during the presentation they had to follow what was being said in order to formulate their point of view. The students seemed to show particular interest and focus when classifying and presenting the questions asked and curiosity about the images and the information presented by the other groups.

At the end of the project, the evaluation sheets were distributed for the participants to complete them. The participants were informed that their evaluations were to be used as a guide in the overall evaluation of the program and they were therefore asked to respond with complete honesty and to present their own ideas and opinions.

5. Results

At the end of the pilot implementation of the educational program, the evaluation sheets were collected with the responses of the 84 fifth-grade students, the four teachers who participated in it, as well as the Museum curator. This was followed by statistical processing of the closed-ended questions, listed below, as well as quoting and commenting on the personal views and ideas recorded with the open-ended questions.

More specifically, initially, the questionnaire for the teachers included some affirmative statements, and the respondents were asked to indicate their level of agreement with them. The first question regarded their opinion as to whether the program met the learning and age-related expectations, and all the participants agreed that it surely did.

Regarding the ability of the training program to contribute to the development of cognitive–mental skills, all teachers stated that they agreed on it being effective, with 60% of them underlying that they "strongly agreed". Regarding the development of communication skills, that is, the ability to understand and produce spoken and written language, all participants answered that the program promoted such skills, with the majority (80%) noting that they "strongly agreed" on it being effective. Regarding the social skills, which include teamwork and cooperation among the students, all teachers answered that the program managed to enhance them, with the majority (80%) stating that they "strongly agreed" with this conclusion. In addition, in relation to the question whether their students had fun during the program, all respondents unanimously agreed that they did (Figure 10).

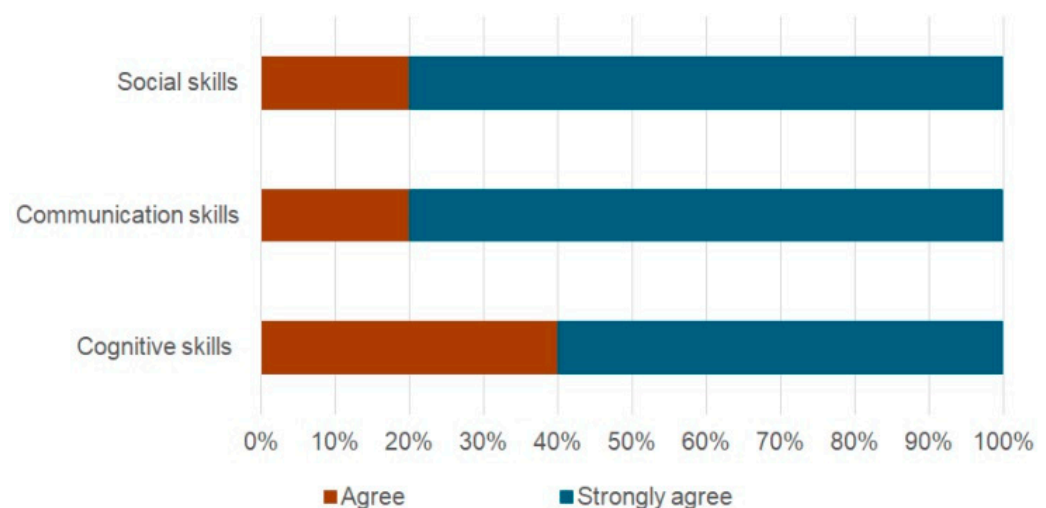


Figure 10. Teachers' opinion on whether the educational program contributed to the development of cognitive, communication, and social skills among the students.

The questionnaire then included two questions, which did not suggest specific answers or request only one answer, but rather encouraged the free expression of the respondents' opinion. The intended aim of these questions is to determine to what extent the objectives of the educational program have been achieved and whether and how this can be improved. More specifically, the participants were asked to report what they considered to be the most successful aspect of the program (Figure 11).

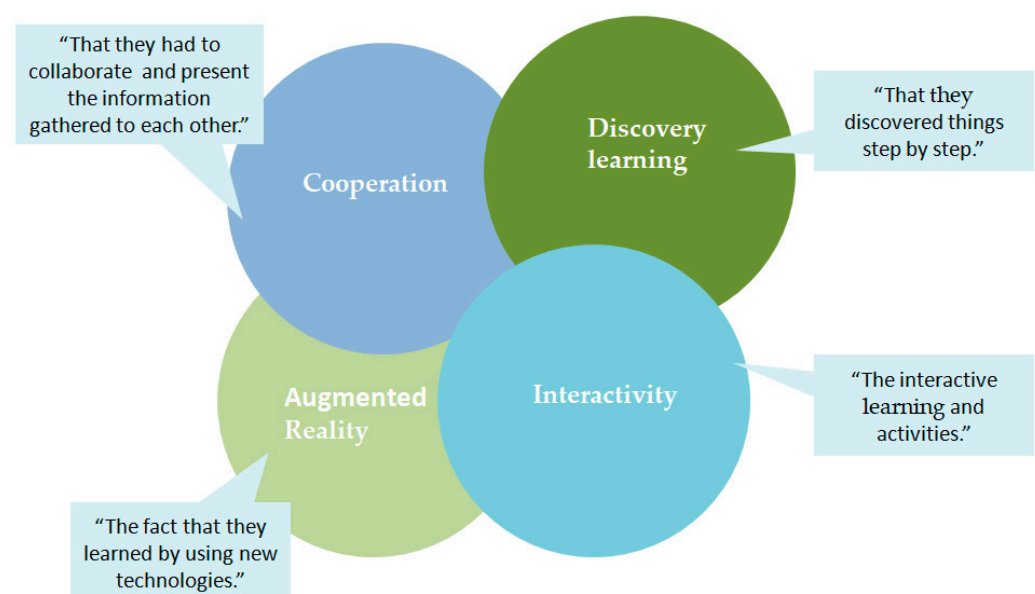


Figure 11. Quotes on the most successful parts of the program.

Indeed, the answers provided were quite encouraging, as it seems that the program was able to meet its initial objectives. They highlighted the promotion of cooperation and discovery learning as well as the smooth incorporation of technology in it with the implementation of the Augmented Reality application and interactive learning and activities. These were among the most successful elements of the program.

Moving on to the second question, the evaluating participants had to make some suggestions for improving the program. Their answers were as follows:

- ✓ Perhaps it would help if there was an activity allowing the students to create something during the program that they could then take with them.

- ✓ It would be better if the number of children per group was smaller.
- ✓ Two more fossils could be added, so that the students can learn more about animals and mass extinctions.

The questionnaires received from the students were eighty-four (84) and consisted of three closed-ended and two open-ended questions. The first question asked them whether they had gained new knowledge regarding the impact of climate change on animals and planet Earth, in general. In total, 86% of them answered that they did, while 1% said that they did not learn anything. A small percentage corresponding to 13% answered “do not know”. The second question was whether they liked the use of the Augmented Reality application in the program. Most of them (95%) stated that they did, with only a small percentage (5%) answering “do not know”. The third question regarded the program’s activities in general and whether they liked them. The vast majority stated that they enjoyed all the activities in the program, with only a few answering “do not know” (Figure 12).

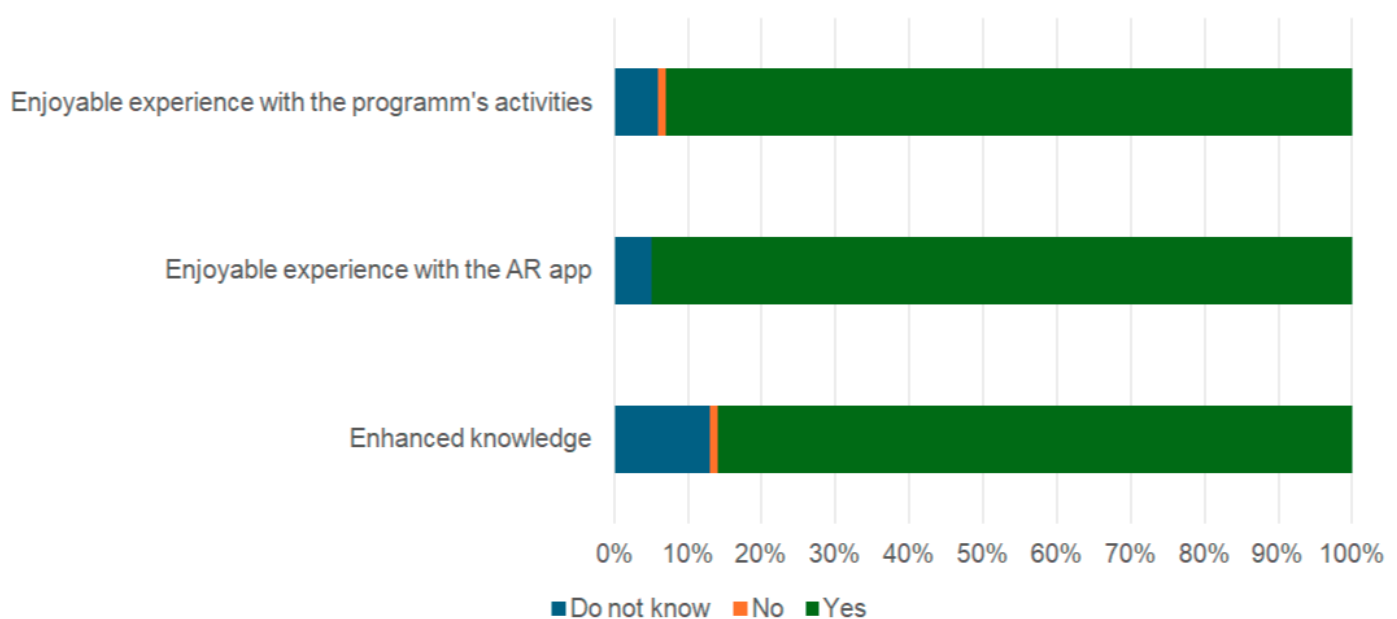


Figure 12. Students’ overall experience of the program.

When the students were asked to comment on which part of the program they enjoyed the most, the vast majority stated that they really liked the scanning activity, that is, using the AR app, and working together as a team. Many were not specific in their answers and said that they enjoyed everything, while some mentioned the activity with the die, the puzzle with the animals, and the wandering around the exhibits of the museum, looking for information on fossils.

As far as the final question is concerned, the students had to indicate something that they liked the least in the program. Most of them did not answer this question or just said they liked everything. Some mentioned the activity with the cards that provided information about the animals and the impact of climate change on them.

In conclusion, the program, for the most part, was considered successful, for both students and teachers, with all the main objectives achieved.

6. Discussion

The climate crisis is undeniably a modern reality. The human societies in the 21st century have made great progress in various fields, but the modern lifestyles and the overexploitation of nature have caused a significant degradation of the environment and climate. Scientific studies show that climate change today is mainly anthropogenic and

threatens not only the environment and the ecosystems but also the human societies, putting the sustainability of undeveloped countries at stake.

Action by the international scientific community and government representatives, the EU, and major institutions such as UNESCO, had been underway for at least two decades before the climate emergency emerged. Climate change mitigation and adaptation measures, international conventions, frameworks, and actions have been defined through international and European conferences involving countries and political leaders around the world to limit the emission of greenhouse gases and climate change. However, the situation is still problematic, threatening our planet's sustainability. The desired results seem to be met with several difficulties and obstacles of all kinds, so that achieving climate neutrality by 2050 does not seem to be very feasible.

Education has emerged as a key tool for tackling climate change and promoting actions for sustainability. Climate change education can lead to understanding, changing attitudes and behaviors, and taking appropriate action to address climate change, according to UNESCO. All forms of education—therefore, formal, informal, and non-formal—are crucial. The role of schools is therefore important, as through the Curriculum, Environmental Education programs, and their overall operation with climate change education in mind, they can instill core values and lead to the adoption of environmentally responsible behaviors. However, the obstacles in the Greek educational reality are many and require a concerted action and a holistic review of the educational policy.

On the other hand, museums can play a very important role in climate change education. As institutions at the service of society, attentive to the contemporary reality, they have a responsibility towards the citizens. In recent years, more and more museums have emerged that deal with the climate crisis as such, and many have adapted their objectives, activities, exhibitions, educational programs, and even their buildings to this issue, in order to contribute to the change towards a more sustainable society.

It is on this principle that the present educational program was designed and implemented (Figures 13–16). It is of vital importance that such programs be introduced in more museums with hands-on activities as well as the use of technological advances like AR applications. This way, a large number of visitors will be drawn to the museums, and more students will have the opportunity to participate in such programs, raising environmental awareness.



Figure 13. Presenting the information obtained by AR.



Figure 14. Looking for the fossils in the Museum.



Figure 15. Matching the animals with the effects on their habitat.



Figure 16. Students playing with the die.

7. Conclusions

To conclude, this educational program that took place in the Arsakeio Natural History Museum achieved its initial goals, as it was evident from the evaluations that it

received. The students as well as their teachers perceived their visit as a pleasant recreational experience, and an enthusiastic response was received by the youngsters during its implementation.

However, it is suggested that the educational program be implemented further and maybe included as an educational program in one of the Natural History museums in Athens or one of the Geology and Paleontology museums.

Informal education potentially holds some power in communicating knowledge in a non-traditional way and thus shifting attitudes through fun activities within a framework very different from a strict classroom setting.

It is proper to state that change in all areas, at all levels, starting from personal change to collective change, can lead to miraculous results. This leaves the path open towards moral evolution and progressive social change with the aim of a harmonious connection between man and environment as well as of achieving a sustainable planet. Actions, synergies, and an appropriate climate policy are therefore required now. So, it is time for change, not just climate change!

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