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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 museums could construct cocreated narratives around climate and implement targeted actions for the audiences through their sensorial and affective experiences. More specifically, Geology and Palaeontology 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. Taking the above into consideration, this study focuses on both the creation and evaluation of an educational program for the Natural History Museum of Arsakeio Campus at Psychicko.

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]. Palaeontological 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 Palaeontology 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 greater potential to communicate scientific knowledge to a broader audience [5]. According to [6] the educational potential of geological and paleontological exhibits could be used in informal education activities. 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. Due to the fact that 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 evaluation of an educational program for the Natural History Museum of Arsakeio Campus at Psychicko. The program is for students in the final years of primary school and endeavours 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 younger generations reconsider their attitude and perception about the harmonious coexistence between man and nature.

The specific educational program was effectively developed overcoming the difficulties arose from the limited number of exhibits and interpretative material while taking the objectives, the opportunities and limitations of the museum into account. The development of the program is 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 targeted recipients, school children, between the ages of 10-11, of Arsakeio Campus.

To conclude, this study contributes to the broader discussion of the 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.

2. Materials and Methods

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

Topic and Exhibits: Selection

The main goal regarding this program was to talk about climate change and how exhibits from a museum collection could create a learning space, thus stimulate a discussion about the current situation and environmental conditions of planet Earth. The initial thought was to look into 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 museum fossils Trilobite and Ammonite as well as one representation of Meganeura that was created to serve the objectives of the program due to the limited number of exhibits.

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 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 children 9-11 and according to Piaget's stages of development [13], youngsters have the ability for "Concrete operations", such as abstract reasoning, based on personal experiences.

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Picture 1. The animals that were used in the programme: Meganeura replica, Trilobite fossile, Ammonite fossil.

Program Development: Activities and Tools

The educational program which 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 number of 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 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.

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 & Paleontology of the University of Athens, as it has similar exhibits (Ammonites, Trilobites) with 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 to 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 the evaluation sheets that were consisted of close - ended (Likert scale) and open- ended questions and 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.

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 in groups of 6-8 participants, social interaction was promoted. Initially, the students were encouraged to wander around the museum, examine the exhibits and locate the specific exhibits which were employed for the program. The educator acted as a mentor, supporting the learning process but not dominate 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].

In order to achieve this, extra focus was placed on the interaction with the exhibits as well as among students. Students were engaged in multiple ways with the materials developed for this program through teamwork, a situation that favors the three-dimensional museum experience, that is the physical, the intellectual, and the 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?' is for the Natural History Museum of Arsakeio Campus at 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 youngsters to change their attitude and perceptions and envision a harmonious interaction between man and nature.

The main objectives of the program are:

- 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 natural environment.
- To develop environmental attitudes, behavior and responsibility.
- To develop critical thinking, problem-solving and research skills.
- To promote teamwork and cooperation.
- To have fun and express their thoughts.

The program consists of the following parts:

Introduction: IntroductoryQuestion

The introductory question serves the purpose of student's connection with the content of the museum and the program. At 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 the 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 follow.

Part I - Climate Change and Big Mass Extinctions: Augmented Reality

During this part of the program, the students have the following mission: to discover not only the geoenvironment and geodiversity in the past, but the root cause of the big mass extinctions[1] on

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[1] A mass extinction event is a widespread and abrupt reduction of biodiversity on Earth. Paleontological data point out five major extinction events, which are known as '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 species made extinct, the mass extinction of the Late Devonian (Devonian period), about 375 million years ago, when 75% of species made extinct, the mass extinction of the late Permian (Permian period), about 250 million years ago, when 95% of marine species and 70% of land species made extinct, the mass extinction of the end of the Triassic (Triassic period), about 200 million years ago, when 70-80% of species made extinct; and the mass extinction of the end of the Cretaceous (Cretaceous period), about 66 million years ago, when 75% of species made extinct.

Earth as well. 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. The students discover three exhibits of the museum in smaller groups and gather information about the environment they lived, their species characteristics, and the causes of the natural disasters that led to their extinction.

Picture 2. Fossils with augmentations.

Each group's tools are a smartphone/ tablet with the ARTutor application [2], where the information is presented to them through texts, images and videos, along with a worksheet, a picture of the fossil- exhibit they have to approach and printed pictures that are gradually distributed to the children in order to gather all the necessary information.

Once the groups stand in front of the exhibits, they are assigned 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 information gathered to each other, the groups join together the clues and reveal the phrase 'Climate change', as it's the main cause of the 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 the communication/discussion and interaction of the children in each group, thus highlighting the social dimension of the museum experience [26]. Furthermore, they 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.

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 Earth. [10,11,23]. Unlike the previous extinction events, many scientists today warn about a sixth mass extinction driven by human-kind 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].

[2] ARTutor is a free of cost, augmented reality educational platform developed by Advanced Educational Technologies and Mobile Applications (AETMA) Research Lab at the International Hellenic University, since 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). See more, http://artutor.ihu.gr/home/.

Picture 3. Providing information through augmentations.

Part II - Human Climate Change and the Threat on 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 on animal species but on the environment and humans as well. It also aims to highlight that 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 the child can relate a topic to their life and personal experience then, a "virtuous cycle" is achieved leading to an 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].

Picture 4. Students collaborating during the activities of the program.

To begin with, the educator pops some questions in order for the students to identify the role of human actions in climate change and the need to take certain action. More specifically, the tools that are used in the first activity, entitled 'The animals speak!', are the cards with the endangered species used at the beginning of the program, 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/impacts on their environment' card. 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!', students actively reinforce that climate change today is not a natural change, but it's 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 which 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 they 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.

Part III - Evaluation

The program is complete with its evaluation sheets for both teachers and students. For this purpose, questionnaires have been formulated. Teachers' evaluation is necessary because they are able to understand to what extent the pedagogical and learning objectives of the program have been achieved and whether the methods and the activities implemented have worked. 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 give feedback of 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 of 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 they are put into practice, so it can be determined if they meet the visitors' expectations and actually accommodate people's current needs.

Evaluating museums comes in the form of "systematic collection of information which can be used to provide answers to specific questions regarding a certain display, collection or educational program" [29]. Evaluation focuses not only on "what makes a good display" but "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 the 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 the program, which is the most common method for collecting data and information, is the use of questionnaires that were filled in after the completion of the program. The questionnaires were formulated in light of the Generic Learning Outcomes (GLOs)[3], which are divided into five main categories:

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[3] 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 at the University of Leicester and Professor E. Hooper-Greenhill,

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- 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 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].

More specifically, 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 [34,31]. Thus, the teachers' questionnaire consisted of two closed-ended, Likert-scale[4] questions in order to collect quantitative data and measure the extent to which respondents agree or disagree with a particular statement as well as two open-ended questions where respondents could share their thoughts and opinions. 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 met the learning and age- related expectations, while the second one aims to canvass its contribution to the development of kids 'cognitive- intellectual, social and communication skills and its recreational value as well. As for the open-ended questions, these focus on teachers' opinion about the strengths and weaknesses of the program and the parts that need improvement, reflecting the overall feeling about it.

The students' questionnaire consisted 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 and whether iii) the students enjoyed the program's activities. These questions are multiple choice questions (Yes - No - I don't know) given as 'happy', 'neutral' and 'sad' emojis in order to make the evaluation process more enjoyable. At the end of the process, the students were asked to write down something that impressed them most and least in the program. Thus, they were given the opportunity to express themselves and provide additional valuable information about their experience.

Last but not least, it was suggested that students create a poster or comic in school, addressing the threatening role of climate change on the environment and ecosystems throughout the history of the planet. This suggestion serves multiple purposes, as it is a linkage between museum and school, where the school group can 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 were observed for the overall data collection. The combination of qualitative and quantitative data contributed 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 3 school days at the Natural History Museum of Arsakeio Campus. The program took place on February 14th, 15th and 28th, 2024 with four different 5th 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, which is addressed to students of grades 5 and

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following specific UK 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 the development of a learning identity. They can be used in planning, and at all stages of the assessment process [33].

[4] For more information on the Likert scale see. [35].

6 of primary school. They were then encouraged to form a circle in order to get acquainted with the group and the Museum, 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 come into contact with a dinosaur or a mammoth. These responses justify and reinforce the choice to use animals that have disappeared and are unknown to the general public, in the educational program. The students seemed to show curiosity about the activities that would follow later on.

At the end of this process, they set out to explore the three different animals that disappeared many millions of 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 had the ARTutor augmented reality application installed beforehand. The combination of the real and virtual world sparked interest and created feelings of fascination for the participants, who saw museum exhibits come to life in front of them. Then, during the presentation process, each group watched the other 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 living organisms today. At this part of the program, there were two different activities which were based on collaboration and communication between the groups. Firstly, the groups were asked to match and present the images of animals with the effects of climate change on them, as presented by the animals themselves. After that, they tried to highlight the role of humans on climate change today in order to discuss the changes we can make as individuals in our daily lives that will help reduce the impact. This process contributed to the interaction of the students, both within their group and with the individual 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, but also curiosity about the images and information presented by other groups.

At the end of the evaluation process of the project, the evaluation sheets were distributed for the participants to complete. They 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 give their own ideas and opinions.

5. Results

At the end of the pilot implementation of the educational program, evaluation sheets were collected with the responses of the 84 5th 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 in the open-ended questions.

More specifically, initially the questionnaire for the teachers included some affirmative statements, through which respondents were asked to indicate their level of agreement with them. The first question regarded their opinion to as the program met the learning and age-related expectations, where all the participants agreed that it surely did (graph 1).

The program met the learning and age-related expectations
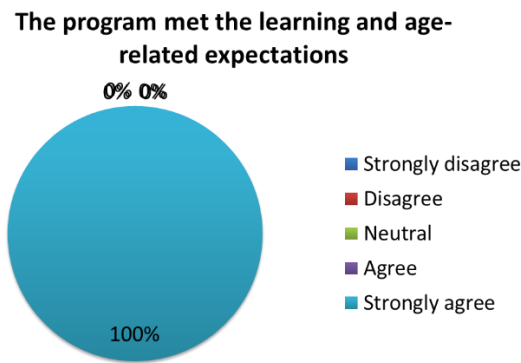
Graph 1. Did the program meet the learning and age-related expectations?

Regarding the extent to which the training program contributed to the development of cognitive-mental skills, all teachers stated that they agreed, with 60% of them underlying that they "strongly agree" (graph 2).
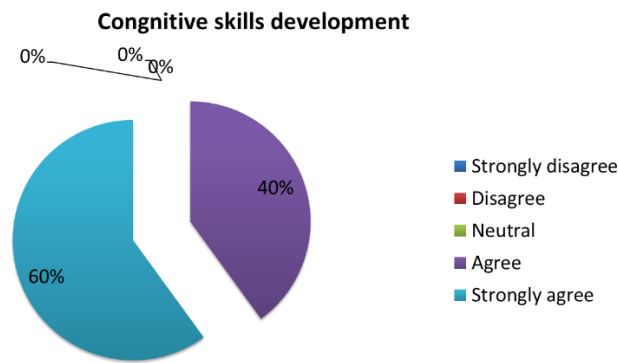

Graph 2. Cognitive skills development

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 agree" (graph 3).
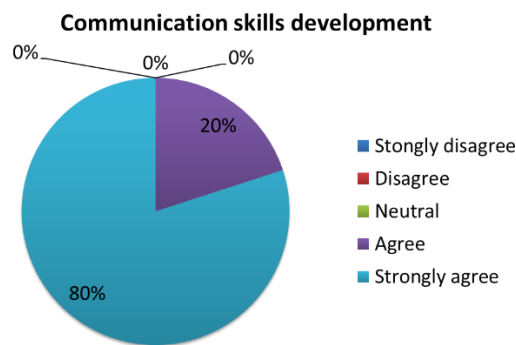

Graph 3. Communication skills development

Regarding 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 agree" (graph 4).

Social Skills

0%
0%
0%
0%
20%
80%

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree
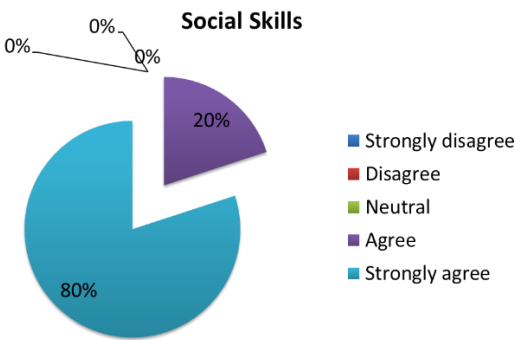
Graph 4. Social skills development

In addition, in relation to the question whether their students had fun during the program, all respondents unanimously agreed that they did (graph 5).

Entertainment

0%0%
0%
0%
100%

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree
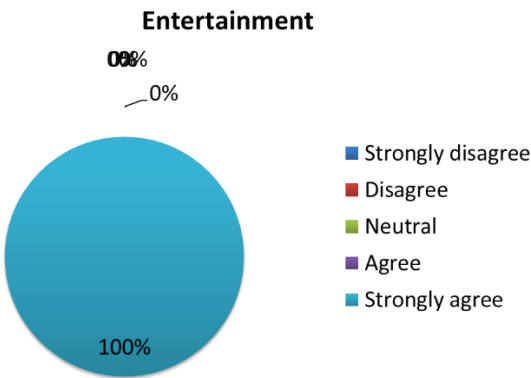
Graph 5. Degree of entertainment

The questionnaire then included two questions, which did not suggest specific answer values or only one answer, but rather 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, participants were asked to answer what they considered to be the most successful aspect of the programme (graph 6).
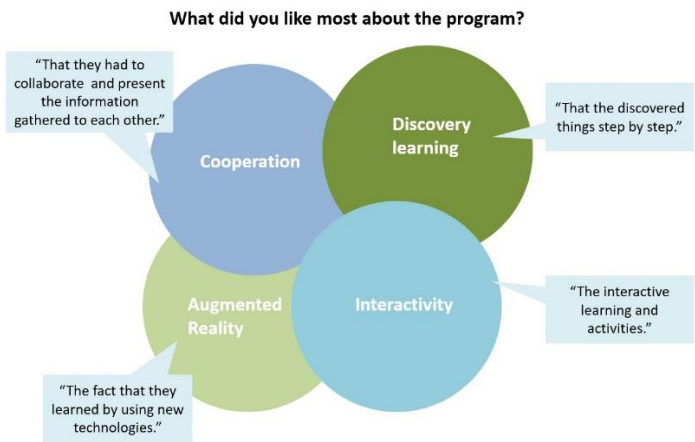
What did you like most about the program?

"That they had to collaborate and present the information gathered to each other."

Cooperation

Discovery learning

"That the discovered things step by step."

Augmented Reality

Interactivity

"The interactive learning and activities."

"The fact that they learned by using new technologies."

Figure 1. Quotes on the mosts successful part of the program.

Indeed, the answers given are quite encouraging, as it seems that the programme has been able to meet its initial objectives. In particular, 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 the interactive learning and activities. These were considered to be among the most successful elements of the programme.

Moving on to the second question, the evaluation participants had to make some suggestions for improving the programme. Their answers were that:

✓ Perhaps it would help if there was an activity that the students could actually make something during the programme that could then take with them.
✓ It would be best if the number of children per group was smaller.
✓ 2 more fossils could be added so that it students get to know more things about animals and mass extinctions.

The questionnaires received from the students were eighty-four (84) and consisted of three closed-end and two open-ended questions. The first question asked them whether they gained new knowledge regarding the impact of climate change on animals and planet Earth, in general. 86% of them answered that they did, while 1% said that they did not learn anything. A small percentage of 13% stated that they "do not know" (graph 6).
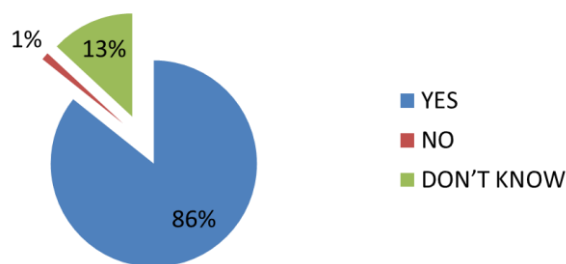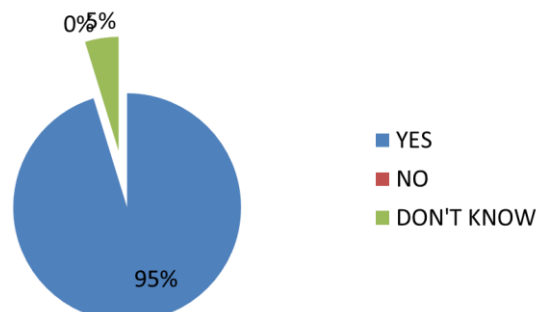

Graph 6. Students' opinions on whether they have gained new knowledge regarding the impact of climate change on animals and planet Earth.

The second question was whether they liked the use of the Augmented Reality application in the programme. The vast majority of them (95%) stated that they did, with only a small percentage of 5% answering that they "do not know" (graph 7).
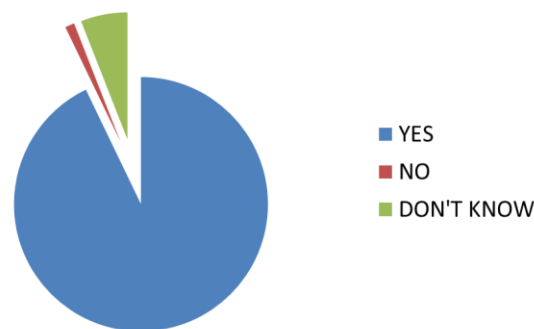

Graph 7. Students' opinions on whether they enjoyed using the AR application

The third question regarded the programme's activities in general and whether they liked them. The vast majority stated that they enjoyed all the activities in the programme, with only a few answering they "do not know" (graph 8).

The students enjoyed the program's activities

Graph 8. Students' opinions on the activities included in the programme, in general.

When students were asked to comment on which part of the programme, 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. A lot of them were not specific and said that they enjoyed everything, while there were some that mentioned the activity with the dice, 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, students had to state something that they did not like in the programme. Most of them did not answer this question or just said they liked everything. Some mentioned the activity with the cards that gave information about the animals and the impact of climate change on them.

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

6. Discussion

The climate crisis is undeniably a modern reality. Human societies in the 21st century have made great progress in various fields, but modern lifestyles and overexploitation of nature have caused significant degradation of the environment and climate. Scientific studies show that climate change today is mainly anthropogenic and threatens not only the environment and ecosystems but also human societies, putting the sustainability of undeveloped countries, in particular, at stake.

Action by the international scientific community and government representatives, the EU and major institutions such as UNESCO, has 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 of countries and political leaders around the world to limit the emission of greenhouse gases and climate change. However, the situation is still problematic. The desired results seem to be met with a number of 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. Climate change education can lead to understanding and 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 programmes and their overall operation with climate change education in mind, they can instill core values and lead to the adoption of environmentally responsible behavior. However, the obstacles in the Greek educational reality are many and require concerted action and a holistic review of educational policy.

On the other hand, museums can play a very important role in climate change education. As institutions at the service of society, listening to contemporary reality, they have a responsibility towards 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.

Picture 5. Various moments of the programme captured during its implementation.

It is on this principle that the present educational program was designed and implemented. 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 larger number of visitors will be drawn to the museums and more students will have the opportunity to participate in such programs, raising environmental awareness.

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

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

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