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RESEARCH ARTICLE

Museum and Kindergarten: STEM connections between exhibits and science

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Abstract: The present work supports the possibility of connecting exhibits of the Museum of Ali Pasha on the island of Ioannina with the Natural Sciences through an educational scenario in the light of the Theory of Activity and the SciEPIMGI design framework. In this way the educational programs designed for Museums of general interest gain added value by supporting the cooperation of formal and non-formal education. The script was designed during the training program of the University of Ioannina and was implemented in November 2021 by students of the Kindergarten of Ioannina. Through selected exhibits of the Museum, bridges with themes were detected from the Curriculum for Natural Sciences in the Kindergarten, focusing specifically on the theme "water". Theoretically, it is based on the approach of Hein's constructivism, Gardner's multiple intelligences and the active participation of Simon's student, with particular emphasis on the student's individual peculiarities regarding the ways of perceiving reality and the personal meanings he forms. The Museum-pedagogical activities that are designed apply a variety of methodologies such as students' oral expression, visual creations, hidden treasure game, writing, experimentation, creating connections, problem solving, interpretation and expression of crises, etc. Special emphasis was given to of students' senses and in experiential and exploratory learning. The museum space was utilized as a constructed environment for learning and application of museum-pedagogical methods and as an invisible educational framework that allows effective learning processes, mobilizes curiosity, evokes emotions and impressions.

Keywords: museum and natural sciences, socio-cultural Theory of Activity, design framework

1 Introduction

Modern theoretical approaches emphasize the individual ways of perception of reality by the Museum visitor and the meanings he forms, such as constructivism (Hein 1998), multiple intelligences (Gardner 1993), but also regarding the concept of experience (Falk & Dierking 2012) and active participation (Simon, 2010), leading to a continuous enrichment of the methods applied in the museum pedagogical practice. According to Dreykorn & Wagner (2007) there is a huge variety of museum-pedagogical methods that include oral expression, writing, music, dance, experimentation, research, reflection, imitation, association and connection, comparison, the interpretation, and expression of judgments while giving importance to the activation of all the senses with the aim of individual and social activation and evolution (Hooper-Greenhill, 2007). Museum pedagogical methods are applied as educational programs, i.e., as educational processes that take place in museum spaces and are addressed to groups of visitors, are developed in different stages, and include different types of individual activities. Museum pedagogy bridges the gap between the museum and the public (Heiligenmann, 1986) and mediates between museum reality and visitor reality (Rese, 1995) through direct communication activities (Dreykorn & Wagner, 2007).

The literature review showed that the application of Natural Sciences educational programs in museums of general interest is extremely limited (Georgopoulou & Koliopoulos, 2017), as a result of which we are led to the study of relevant bibliography by science museums. According to Mujtaba, Lawrence, Oliver, & Reiss, 2018, students in science museums are actively involved with scientists and with authentic scientific activities through scientific methods, gaining more knowledge, while Falk, Needham, Dierking, & Prendergast (2014) argued that collaborations between scientists lead to enhancing the effectiveness of education in the Natural Sciences.

The educational programs in the Natural History museums aim at the involvement of the students and the enhancement of their interest through the bridging of the formal and non-formal education and giving them the necessary opportunities in order to know the challenges of the present and future world (Mujtaba et al., 2018).

Through dealing with authentic objects, contact with culture, cultivating scientific method skills and collaborating in group projects, the cultivation of positive attitudes towards science (Roth, 2011) and the museum (Plakitsi, 2013) is sought.

The peculiarity of the present study concerns the involvement of the students with the Natural Sciences, through the connection of the exhibits of a museum of purely Folklore with themes of the Natural Sciences of the Curriculum of the Kindergarten.

2 Theoretical approach

2.1 Theory of Activity

Based on the Theory of Activity, a predominantly sociocultural theory, and the view that learning is the result of interaction, the aim was to extend the learning environment outside the classroom and "open" the school to the wider community, by applying formal, non-formal and non-formal form of education, in which the natural, social, and cultural environment is utilized as a primary source of knowledge (Plakitsi et al., 2018). This theory bridges imaginary simulated and real situations, through personal engagement with material objects and artifacts that follow the logic of a future model of activity (Engeström, 2007).

In such an expanded learning community, students, having with them their own personal socio – cultural burden, interact with classmates, museum people and teachers, acquire scientific research skills and come into contact with the historical, social and their cultural environment, while developing a positive attitude towards the natural sciences and the museum (Plakitsi, 2013).

Educational programs from the world of science in the light of Activity Theory differ from the usual, because although they cultivate scientific method skills, they are not intended for science museums or centers but are designed for museums and non-formal learning environments of general interest. The process of designing such programs is based on the following:

(1) Defining the target group of the educational program;
(2) Connection of the museum exhibits with themes of natural sciences;
(3) Connection with the Curriculum for Natural Sciences;
(4) Collaborative learning;
(5) Experiential learning;
(6) Balance between free choice and guidance;
(7) The role of the animator.

2.2 ScIEPMGI design framework

The design framework SciEPIMGI (Scientific Educational Programs in Museums of General Interest), proposes the implementation of educational programs in museums of general interest, thus enabling every school class to come into any Museum they want, no matter how far away it is. It concerns educational programs for students, which are related to themes of the curriculum of formal education, which requires a precise definition of the age range of the target group (McLean, 1993).

The widespread methodology of development of museum exhibits and collections and participatory design and involvement, adapted to the needs of the specific design framework consists of 4 phases: a) the conception of the idea or otherwise the development phase, b) the design, c) the implementation and d) evaluation (Radice, 2014).

Specifically, the development phase includes 1) the motivation for the design of the educational program, 2) the goals of the design, 3) the identification of the bridges between the museum exhibits and thematic Natural Sciences and 4) the definition of the target group.

The design phase includes: 1) the selection of the museum exhibits that will be used in the educational program, 2) the connection of the selected exhibits with the subject of Natural Sciences that the educational program deals with, 3) the development of the plot of the educational program and of the case through the educational program, 4) the planning of the actions integrated in the educational program, 5) the choice of pedagogical methods and teaching techniques, 6) the choice of the evaluation method, 7) the determination of the role of the animator. The SciEPIMIGI design framework attaches great importance to the role of the educator-animator, as the implementation of educational programs is a dynamic process. In order to have an educational benefit in such a system of continuous interaction, the animator will have to adjust the time of the actions each time, according to the interest of the students and the group (Kornelaki & Plakitsi, 2018).

The implementation phase concerns the approval by the director of the museum, the construction of the necessary extra -museum material, the materials of the experiments and their

placement in the collection of the museum, the items that the students will have with them, the maintenance of its material educational program and the renewal of consumables for its next applications, etc.

Finally, the evaluation consists of four stages using the ex-ante, formative, corrective, and summary evaluation through different methods (Radice, 2014).

3 Applied educational intervention

3.1 Objectives of the program

(1) To acquaint children with the properties of water, through their contact with the exhibits of the museum and with playful ways of experimentation;

(2) To distinguish objects from their construction materials;

(3) To express their ideas about simple natural phenomena and to negotiate them with others;

(4) To answer the questions, they are researching and to use the results of their research in new situations;

(5) Acquire 4 Cs skills (collaboration, communication, critical thinking, creativity);

(6) To argue and support their point of view, while respecting the views of their classmates;

(7) Gain perseverance and patience in the search for a solution to a problem;

(8) Do not be afraid of error and accept failure as something natural, starting from the beginning;

(9) Maintain interest in observations and experiments;

(10) Make classifications and predictions;

(11) Address the alternative ideas of children of their age

3.2 Reason for dealing with the subject

The impetus for the planning of this educational scenario was given after the call of the Ministry of Education for the planning of actions related to the 200 years since the revolution of 1821. In this context and visiting the Museum of Ali Pasha online during the year, the interest of infants in this area was evident. So, we decided to connect the program with the Natural Sciences due to our involvement with them, through the pilot program of IEP R 4 C which we implemented in the specific school year.

The modules “objects and materials”, “time: then and now”, “rocks”, “colors”, “concepts and phenomena from the natural world” were utilized from the curriculum of the kindergarten and the subject of Natural Sciences. And from the thematic “water” the program focused on the concepts of filtration, solubility, water permeability and flotation-immersion. The exhibits selected by the Museum of Ali Pasha to be used in the educational pro-gram were:

(1) Water jug (winter being room);

(2) Boat with Kyra-Frosini (Kyra-Frosini Hall);

(3) Curtains (curtain room of Sultan Mahmut II);

(4) Silver hairpin early 20th century (jewelry salon);

(5) Authentic silk costume of Kyra Vassiliki (silver jewelry room);

(6) Silver ball, ceramic jug, cloth costume, wooden base for pistol (revolutionary period room);

(7) Daily food containers (winter being room);

(8) Ceramics of Puglia (19th century) (room with traditional continental costumes);

(9) Silver box of tobacco in the form of Ali Pasha and Kyra Vassiliki (France, 19th century) (hall of Ali Pasha).

3.3 Factors for construction of concept

The mental representations of preschool children contribute not only to the understanding of how children think, but also to what are the important obstacles they encounter (Panagiotaki & Ravanis , 2013).

Children’s ideas for floating and sinking were explored by Biddulpf & Osborne (1984) who observed that when floating objects were largely out of the water, children considered them floating. In the float study some children thought that objects floated when a large part of the object was out of the water, whereas when only a small part of the object was out of the water then they believed that a small part sank and another floated. Some other children thought that objects that were all on the surface or floating in the water did not float. They often believe that objects float because they are not very heavy or because they are short or even because the water is not very deep. Most children are unable to explain why objects float without being able to give a generalized answer (Driver et al, 2000).

Regarding the phenomenon of dissolution, the youngest children under the age of 8 seem to focus only on the dissolved substance, saying that it "simply leaves", "disappears", "melts", "dissolves" or "turns into water". Researchers say that when the answer "melts" is carefully considered, then many children tend to describe it as ice that "becomes fluid". The results show that older students imagine that when sugar dissolves it "breaks into small pieces" (Driver et al, 2000). Hatzinikita, Koulaidis & Hatzinikitas (2005) studied the mixing of salt and water by studying the mental representations of 11–12-year-old students about the changes in matter. The results showed that children tend to think of microscopic entities as very small pieces of macroscopic material. Panagiotaki & Ravanis (2013) studying the experiential mental representations of infants for the concept of dissolving soluble and non-soluble substances in two different solvents, water, and oil, found that color seems to be the axis around which the interpreters move children's figures to explain the phenomenon of dissolving a substance in one solvent and not dissolving it in another solvent (water and sugar, sugar, and oil).

3.4 Development of the scenario pilot

3.4.1 Screenplay title: *Looking for the lady's comb Frosinis*

Upon entering the museum, the students were first divided into groups through a digital wheel of names and then the children toured the Museum and explored the exhibit-it's to get a general picture of the space. Everyone was given an individual notebook and a pencil to record their observations. Finally, they discovered Kyra 's letter Frosinis who asked them to find her a comb for her hair because what she was wearing was thrown by Ali Pasha in the lake because he refused to become his wife. This will be the occasion from which the infants will start the search for this exhibit, moving from room to room, intertwining with exhibits, solving puzzles, making assumptions, chasing treasures, finding secret keys, working with flexible grouping, making predictions, and drawing conclusions and formulating functional definitions.

3.4.2 Activity 1

Inside the lady's letter Frosini also find the 1st puzzle ("with what do I drink water?") Together with a photo of the winter being room and the floor plan of the museum so that after finding the room, they end up in the exhibit of the central jug that is located there. Inside the jug they will find another problem they have to solve: the water of the lake is not as clean and drinkable as it used to be, and the fish and birds can no longer survive. They need to find a way to purify the water so that it becomes viable again for the animals (we process the concept of filtration).

Each group is given materials to experiment and find ways to clean the dirty water in a plastic bottle. They have coffee filters and a funnel at their disposal but to achieve the desired result they will have to repeat the process several times. They will suggest solutions, try suggestions and whether or not they will reach the desired result.

Returning to the plenary an infant who will be appointed as coordinator, will ex-plain to everyone how they worked as a team, and only then will they be able to get a key from the people of the Museum to open the secret chest of Ali Pasha that will lead them to the next room and in the next puzzle.

3.4.3 Activity 2

The title of the 2nd activity is "where the sugar of Mrs. Vasiliki was hidden" and the concept we are working on is solubility. Toddlers in the chest discover a papyrus with the poem:

"*A thousand scales of sugar*
To throw in the lake
To sweeten the water
drink Kyra Frosini"

On the occasion of this poem and the photo of an exhibit (specifically a food container) inside the chest, the children experiment by throwing sugar in the water to see what will happen. They make predictions, recordings, test ideas, control, experiment with other materials and quantities (coffee, oil, salt, and rice) and find the invisible power of water to make some of the materials we throw in disappear, while others re-main visible.

We work again in subgroups and in plenary and so they find in the room a new key that opens the third chest of Ali Pasha.

3.4.4 Activity 3

In activity 3 the infants are looking for a solution to the problem "with what materials will I build a boat for the mistress to pass Frosini opposite, from the island to Molos". The concepts

of floating and sinking are elaborated.

They have at their disposal 4 materials (metal, ceramic, fabric, and wood) on the occasion of 4 museum exhibits made of the specific materials, and the children experiment, make predictions, and come to conclusions and formulate functional definitions, working in plenary and in subgroups. Once they reach the solution, they are given the next key to the next room.

3.4.5 Activity 4

In the next room we deal with water permeability through the solution of the problem "with what material will Mrs. Vasiliki make her umbrella, today that it is raining".

Toddlers have a variety of fabrics at their disposal, waterproof or not, and work again with experiments and hypotheses ending up with functional definitions and finding the key to the last room.

3.4.6 Activity 5

In the last room they find the comb that was originally requested from them. They observe with a magnifying glass the symmetry they have and then on an open worksheet, everyone makes their own comb, decorating it as they wish and paying attention to the concept of symmetry. All the paintings are tied in a book and donated to the Museum.

3.5 Choice of evaluation method

Three proposed levels of analysis regarding the cultivation and promotion of the scientific method are highlighted:

(1) The skills of critical thinking and scientific research processes;

(2) The study of social interactions that occur during the implementation of the educational program between the involved subjects;

(3) The study of the structural elements of the system of activity and the interactions between them utilizing the extended triangular model of the Theory of Activity (Engeström, 1999) and highlighting the contradictions that occur within the system and between its neighboring systems during the implementation of the teacher program.

The dominant subject of the system is the Subject (students and teacher-animator), the Tools are the museum exhibits, the history, the materials for the experiments, the educational drama techniques and the Language, the Object is to experience the properties of water and to practice scientific method procedures, with the final Outcome the positive effect of alternative learning experiences in the formation of positive attitudes for the Natural Sciences and the Museum.

The evaluation is carried out throughout the program indirectly, through the interest and enthusiasm of the children for the continuation or not of the program, while the final evaluation is done:

(1) With an open individual worksheet where toddlers will have to paint one of the museum exhibits that floats and one that sinks in the water;

(2) By creating a story about the construction of waterproof feathers for a blue bird that is painted on the museum ceramics, from a selection of different materials;

(3) By creating a problematic situation and solving the problem: "what will we use as a boat to cross the lake? a wood or a stone and why?"

(4) With the solution of the problem: "a paper boat full of salt sank in our lake. "Where did the salt go?"

3.5.1 Before the visit

We utilize relevant fairy tales (*e.g.* Ariadne in the new museum of the Acropolis), we bring the children in contact with various museums of general interest by doing virtual tours (*e.g.* museum of the Acropolis), we observe books that present collections of works of art and exhibits, we have a first contact with the Ali Pasha Museum that we will visit (*e.g.* by telling stories from mythology about water and the people mentioned in the Museum, by creating a floor puzzle of the photo with the original silk costume of Kyra -Vasiliki that exists in the Museum, through an online visit), we come in contact with various water experiments in the classroom, we create a poster or collage with a theme from the specific Museum to give as a gift during our visit, etc.

Smart mobile devices and their applications prove to be effective in educational practice by helping students to acquire knowledge through play and interaction. It is no coincidence that gamification that combines learning with play enhances students' interest and motivation, especially in science and mathematics, leading to positive learning outcomes (Xezonaki, 2022).

The lack of modern technological equipment was an issue that made our work difficult in terms of distance activities, both regarding the Internet connection and the WebEx program, something that Poultsakis, Papadakis, et.al highlight in their own research, 2021.

3.5.2 After the visit

Upon our return to class one of the first activities that can be done is an individual free drawing on what impressed the students or what they remember most vividly from the visit without being preceded by discussion, views, feelings, or descriptions. In the plenary of the class, everyone explains, describing what he did.

We refer to the concepts of Natural Sciences that we negotiated during our visit and through experiential problematic situations of everyday life we try to find out whether the students have consolidated them and can apply them in everyday life.

We continue the program in the classroom enriching the experiences of infants with additional experiments and actions related to water (*e.g.*, experiments for the 3 water conditions, experiments for the pollution of the seas by oil slicks, information actions for the usefulness of water in the life of the planet, games in the school yard etc.) and we put educational robotics (ER) in the classroom, as research underpins the value of STEM education from an early age and ER creates a fun and engaging learning environment that enhances learning (Papadakis et al., 2021). Moreover, according to Yore & Treagust (2006), the use of a robotic system at an early age provides children with the opportunity to access knowledge in multiple ways and to create relevant representations and cognitive structures. We create a track on "floating and sinking materials" and the toddlers' program BeeBot to, based on previous experiments, distinguish which materials float and which sink.

Finally, the students themselves create an Eco -code of conduct for water, print it in multiple copies and distribute it in leaflets to classmates, families, and the local community to raise awareness.

4 Conclusions

The findings of our study show that the Museum of general interest is an extremely supportive and effective learning framework for preschool children in understanding the content of the Science subjects of the Kindergarten Curriculum. The educational programs of the museums thus acquire added value and require more and more urgently the cooperation of formal and non-formal education in order to offer students a potentially complete educational program (Kornelaki, 2018). The SciEPIMGI design framework (Science Education Programs in Museums of General Interest), acted as an adjunct to the above process.

The children applied new knowledge that was based on their pre-existing perceptions and led to the scientific knowledge and the confrontation of the alternative ideas of the children of their age. Our findings confirm many researchers who claim that the multimodal approach to scientific knowledge leads to more effective learning, as it actively engages students, stimulates their interest, and promotes the development of scientific thinking skills and therefore science (Alade et al, 2016; Ainsworth, 1999; Brooks, 2009; Papandreou & Terzi, 2011; Smyrnaioy & Weil-Barais 2004; Yore & Treagust, 2006).

Research on preschool children (Tsoukala, 2021) demonstrates that play-based teaching practices that provide children with multidimensional learning environments engage them in authentic and meaningful learning, promote teamwork, communication and social skills, challenge and motivate them to make sense of their learning.

Through the testimonies of the exhibits, the bridges that connect the culture and the culture with the Natural Sciences are identified and detected and offer potential possibilities of utilizing the museum exhibits in educational material from the field of Natural Sciences which can be progressively led to comprehensive training programs. The latter thus acquire added value and make the cooperation of formal and non-formal education more and more a renounced (Kornelaki, 2018).

Conflicts of interest

The author declares that they have no conflict of interest.

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