MARBLE SUSTAINABILITY MATTERS: AN EDUCATIONAL PROGRAMME ON MARBLE, INTEGRATING SCIENCE, CULTURE AND THE ENVIRONMENT

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ABSTRACT
This study presents the qualitative and quantitative evaluation of an educational programme that combines an online game and an outdoor activity with mobile learning in science education. The object of the study is to test the capacity of the programme to integrate science, culture and the environment, while transferring knowledge about marble. To this end, we align our theoretical orientation with the overall project design to devise an initial scheme that is pilot-tested by 155 university students of early childhood education and evaluated through a questionnaire. Qualitative data through participants' feedback after the programme, observation notes and data from video recordings supplement the overall assessment. The results show high levels of satisfaction among the participants in terms of the quality of the activities, the distance between stations, the duration and structure of the programme, contact with marble, and the knowledge acquired.
KEY WORDS: *science education, mobile applications, cultural heritage, biodiversity, materials science.*

JEL CODES: L8; L83.
DOI: https://doi.org/10.15181/rfds.v37i2.2428

Introduction

In this paper we present a programme that aims to integrate science, culture and the environment in a combination of an online game and an outdoor experience. The problem in this paper is to find a flexible means of delivering a holistic educational ecology that is based on principles of interdependence and connectedness, seeking to connect the part with the whole, and contribute to the primary goal of education for sustainability (Mahmoudi *et al.*, 2012). Consequently, the purpose of the study is to present ecology that can also serve as an educational tool and an alternative to a traditional tourism product, by means of diversifying

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a tour around historical monuments and natural environments. More specifically, the object of our endeavour is to transmit knowledge about marble as a cultural heritage material through a didactic transformation that promotes the natural and cultural beauty around Lake Pamvotis. The scenario consists of historical and scientific elements, and guides participants through the geology, chemistry and physics of marble via specific tasks that help them discover the mystery hidden in the castle.

iNaturalist contributed to the creation of a raw database with the biodiversity around the sculptures and historic sites through its crowdsourcing affordances. Geocaching was the perfect link navigating students to the first station in the outdoor activity through a hint at the last task in the online game.

Regarding the tasks to be accomplished, we will first concretise our theoretical reflections through a visualisation of the overall programme, and then test the proposed programme against its structural aspects and pedagogical objectives through a pilot implementation and an evaluation of the participants.

Based on all these considerations, our paper focuses on the following two research questions:

1. How can knowledge about marble be transmitted through the integration of science, culture and the environment?
2. How do participants evaluate different aspects of Marble Sustainability Matters (MSM), and to what extent were the objectives of the proposed scheme achieved?

In terms of the methods that we will use to answer the above questions, we will first provide the reader with the theoretical orientation of MSM, and accordingly delineate the different facets of the programme by instrumenting a design that leads to an initial model. Then we will go through an analysis of quantitative data (questionnaire) and qualitative data collected through participants' free comments and feedback, researchers' notes, and the analysis of video recordings, to see how such a programme is evaluated, to arrive at discussion and conclusions.

1. Theoretical background

Museum pedagogy and science education

In this paper, 'museum' is perceived in its extended definition, and museum and science education are seen in an informal frame (Plakitsi, 2013). Informal education considers elective learning environments, the connection with everyday experience and experiential learning, lifelong and human learning. These objectives are sought considering different kinds of museum exhibitions as strong cultural tools which mediate learning and culture making (Plakitsi, 2013).

The connection between the cultural heritage and science constitutes the meeting point of museum and science education in a cultural-historical perspective, and as such the developed actions originating from the above idea acquire added value (Kornelaki, Plakitsi, 2018).

As Plakitsi points out (2013), 'we need new models of student inquiry based on the use of ICTs in a dialectic between the minds-on and hands-on skills of a learning subject in correspondence with an inspiring object' (p. 7). That inspiring object may be reachable only through a collective activity that, according to Kolokouri and Plakitsi (2013), 'is scientific literacy connected with the needs of all citizens'. And they continue by adding that *'...scientist and citizens interact in a dynamic system in order to gain knowledge and achieve scientific literacy within the sociocultural framework*' (2013: 199).

Citizen science

Ideally, and in terms of expanding science education to society, the above view fits well with the promising citizen science (CS). For Alan Irwin (1995), CS means the development of concepts for a knowledge-based society, characterised by the need to open up science as well as research policy to society. Rick Bonney (1996) defines CS as the participation of amateurs in scientific programmes for the purpose of collecting data, the well-known 'crowdsourcing' (1996). In a similar vein, one could think of it as the volunteer contribution to science (Roy *et al.*, 2012).

And while these two perspectives persist until today, Eitzel *et al.* (2017) try to map the global debate on the definition of CS, and come to their conclusions with two questions that need to be highlighted:

- Who gets to decide what people involved in all aspects of citizen science are called, and why?
- Who gets to decide what science consists of?

Wiggins and Crowston (2011) take us to a different perspective by providing five types of CS, with examples, scientific, organisational and technology issues for each one of them, and these are action, conservation, investigation, virtual and education CS, while Haklay (2013) suggests that there may be four levels of participation (Fig. 1). Finally, we should also consider the ten principles of CS developed by the European Citizen Science Association (ECSA, 2015).

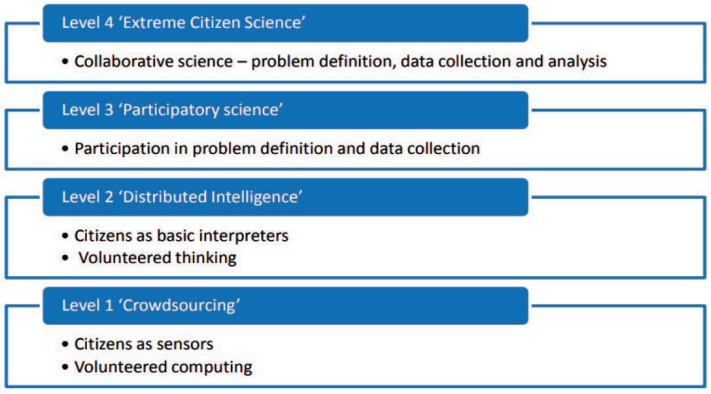

Figure 1. Levels of participation and engagement in citizen science projects

Mobile learning

Finally, another direction that is crucial to our research approach, as it substantiates our methodology, is the application of mobile learning. An early definition of mobile learning was given by Quinn (2000), 'it's e-learning through mobile computational devices: Palms, Windows CE machines, even your digital cell phone.' A good picture of the use of mobile learning in science is provided by the findings of a recent systematic review by Crompton *et al.* (2016).

1. The most common purpose of the studies was to design a mobile system for learning, to evaluate the effects, and investigate the affective domain.
2. Most adopted research methods were case studies, mixed methods and quasi-experimental design.
3. All of them reported positive outcomes.
4. Most of them were conducted in the area of life science, took place in elementary school settings, and occurred in an informal educational context.
5. The device type was not important.
6. While the research was conducted in 13 countries, most of them were conducted in Taiwan.

Keskin and Metcalf (2011) provide a brief but concise paper that sums up current mobile learning theories in an exhaustive and thorough list. We have edited the table, and added a column to check the consistency of Marble Sustainability Matters with each learning theory (Table 1).

Learning Theories	Focus	Marble Sustainability Matters
Behaviorist	Information and content delivery in mobile learning	N/A
Cognitivist	Information and content delivery in mobile learning	Using multimedia, audio &video, images, text
Situated	Content and content-dependent mobile learning Collaboration and interaction in mobile learning	Authentic domain activity, natural science learning
Problem-Based	Problem-based context and solved based content-dependent mobile learning	N/A
Context-awareness	Context aware in mobile learning	Context-depended content management, Contextual event notification, Context-aware communication Navigation and retrieval of learning materials, ebooks, iNaturalist and Geocaching apps
Socio-cultural	Social Context and Social Participant dependent mobile learning	Community of practice, Ioannina Castle crowdsourcing project
Collaborative	Collaboration and interaction dependent mobile learning	Communication between peers via mobiles
Conversational	Interaction and communication dependent mobile learning	Solving a task, Exploring an environment, Field trip
Lifelong	Lifelong information and interaction with education content in informal mobile learning setting	Social networks, ecourses, information resources
Informal	Information and interaction with education content in informal mobile learning setting	Social networks, tour around the monuments, science field work
Activity Theory	User actions in social context dependent mobile learning	Actively participation, Activities
Connectivism	Diversity of information sources in mobile learning	Connecting nodes with information sources, manage information via different stations
Navigationism	Complex of information sources in mobile learning	Sense making and chaos management, deal with nonlinear narrative
Location-based	Location context in mobile learning	Geocaching app, Google maps, field trip, conceptual knowledge

Table 1. Marble Sustainability Matters and mobile learning theories (based on Keskin, Metcalf, 2011)

We understand that m-learning offers flexibility in a non-formal education context, as it provides affordances to the learner, but it is not without its flaws (social media distractions, message notifications, compatibility problems with apps, bad reception, etc). For example, during the event there was an excessive use of mobile phones (INaturalist, Camera, Maps, Website, social media, etc), and mobile batteries ran low.

2. Heritage education and information and communications technology (ICT)

Although there has been an exponential growth in ICT applications for supporting and enhancing cultural heritage education, it seems that technology has poor participation in affecting approaches to teaching and learning, as it is still based on instruction. This calls for further research, with a view to bringing technology enhanced learning and cultural heritage education closer (Ott, Pozzi, 2011).

In this direction, a framework (Fig. 2) which is based on the learning technology system architecture (LTSA), a conceptual architecture about how learning is supported by information technology, is presented by Mendoza *et al.* (2015).

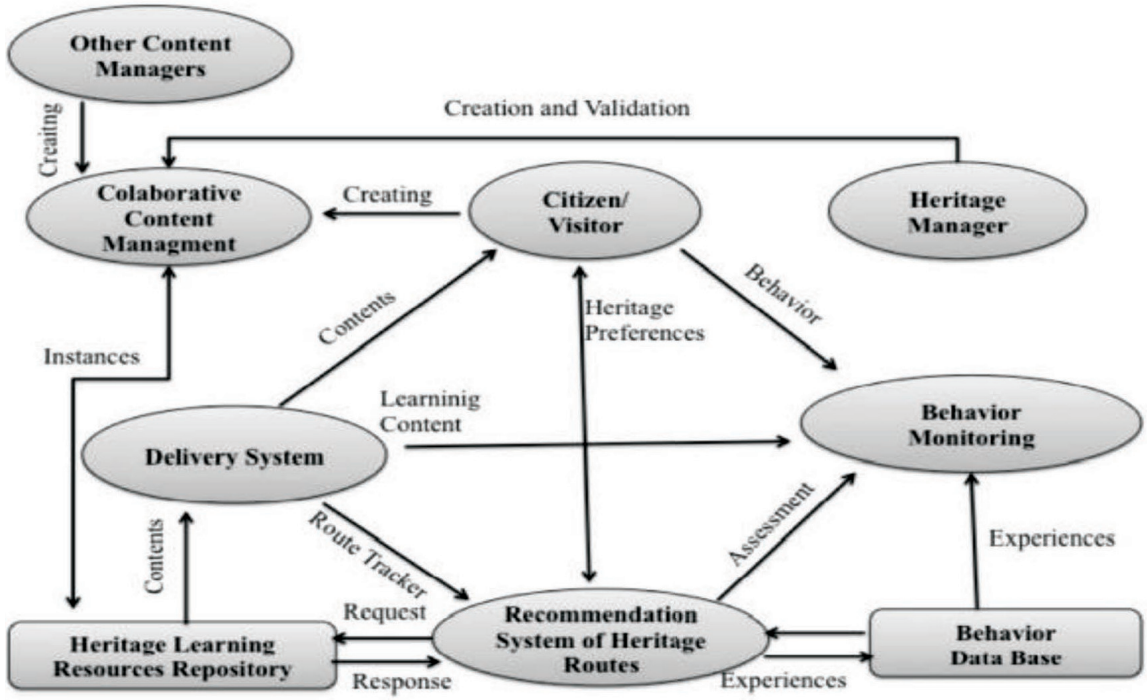

Figure 2. Framework of heritage education

Methodology

The rationale of Marble Sustainability Matters

The whole project originated from the two marble pessaries that frame the prayer niche (*mihrab*) of the Fethiye Mosque. According to rich historical references as they are summarised in the work of Kordosis (2002), the pessaries may be the remains of the old Christian temple that was a former metropolis of Ioannina and was dedicated to the Archangel Michael, once the patron saint of the city. According to the same references, the temple was probably built between 1205 and 1215 AD by Michael I Komnenos Doukas, the founder and first ruler of the Despotate of Epirus. The concept of the game was triggered by a question that seems very hard for an individual to answer on their own. This question can provide a great stimulus for the design of a citizen science project, and is formulated as follows: what are the origins of the pessaries in the Fethiye Mosque, and, more specifically, where does the marble come from?

Our team was also motivated by the restoration of the Ottoman Baths and the Ottoman Library that is currently being carried out inside the castle, and it is the first intervention project for the creation of a Cultural Park which is included in the Sustainable Urban Development Plan of the Municipality of Ioannina, and is expected to be completed by the end of 2023 based on the schedule.

The potential of the application of a citizen science project that is open to the public and to tourists will add value to the promotion of the city.

Selection of monuments

The three main sites we selected for this game, both via the online game and the treasure hunt, are depicted in Image 1. The reason for their selection was that all of them are surrounded by water, and invite participants to make a tour around Lake Pamvotis and enjoy the natural and cultural beauty of the area. Furthermore, from what our on-site visit revealed, another connection was discovered that could work perfectly with science education and marble. All the sites have an interesting chemical compound in common, and that is calcium carbonate (CaCo3).

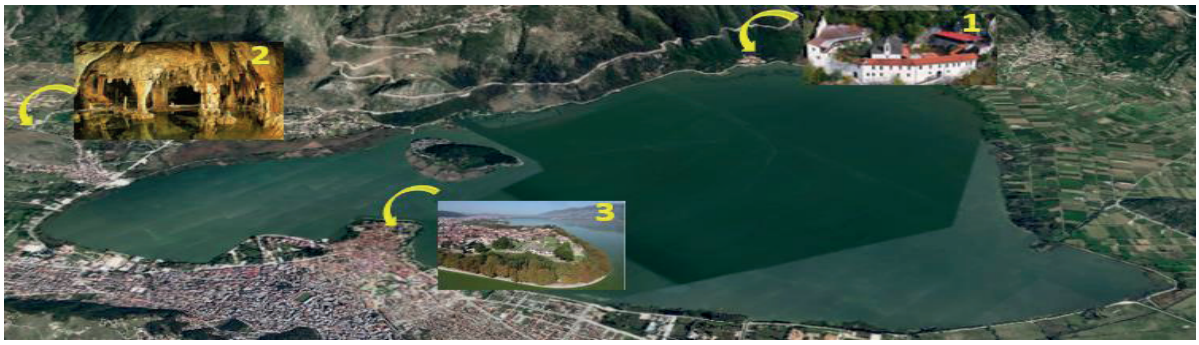

Image 1. The three monuments around Lake Pamvotis: 1. Dourahani Monastery; 2. Perama Cave; 3. Ioannina Castle

The Acropolis of Kastritsa, in the eastern part of the Ioannina basin (on the right-hand side of Image 1), which was initially planned to be included in the game, although it is a monument of great archaeological importance, was finally screened out due to accessibility and transport issues, as there is no bus route around the lake, and it was not possible for students to get to that destination.

For the above reason, we decided that Dourahani Monastery and the Perama Cave would be two of the three stations in the online game, referred to as Marble Mania, leading to a hybridisation of a remote game (Marble Mania) and outdoor hands-on activity that would take place around the castle and inside it. In essence, the outdoor activity called 'Mystery in the Castle: The Three Angels' took place in two stages. The first was along the banks of the lake around the castle, with the participation of 12 sculptures from the First Symposium of Sculpture that have been exhibited since 1996, and the second was carried out through the historical buildings inside the castle.

Marble Mania: connecting sites through historical figures and calcium carbonate

Unlike the famous Marble Mania racing game, where you control a marble and race it against other marbles, our Marble Mania aims to transfer scientific knowledge about the stone marble, incorporating elements of the history of science and education, geology and chemistry through a role-playing game (RPG).

The basic characters that guide the recipient with simple quests through the area from the monastery are based on real characters with a notable presence in the history of the monuments, such as the cleric Athanasios, who rebuilt the monastery with his own hands along with a boarding school-refuge, a primary school and a high school, and Anna and Ioannis Petrocheilos, who explored the cave. Surprisingly, the academic and the educational reformer James Pillans, and the great chemist and inventor Sir Humphrey Davy, worked perfectly as links between science and culture (Table 2).

A beta version of the RPG game was developed through the Unity game engine, and the following screenshot gives an idea of the environment of Marble Mania (Image 2). This version, which is available on the website of the Research Centre, currently runs only on desktop, but it is expected to be released in an updated version, and will be available for androids and IOS. The last encounter with the sculptures provides the user with directions on how to get to the first station in the outdoor activity through the Geocaching application.

Table 2. Basic characters of the game with the corresponding items, quests and facts[7]

Characters – Wizards	Items	Object	Fact
James Pillans	Slate	Give it to the Father to hang it on the wall of the school.	In 1800s, James Pillans was officially one of the first to think to hang a big piece of slate the wall of the school and use chalks to write on it according to the Oxford Dictionary (Day, 1967;Pillans, 1856).
Father	Collect chalks [1]	Give it to the Father to use them on blackboard.	Father Athanasios built with his own hands a shelter, a primary and secondary school next to the Durahani Monastery.
Humphrey Davy	Marble [2]	Give it to Humphrey Davy to put it on the floor of the school.	In 1808, Sir Humphrey Davy first described the electrochemical isolation of calcium.
Ioannis Petrocheilos	Limestones [3]	Give it to Ioannis Petrocheilos so he can further explain the formation stalactites.	In 1951, Ioannis Petrocheilos entered and discovered a notable number of rooms inside the cave.
Sculptor	Collect different colours of marbles	e.g. Black Marble means presence of organic matter or iron oxides/manganese oxides.	

Image 2. A screenshot from Marble Mania

Mystery in the castle: the 12 sculptures

The first part of the outdoor activity started outside the castle. Three teams consisting of eight to 15 students, followed by each of the authors, had to walk around the castle, find a geocache hidden near the first sculpture, and then carry on along the shores of the lake and discover the other 11 sculptures.

Each time they encountered a sculpture, they had to scan the QR code, collect the bold letter, and finally create the right scramble word. The right order of the sculptures was available on the website of the Centre for Research, Qualitative Analysis of Materials, Cultural Heritage, and Communication of Science (Image 3).

The use of the iNaturalist application (Matheson, 2014; Nugent, 2018) was an optional side project that perfectly matched the mystery game, 'connecting' students with nature. A total of 155 students attended the field course, and 109 of them added a total of 952 observations of 194 species on Ioannina Castle BioBlitz, which was set up through iNaturalist. Almost 25% of the observations became research grade, and most of them have been added to the Global Biodiversity Information Facility (GBIF), a well-respected and highly cited repository for organism occurrence data funded by the OECD since 2001, which supports citizen science initiatives such as INaturalist and eBird.

[7] 1) Chalk is a type of limestone and another form of CaCo3 just like marble; 2) marble is a metamorphic rock that can be nearly pure Calcite (CaCo3); 3) limestone is a carbonate sedimentary rock composed mostly of calcite and aragonite (different crystal forms of CaCO3).

Image 3. The 12 sculptures as they appear along the shores of Lake Pamvotis and the corresponding sculptors

Mystery in the castle: from Kaaba to the marble pessaries of the 'hidden' temple

By the time the teams reach the last sculpture, they will have discovered the mystery word that would partially reveal the identity of the first angel. Then they would automatically be directed by the coordinates that appear under the text that come up with the QR code, inside the castle with the order of stations as they are shown below (Image 4).

Image 4. The historical buildings inside the castle

Photograph 1. Decoding four local marbles

Overall, 18 QR code stickers were used (12 sculptures and seven stations inside the castle), along with texts on paper and cards describing the physical and chemical properties of marble. Scrambles, coordinates and riddles were also applied, while historical references about the Ottoman and Byzantine periods of the castle and stories from the Christian and Muslim religions and traditions were combined, to devise a narrati-

ve based on the work of Kordosis (2002). The first station sends participants to Mecca to discover the identity of the marble that covers the floor around the Kaaba. The last station is Ali Pasha's Tomb, just next to the Fethiye Mosque, where the two marble pessaries, remnants of an old temple, reveal the identity of the first angel. The café inside the acropolis of Its Cale is a station where four pieces of local marble are exhibited and call for identification by the students (Photograph 1).

Outside the Silversmithing Museum, when the students solved the following textual puzzle, the name Komnenos Doukas came up. Doukas vertical in red and Komnenos vertical in black (Fig. 3).

S. Electronic Paramagnetic resonance (EPR) spectr**O**scopy, which measures paramagnetic ions, crystalline defects and organic root**S** (Gordichi et al., 1983)

U. Measurement of the maxi**M**um grai**N** of marble with optical microscopy.

A. Analysis of Stable Isotopes determining the ratio of carbo**N** isotopes (13C/12C) and oxygen (18O/16O) (Herz, 1988; Moens et al, 1992)

O. Petrographic Analysis, which requires an intersection of a piece of marble and the creation **O**f a thin incision which is examined under the optical microscope.

D. Analysis by Neutron Activation, which determines the concentration of very minimal amounts of chemical elements (trace elements), using a nuclear rea**K***tor.

K. Cathodoluminescenc**E** by which the light emitted when pieces of marble are exposed to electron beams is measured (Barbin et al., 1992; Maniatis et al. 1988)

Figure 3. A vertical and horizontal scramble. Please note that the original text is in Greek.* The correct word is 'reactor'

The Marble Sustainability Matters scheme

In a nutshell, we initially conducted field research around the lake to find appropriate natural and cultural sites to host an activity about material science, and specifically marble. Although it was difficult to find marble on site and investigate it further as a building material, our field research was fruitful, as it revealed hidden nods between sites based on the chemical compound with the name, calcium carbonate (CaCo3). The marble pessaries of the *mihrab* at the Fethiye Mosque on the top of the castle worked as an object in an expansive design process that is fuelled by a research question with regard to the origins of the marble.

A hybrid game was then produced through an interdisciplinary approach that combined the development of an online game that utilised significant figures related to the art, science and history of the three sites of interest and the implementation of an outdoor activity that incorporated existing mobile applications such as Geocaching and iNaturalist into a narrative about the history and culture of the castle. QR codes were attached near the sculptures along the shores of Lake Pamvotis and near the historical buildings inside the castle, and a navigation of the students from one station to another helped to gradually unfold the mystery of the hidden temple in front of their eyes through the mediation of marble as a material of the cultural heritage.

A side project was prepared using the iNaturalist platform, and worked as a relaxing crowdsourcing activity that complemented the treasure hunt. Finally, throughout the activity, guidance from the Centre for Research, Qualitative Analysis of Materials of Cultural Heritage and Science Communication was provided. All the above can be summarised by the following activity scheme (Fig. 4), aspects of which were evaluated by the participants.

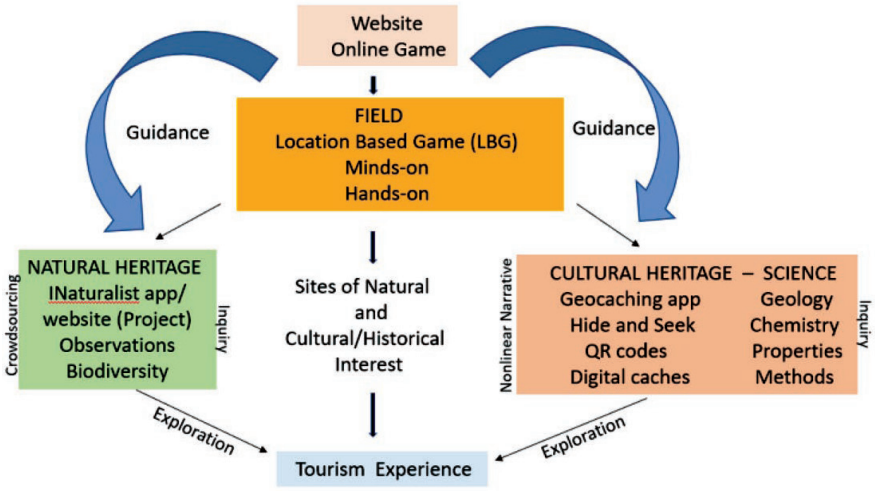

Figure 4. The Marble Sustainability Matters scheme

Participation and data collection

Marble Sustainability Matters was first uploaded as a project on the European Sustainable Development Week (ESDW) platform, and then implemented as part of the course 'The Role of the Museum in Science and Technology Education' for students in the fourth year, and 'Introduction to Science Education Concepts' for students in the first year of study.

Shortly after the activity ended, each team gathered to reflect on their experience. Students were encouraged to ask questions and discuss the various notions during their participation in the activity, as is suggested in another paper that presents a system that was designed for fostering history learning at archaeological sites (Ardito, 2007). The participants were also asked to provide feedback soon after the end of the activity by writing comments on a piece of paper, and a week later they were asked to fill in a questionnaire that was available on the Research Centre's website. The questionnaire was anonymous and confidential, and the results were used strictly and only as part of the statistical analysis of the research and an evaluation of the activity. Finally, data were also collected through personal notes taken by the authors, who followed and observed the teams throughout the activity. A video from one team at Soufari Sarai and two from the last station were also part of the data triangulation.

3. Results

The pilot that was conducted on 12, 19 and 26 October 2021 received a very positive evaluation score and feedback from a total of 15 teams. The large volume of students' comments was thematically analysed and codified.

Popular phrases among the participants were 'We learned a lot about the history of the castle through an entertaining game'; 'this was the first time I noticed those sculptures'; 'MSM changed my perspective about cultural heritage and biodiversity'; 'I did not know that marble had anything in common with chalk, speleothems and even eggs!'; 'I decoded the physicochemical properties of different marbles to travel from Kaaba to Ioannina'.

Out of a total of 155 participants, only 59 filled in the evaluation questionnaire, and the results are shown in the following figures. Students were not obliged but were invited to answer the questionnaire after the programme via email, so it is possible they neglected to do so.

More specifically, more than half of them found the number of stations to be perfect, while 37.3% said that there should be less. Almost 70% were satisfied or very satisfied with the quality of the stations, while 22% provided a neutral response. With regard to the distance, we were delighted to see that 62.7% found the distances between the stations to be perfect (Fig. 5), considering that the students covered more than four kilometres during the pilot.

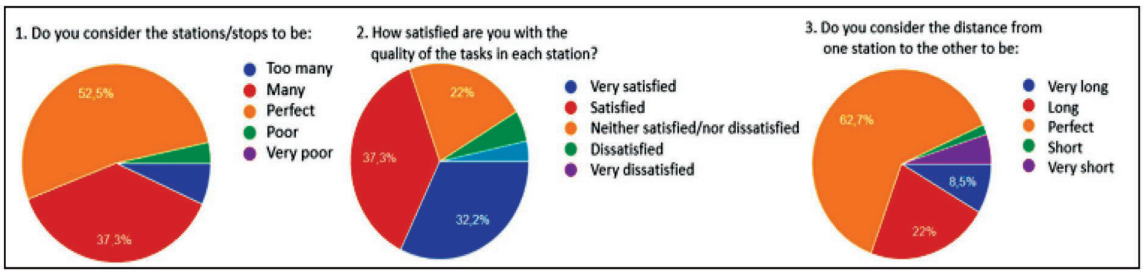

Figure 5. Evaluation results on the number, quality of the stations, and the distance between the stops

Regarding the cohesion between the tasks on each station and the narrative, the results are surprisingly good, as 57.6% found it to be perfect. With respect to consistency with the level of knowledge, most of the students answered positively (Fig. 6).

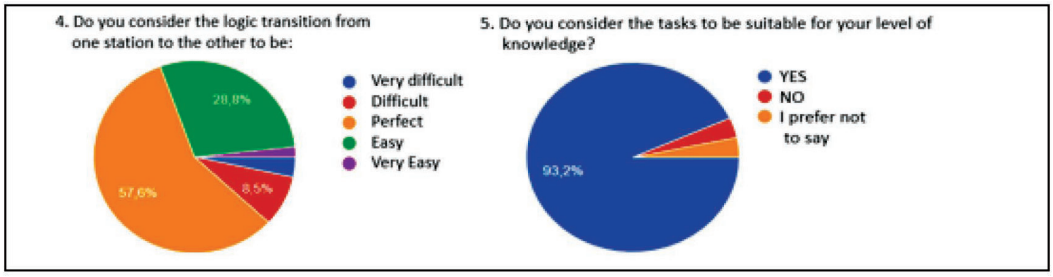

Figure 6. Logic transition and level of difficulty according to the level of knowledge

More than 96% of the students considered MSM to be from 'as well organised as it should be' to 'very well organised', and only 11.9% found it to have a very long duration (Fig. 7).

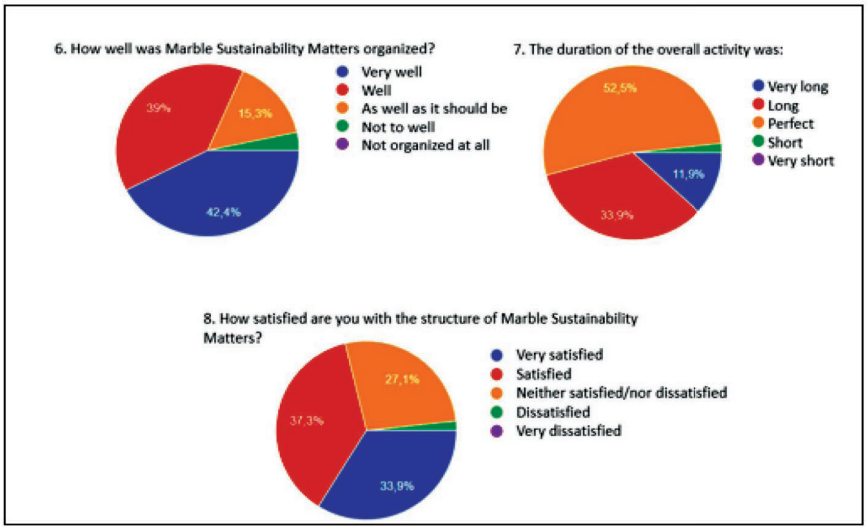

Figure 7. Evaluation results on the duration, structure and how well organised the activity was

Overwhelmingly, nearly 95% of respondents were satisfied or completely satisfied with the use/combination of the two mobile applications. We realise that this should be explored further, and we will have a clearer picture when

MSM is released to the public. When asked about future activity, 60% of respondents preferred the activity to be outdoors. This may be because people spent most of their time indoors during the pandemic, but that may change as we update the game and incorporate virtual reality elements into it. A very recent paper by Kolokouri *et al.* (2021), which looked at prospective teachers' views of museum education in distance learning, and attempted to identify conflicts or contradictions during a distance learning course, supports this ambivalence, reporting that 56.8% of them affirmed that museum education can be implemented with distance learning courses.

In the overall assessment, we found the following:

1. Strong engagement, which peaked from the middle of the game towards the finale. However, some students commented that the teams should be smaller for better communication.
2. The development of a strong team spirit and division of labour among students (note-taking, species observation, navigation in the castle, dialectics).
3. Scientific inquiry related to the qualitative properties of marble.

Furthermore, the data from the questionnaire showed that 91.5% of the respondents answered positively concerning the level of contact with marble as a material and the knowledge acquired (Fig. 8).

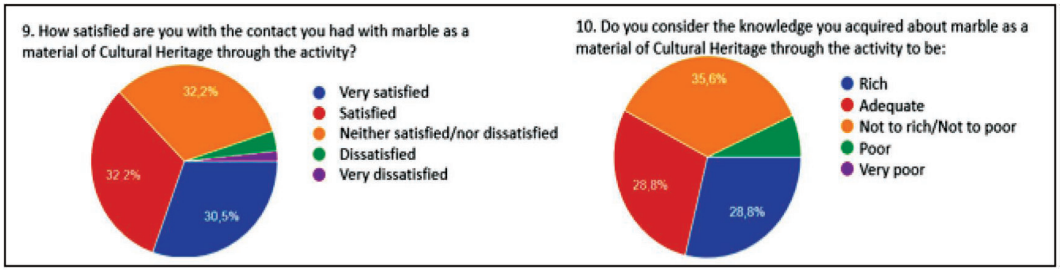

Figure 8. Results on the level of contact and knowledge acquired through the activity

There also seems to have been a good integration of science, culture and the environment, since the thematic analysis of the qualitative data in both the written notes and the videos showed that the frequency of the use of words coded under each of the above themes was almost the same. In addition, the questions we received at the end of the activity were also balanced across the three themes. Finally, 91.5% of respondents agreed that science, culture and the environment were treated fairly in MSM (Fig. 9).

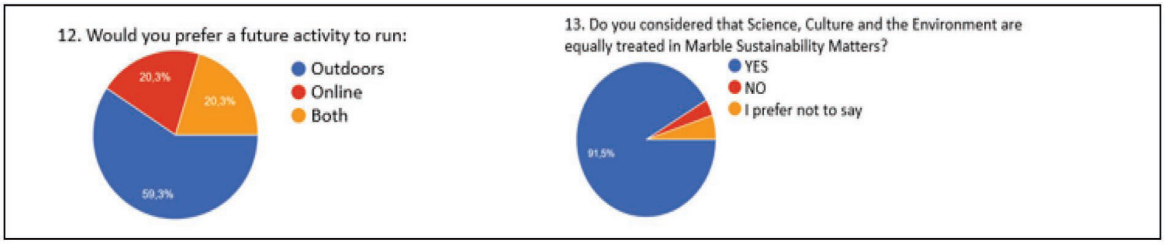

Figure 9. Results on the type of activity and the balance of science, culture and the environment across MSM

Conclusions

Overall, the first results of our empirical study confirm the need to carry on with the evaluation of the MSM programme and further explore different facets of the proposed scheme. Although our mixed methods approach provided us with positive feedback from the participants concerning the balanced integration of science, culture and the

environment, and the structural components and educational objectives of the programme, answering our research questions, we acknowledge that further testing with a larger sample is required. The limitations also include: i) the lack of autonomy of the programme, as it relies on existing mobile applications and QR codes; and ii) the need for a better connection with theoretical frameworks and theories, such as activity theory, connectivism (Goldie, 2016), material engagement theory (Malafouris, 2018), and modern scientific research concepts, such as citizen science for enhancing citizenship and facilitating engaging and sustainable tourism. Consequently, we acknowledge that MSM is still in its infancy, and seeks meaningful orientation to meet the needs of modern society. On the other hand, a didactic transformation in teaching the science of marble as a cultural heritage material has been achieved through a multidisciplinary scheme that delivers a holistic educational approach in a physical context applying mobile learning. Clearly, there are no special requirements for MSM to be used by educators and even organisations in the tourism industry in different regions as a cost-effective toolkit for Geocaching, iNaturalist, QR codes and narratives. However, a narrative that depends on content creation should be carefully considered, as the content must be based on existing artefacts, descriptions and remains (Doukianou *et al.*, 2020).

Finally, this is only the first of a series of steps in an expansive design that seeks to take place in tandem with other departments at the University of Ioannina, local authorities and relevant organisations (municipalities, museums, tour operators, educators), producing an innovative science education tool, and ideally a citizen science project.

Recommendations and future steps

Our next step will be to contact scientists in the Department of Physics at the University of Ioannina to gain access to the database they have been creating over the last few years, and ask them to assist in setting up an experimental laboratory on site, if possible, with the permission of the Ephorate of Byzantine Antiquities, or alternatively a virtual simulation.

On receipt of the scientific organology, we plan to include two separate activities using: i) virtual reality; and ii) solar boat tours around the lake. In fact, we may also take inspiration from the augmented reality application Oracle of Delphi (Ekonomou, Vosinakis, 2018).

In this sense, the Framework to Heritage Education could be used in the development of a future application that enhances the learning experience mediated by ICT. Thus, it is expected that the appropriation phase of the tourism product will involve enriching the experience by immersing the user in a technologically stimulating environment, e.g. a virtual laboratory as a complementary task to the overall mission, or the use of the solar boat to stimulate scientific inquiry about photovoltaics and aquatic ecosystems.

MSM was recently translated into English, and it will be available for Geocaching users by the end of the spring of 2022.

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SU MARMURU SUSIJUSIOS EDUKACINĖS PROGRAMOS KŪRIMO ASPEKTAI

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Santrauka

Straipsnyje pristatomas pirmasis autorių bandymas sukurti novatorišką mokymosi aplinką, kuri apimtų gamtos mokslus ir kultūros paveldą, tai leistų atitinkamai mokyti jaunimą. Siekiama apmąstyti metodologinį požiūrį ir atskleisti programos galimybes pritaikant mobiluįjį mokymąsi ir naujausias technologijas. Edukacijai, kartu ir tyrimui pasirinkta medžiaga – marmuras. Taigi norima per marmuro, kaip realios gamtinės medžiagos, pritaikomumą atskleisti, kaip gamtinės medžiagos panaudojamos kultūriniame pavelde realiame mieste. Atliekant tyrimą domėtasi, kaip tokia integracija galėtų sudominti potencialų vartotoją. Parengta mokymo programa apie marmurą, apimanti tiek gamtos, tiek kultūros paveldo aspektus, ji įdiegta ir mobiliojoje programėlėje, kuria naudodamiesi respondentai atsakinėjo į klausimus ir fiziškai aplankė nurodytus objektus, kur panaudotas marmuras. Šią programėlę išbandė 155 studentai ir vyresniųjų klasių mokiniai. Vėliau jie atsakė į anketos klausimus apie šios mokymo programos privalumus ir trūkumus. Nors šioje edukacijoje dalyvavo nedidelis dalyvių skaičius, gauti teigiami dalyvių atsiliepimai atskleidžia, kad tai yra tradicinių turizmo produktų alternatyva, kai pasakojami tik buvę istoriniai įvykiai. Tad skirtingų žinių ir informacijos susiejimas yra kur kas įdomesnis dalyviams ir gali būti taikomas įvairiose kultūros aplinkose, nors kuriant turinį daugiau dėmesio vis dėlto reikėtų skirti naratyvams. Straipsnio autoriai mano, kad būtina ir toliau plėtoti mobiliąsias programėles, kur būtų susieta tiek gamtinė, tiek kultūros paveldo informacija, analizuojant konkrečias gamtines medžiagas.

PAGRINDINIAI ŽODŽIAI: *mokslinis švietimas, mobiliosios programos, kultūros paveldas, biologinė įvairovė.*

JEL KLASIFIKACIJA: L8, L83.

Received: 2022-04-10
Revised: 2022-05-23
Accepted: 2022-06-15