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The laboratory didactics in the training-learning processes of sea sciences applied to cultural heritage and environment: the case of "An Ocean of Science" project

Michela Ricca[1], Loris Barbieri[2], Maria Pia Albanese[1], Fabio Bruno[2], Andrea Macchia[1], Mauro F. La Russa[1]

[1] *Department of Biology, Ecology and Earth Science (DiBEST), University of Calabria, Via Pietro Bucci, Cubo 12B II piano, 87036 Arcavacata di Rende, CS, Italy*
[2] *Department of Mechanical, Energy and Management Engineering (DIMEG), University of Calabria, Via Pietro Bucci Cubo 46C, 87036 Arcavacata di Rende, CS, Italy*
[3] *YOCOCU, Youth in Conservation of Cultural Heritage, Via T. Tasso 108, 00185 Rome, Italy*

ABSTRACT
The "An Ocean of Science" project encourages effective interventions and innovative educational paths to support the growth of knowledge and skills in schools, helping competent institutions to guarantee more inclusive cohesion policies with a high cultural and scientific impact. The project also provides innovation in education and training by providing cultural and socio-educational development opportunities in the framework of cultural heritage located in the marine environment and sea protection. The purpose of this study was to evaluate the effects and involvement of secondary school students during several educational laboratory activities, focusing on the development of their practical skills and training. With a view to active learning, which makes the students actors, responsible and aware of the learning process, this study shows an experimental work designed to demonstrate the usefulness and the validity of the scientific approach as the main pillar of the teaching of the sciences related to the marine issues, with special focus to submerged cultural heritage and sea pollution.

Section: RESEARCH PAPER

Keywords: Educational innovation; teaching/learning experiences; underwater cultural heritage; virtual reality; serious games

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Corresponding author: Michela Ricca, e-mail: michela.ricca@unical.it

1. INTRODUCTION

The protection of the underwater cultural heritage, as an integral part of the cultural heritage of Humanity, is exercised according to the same general principles envisaged for the underground archaeological/historical heritage. Archaeological and historical items from underwater sites are of great importance for the study of technologies, the origin and progressive evolution of past civilizations and for a better understanding of historical events [1]. These principles are reaffirmed and extended in a fundamental international legal instrument, the Convention for the Protection of Underwater Cultural Heritage (UCH), adopted in Paris on November 2, 2001, by the General Conference of the Member States of UNESCO [2], [3]. Shipwrecks, sunken cities, submerged settlements, and other artefacts represent irreplaceable historical resources that also constitute habitats for flora and fauna [4]-[7].

The underwater archaeological/historical sites are highly dynamic environments that are influenced by the entire marine system [1] and as such must be protected over time. In places with a long maritime history, such as the Mediterranean, they are particularly abundant [4]. For example, in Italy, there are over 30 marine protected areas and submerged parks for a total protection of 228 thousand hectares of sea.

The submerged historical and archaeological sites are of considerable interest for their natural, geomorphic, physical, and

biochemical characteristics and with particular regard to marine and coastal flora and fauna, as well as for their scientific, ecological, cultural, educational and economic importance. Being the umpteenth testimony of the vast culture that enriches our territory, the submerged heritage testifies to our cultural identity.

The poor degree of protection and attention to the treasures that lie in our seas, in addition to the well-known illegal trafficking activities, contribute to the environmental damage and, consequently, the protection of the submerged cultural heritage.

"An Ocean of Science" promotes the improvement of educational processes through innovative educational paths that aim to change the attitude of the younger generations towards significant areas of knowledge, increasing knowledge and skills.

The project is aimed at high school students with the aim of raising awareness of the enhancement and use of the finds and testimonies of the past culture that lie on the seabed and also to study the pollution of the seas, as one of the greatest threats to the marine ecosystem. The results will be aimed at increasing students' knowledge and awareness of their own cultural identity and at promoting the enhancement of the national submerged cultural heritage, also acquiring awareness of its environmental relevance [8].

An important section of the project was dedicated to raising awareness of the issue of pollution of the seas due to plastics [9]-[11] and, on a large scale, port discharges, oil and waste. Specifically, the younger generations were entertained through lectures and laboratory activities. Part of the experimentation carried out in the classroom was aimed at recognizing microplastic pollution, studying underwater finds and understanding the causes and effects of degradation in submerged contexts. The project activities included also the adoption of serious game technology because of its considerable potential for facilitating both informal and formal learning. In fact, intrinsic motivations, such as enjoyment or fun, produce deeper engagement and higher persistence in learning activities.

Innovative learning opportunities, oriented to scientific disciplines and research themes functional to the Conservation and Enhancement of the Historical-Archaeological Heritage preserved on the seabed and to the Environmental Protection of the Seas, were at the centre of the didactic-laboratory activities.

Furthermore, these activities were made even more interactive thanks to the adoption of a Serious Game (SG), specifically developed for this project, that allows to raise awareness and encourage learning in a playful manner. Students will challenge their ideas and attitudes within the scientific-cultural context analysed.

2. LABORATORY ACTIVITIES: ARTEFACTS AND MICROPLASTICS FROM SEAWATER

During the laboratory activities carried out at school, the students learned about what submerged finds look like and what issues afflict our seas. Specifically, three didactic-laboratory experiences were performed at the school facilities involved in the project. In particular, during the course of the first two activities, students learned and experimented the use of diagnostic and sampling tools and the procedures required for the treatment of ceramic and metallic remains and the detection of microplastics in seawater. Whereas the third activity focused on the adoption of Virtual Reality technologies and educational games in order to engage and motivate students, as well as provide a unique and immersive learning experience.

2.1. Diagnosis and sampling tools and procedures

The first activity, i.e. "treasures in the sea", was supported by the use of microscopic tools capable of recognizing the surface morphology of the samples and the damage forms affecting the archaeological/historical items coming from the sea, mainly due to marine flora and fauna. (Figure 1 to Figure 3).

Under the portable microscope (Dino-Lite), the students analysed fragments of ancient altered limestone colonized by microorganisms (Figure 1 and Figure 3) and metal finds (e.g. bullet, rifle plate) dating back to the First World War, whose state of decay was clearly detectable by metal corrosion processes (Figure 2).

The practical activities were joined by didactic ones, illustrating the causes for which materials suffer alteration processes in contact with seawater. This first approach to Underwater Cultural Heritage has led to greater awareness among students who have acquired knowledge of the treasures hidden in our seas and the importance of their protection and conservation.

The activity made it possible to ascertain that, despite the great attention paid to the subject, widespread knowledge among the younger generations still missing.

The second laboratory activity, called "a sea of plastic", was dedicated to raising awareness of the pollution of the seas due to plastic, in particular microplastics smaller than a millimeter. Students became aware that plastic released into the sea can have land or marine-based origins as well as a strong dependence on human activities (i.e. products reaching the sea through waste

Figure 1. "Treasures in the sea" laboratory - Ancient stones from underwater site [8].

Figure 2. "Treasures in the sea" laboratory - Ancient metals from underwater site [8].

Figure 3. "Treasures in the sea" laboratory - Ancient stones from underwater site [8].

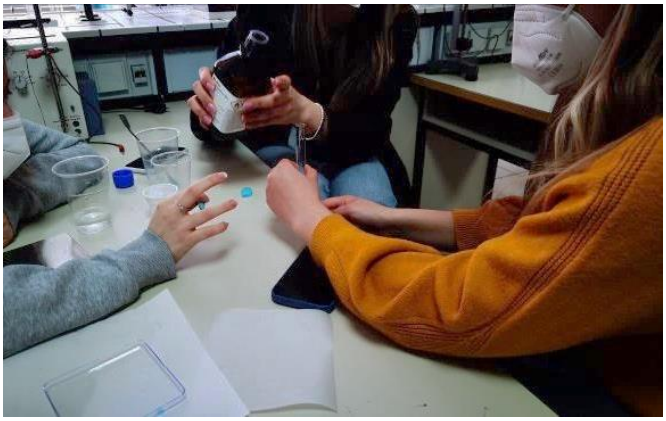

Figure 4. "A sea of plastic" laboratory [8].

Figure 5. "A sea of plastic" laboratory [8].

treatment, nylon nets used for fishing) [9]-[11] and due to different physical mechanisms of transport (currents, tides, etc.) plastics are widespread in all marine environments. Through some experiments, the students were able to evaluate how plastics are generated, how their composition varies and how slow their disposal processes are. For example, in Figure 4 to Figure 6 using sodium polyacrylate (i.e. synthetic polymer) in contact with water, it was possible to observe how it develops rapidly and increases in volume. This process is the same as in baby diapers and is also used in the world of cinema for the creation of fake snow, even if it is very polluting. Then, with a portable Raman spectrometer (Figure 7), the scholars observed,

Figure 6. "A sea of plastic" laboratory [8].

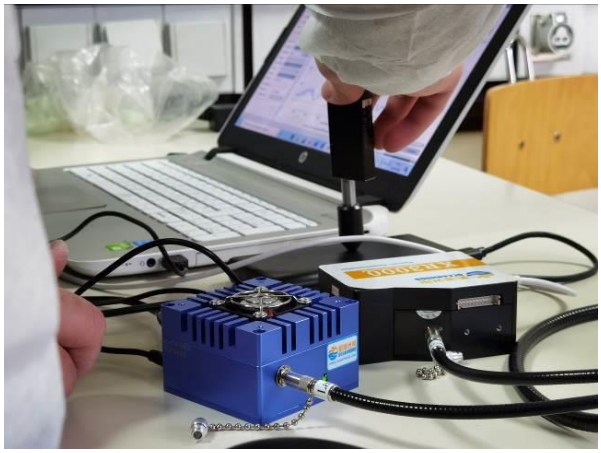

Figure 7. "A sea of plastic" laboratory [8]

the different nature of plastic materials, i.e. the polymers of which they were composed. Further evidence is shown in Figure 4 and Figure 5 where the scholars conducted an experiment, simulating the accelerated degradation of plastic and the relative disposal times, in real time, evaluating its effective degradability.

2.2. VR technologies

In the third activity, called "Virtual Exploration of Underwater Archaeological Sites", students were informed about modern technologies and methods employed for the development of virtual 3D reconstructions of underwater environments. The laboratory activities consisted of an immersive virtual experience set within an underwater archaeological site. In particular, the immersive experience was based on HMD (head-mounted display) technology for the visualization of both 3D data and learning contents and a controller for the interaction (Figure 8). In particular, the HMD device isolates the user from the distractions of the actual physical environment and encompasses the entire field of view, including the peripheral space. The user navigates in the virtual environment by moving his/her head and interacting with a single wireless handheld controller.

The adoption of VR technologies allows to provide a learning and educative experience in a playful manner [12]-[16]. VR, in fact, can simulate real-world scenarios that would be difficult or impossible to experience in real life, such as the UCH which, in most cases, is not easily accessible by humans due to a number of limitations imposed by the underwater environment. Usually, only expert tourists, with a proper diving license, can overcome the difficulties imposed by the environment and depth and eventually enjoy the submerged cultural treasures.

Figure 8. Students wear HMDs for the virtual exploration of a submerged environment.

Students, in fact, had the opportunity to simulate a realistic diving experience, in the virtual reconstruction of a submerged shipwreck site, through the use of modern technologies popular in the gaming field. Nevertheless, the recreational activity is coupled with the educational one, as the interactive content of the virtual scenario allows students to learn archaeological, historical and biological information about the specific site.

2.3. Serious game

Intrinsic motivations, such as enjoyment or fun, produce deeper engagement and higher persistence in learning activities [17]. This would explain the successful adoption of games for educational purposes, i.e. serious games, in several domains such as education and social impact [18]. These educational games, in fact, can be used to raise awareness about social and environmental issues and to teach subjects and skills related, for example, to the cultural heritage [19]-[23]. In all these cases SGs use game technology to create entertaining and cultural learning experiences. Both these characteristics can coexist without conflicting, because the entertainment factor engages the public to participate, but their understanding of what they have learnt could take place after the experience [24].

Because of these considerations, creative educational practices mediated by the use of learning games were implemented during the laboratory activities. In fact, students were instructed to use the Serious Game “Ocean Champion” specifically developed for the project, that allows to infuse instruction into the game play experience. In fact, the player's goal is to protect and clean up an area of sea through the detection and removal of different types of plastic waste (Figure 9) present both on the surface and in the depths.

The goal of the game is to collect as much plastic litter as possible in a predetermined amount of time. The greater the amount of waste collected, the higher the score. Each type of plastic waste is also associated with an informative card (Figure 10) through which the player acquires specific information and, at the same time, increases his/her personal score. This information concerns the type and composition of marine waste and how to properly dispose of it.

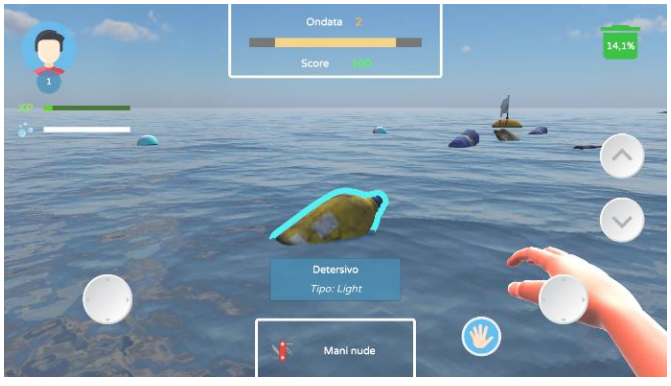

Figure 9. Serious Game - collection of plastic waste found in the sea.

Figure 10. Serious Game - informative card by waste type [8].

In addition, to make this SG as widely spread as possible, its download is free of charge [25].

3. FINAL REMARKS

The awareness of the treasures hidden in our seas and of the problems linked to pollution was at the center of the "An Ocean of Science" project (CUP H23D21002060001). The experimental research was implemented in various secondary schools and its purpose was to test the potential of a teaching laboratory approach based on the scientific method, in the teaching of marine sciences, focusing on underwater cultural heritage, their methods of conservation and fruition, and on the topic of sea pollution. Students in the role of scientists have learned, as protagonists, the importance of our seas, not only as places of hidden treasures but also as places threatened by human actions, encouraging awareness of their cultural identity.

During the laboratory activities, various theoretical phases were carried out always followed by a practical approach where students were supported in the use of scientific instruments. Direct observation and use of scientific tools reinforced the concepts theoretically exposed, confirming the high didactic potential of an integrated and practical approach.

At the end of the laboratory activities, it was elaborated a questionnaire to be administered to all the students involved in the experiment, to detect their satisfaction rate and their understanding. The questionnaire was constituted of 11 questions specifically thought to have a general view on the covered topic, on the utilized methodologies and on future insights and studies. Through this survey, it was possible to verify the full satisfaction on the part of students in the activities carried out and their interest in sea-themed disciplines (100 %). Furthermore, 60 % of the students declared that the experience and topics covered were useful for choosing more consciously their future university career and that among the various topics analysed, the one that most attracts their interest concerns the pollution of the seas (40 %).

In conclusion, the laboratory teaching and the scientific instruments used in the "An ocean of science" project at various secondary schools have demonstrated their importance for the transferability of knowledge and for meaningful learning in marine science issues, with particular attention to underwater cultural heritage and the marine environment.

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