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# Promoting Sustainable Behavior Using Serious Games: SeAdventure for Ocean Literacy

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**ABSTRACT** In the environmental sector, in recent years, policies and governance of marine issues have seen greater enhancement of participatory and community-based processes (for example the Blue Growth Actions of the Interreg Med Program of the European Union). The greater involvement of citizens in the processes and policies of the sea can greatly benefit the survival of the marine environment and support reforms, since most environmental problems are caused by human behavior. Changes in individual behaviors are desirable to ensure sustainable use of the ocean and its resources. These changes are possible only if there is an improvement in people's knowledge and awareness since the childhood. Ocean literacy interventions will allow people to understand their responsibilities towards the oceans and their health. For this reason, it is necessary to promote sustainable behavior changes using new educational approaches that can be effective with young pupils. The research presents a serious game and an explainer video, used in order to introduce the problem of marine litter, one of the main dangers for the marine species. The aim of the serious game was to enhance ocean literacy with a particular attention to the biodiversity of the Apulian and Mediterranean sea to raise children's awareness of the issue of caring for life in the sea. The measure of learning effectiveness confirmed that the knowledge gained can be actually acquired by children using new technologies, in general, and serious games in particular.

**INDEX TERMS** Educational technology, multimedia systems, serious games, STEM.

## I. INTRODUCTION AND MOTIVATION

The United Nations Decade for Education for Sustainable Development (DESS) was characterized by a large number of initiatives addressed both to promote debate (among politicians, teachers, educators, etc.) and to act in defence of the environment and sustainable development, both in the educational and extra-curricular contexts. The final aims were to innovate the curricula and to encourage the development of skills useful for living in our complex world [1].

Despite the high number of educational paths and initiatives, as well as the wide research tradition involving various disciplines in this field, education for sustainable development struggles to emerge. Sustainability is not a new topic to be included in curricula, it is rather a lifestyle that allows people “to think about and work towards a better world,

now and in the future, for ourselves and for others, here and elsewhere on the planet” [2].

As a matter of fact, education for sustainable development aims at providing necessary tools to students which should take active role in the growth of the current society. It is an expression of citizenship process that does not remain anchored to the places lived, but which opens up to the global dimension and which goes beyond the temporal dimension of the present to take on meaning in the future as well.

Education for sustainable development accompanies all ages of life and it is a *conditio sine qua non* for quality education (Sustainable Development Goal No. 4 - <https://sdgs.un.org/goals>), as it allows citizens to make informed decisions and take responsible actions to preserve environmental integrity, economic profitability and a fair society, whilst respecting cultural diversity [3].

Sustainability is an evolving issue, which requires continuous changes in individual and collective policies, actions and behaviors. As highlighted during the DESS and confirmed in

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the 2030 Agenda, education is the basic instrument to build sustainable development. Education provides the resources to evaluate consequences that personal behaviors can cause on the environment or people, in time and space.

Education for sustainable development means educating to tackle and understand the complex interconnections that shape the real world by taking an interdisciplinary and trans-disciplinary perspective. This perspective requires us to adopt new knowledge approaches different from those used so far that have made us focus on individual disciplines and sectors, without paying attention to the relationships between them [4]. Therefore, new ways of thinking and learning are required to let the society moves towards a truly sustainable development [5]. This awareness concerns also the oceans and the sea that have a decisive importance for the life and survival of our planet, but to which the world of education does not devote the necessary attention.

The oceans cover 71% of the earth's surface and they contain about 97% of the planet waters. Ocean protection and health are fundamental for the survival of the life on our planet. The oceans supply food and oxygen, regulates climate and weather conditions, absorb about 40% of the carbon dioxide emitted into the atmosphere [6]. Human activities are seriously compromising the survival of the oceans [7]. There are eight million tons of plastic waste that end up in the oceans every year. The Mediterranean Sea is one of the most critical realities from this point of view: it has the highest concentration of microplastics per square kilometers in the world.

The problems of the ocean are multidimensional and involve everyone: we need scientific support, but we should also adopt behaviours that can guarantee the survival of the oceans. Science alone is not enough, bringing people closer to the sea, its ecological aspects, its culture and its values is very urgent today [8].

Therefore, there is an urgent need to provide technical, social, cognitive, scientific and citizenship skills to a large part of the population, enhancing the link between students and sea can guarantee the overcoming of "oceanic blindness" [9]. For this reason, activating Ocean Literacy projects is very important to encourage changes in humans' behavior and greater democratic participation in the identification of problems and solutions related to the sea and the many species that inhabit it. To bring out an awareness of marine environment, educational processes should involve individuals since childhood. Research studies in pedagogy field have discussed how to design effective educational paths [10], in some cases have outlined new models to support environmental education, for example, the Outdoor Education [11] has influenced Italian environmental education practices. This approach considers the nature as an educational context that offers the opportunity to enhance respect of environment and to express and increase emotional, social, expressive, creative, and sensorimotor skills [12]. However, experiences in natural context are not often possible due to economic reasons or distances. In addition, some kinds of environments, such as the ocean,

are difficult to visit or to reach. Thus the new technologies and the virtual environments can help to overcome these limits.

In this view, a multimedia educational path, composed of an explainer video and a serious game, has been designed and developed. The explainer video, entitled "A plastic ocean", aimed at introducing the marine litter problem and to make people aware how harmful it is to the marine environment. The serious game, named SeAdventure [13], [14], aimed at fostering the theme of sea protection through the promotion of behavior able to reduce the spread of marine litter. The multimedia as well as the video game have been used to enhance motivation and engagement in young children. Hence, the game-based learning approach has been largely proved to be effective in acquiring new knowledge and skills.

The remainder of the paper is organized as follows. In Section 2 game-based learning approach is introduced in order to highlight how it can enrich environmental education. Section 3 describes the state of the art of new technologies to support sustainable education. In Section 4 the multimedia path is described in detail. Section 5 describes the pilot study and the experiment aimed at evaluating the learning effectiveness of the game and the users' perceived usability; the outcomes are discussed in Section 6. Concluding remarks and future directions are outlined in Section 7.

## II. GAME-BASED LEARNING APPROACH

A large part of environmental problems is caused by human behaviour. This is guided by values, points of view, attitudes, life prospects [15]. These values start to develop already from early childhood, when the predisposition to behavior change is stronger [16]. This is one of the reasons why education for sustainable development primarily targets school students.

Thus, currently educators build educational pathways for sustainable development by relying on the direct and concrete learners' experiences [17], since effective sustainable educational paths must simultaneously pursue cognitive, socio-emotional and behavioral objectives [18]. This is even truer the more we consider that the sea is often perceived as a faraway and unusual environment. Experiencing the sea could potentially increase motivation for students learning. Unfortunately, distances and high costs are often considered obstacles to the direct experience of sea. These limits can be overcome using technologies, such as serious games, virtual reality, augmented reality, and so forth can help students to better know the sea and life in it [19]. The idea of using games to engage students in the learning process is not new [20]. Game-based learning takes advantage of the motivational effect that play can have in capturing students' attention. An increasing number of empirical data support the theory that games and simulations can promote and improve knowledge in a wide variety of educational contexts [21].

One of the most used tools of educational technologies used are the Serious Games, namely simulations of real-world or processes designed to solve a problem, especially for educational purposes. Thus, the game is designed

and implemented not for entertainment purposes [22] but to promote knowledge and skills acquisition [23].

In particular, in the field of environmental education serious games can support educational processes to face complexity, “requiring players to deal with ill-structured problems, unpredictability, emerging systemic properties and behaviors, and non-linear development of events” [24]. In digital games, players receive immediate feedback about the consequences of their actions. In addition, serious games are useful for educating to sustainable development thanks to their ability to motivate and engage players on both emotional and cognitive levels. If they are designed with attention to the complexities of the environmental phenomena that they simulate, serious games can facilitate the understanding of the systemic processes that shape sustainability.

The paper aims at measuring the evaluation of effectiveness and usability of a multimedia educational path, composed of a serious game and an explainer video, addressed to primary school pupils. The aim is to encourage the acquisition of knowledge about the marine life using an active learning approach.

### III. BACKGROUND: EDUCATIONAL TECHNOLOGIES TO IMPROVE SUSTAINABLE EDUCATION

Currently a large number of experimental evidences have proved that technology enhances learning and teaching practices [25], [26]. Different approaches and solutions have been applied in many contexts, such as social robots [27], augmented reality [28], recommender system [29], even applied in different real context of use, such as empowerment [30], special education [31] traditional learning [32], just to cite some.

In the context of environmental education, different approaches have been used successfully. In [33], for example, a list of 77 Serious Games have been found in the literature, each of them is focused on a particular aspect of sustainability, such as energy conservation, water management, Eco innovation, and so forth. In the context of ocean literacy, it is interesting the project ResponSEable [34], which proposes an interactive game for children and adults to facilitate the understanding of the complex system of relations between human activities and the sea. The aim of the game is to conquer all the stages of the game by solving the quizzes presented in the five key stories (Microplastics, Eutrophication, Sustainable Fishing, Ballast Water, Coastal Tourism).

Even social robots have been used in order to support sustainability education, in [35] an empathic robotic tutor for school classrooms was defined to support collaborative activities in a collaborative multiplayer serious game for learning sustainability. In [36] a social robot plays the role of an opponent in a game to teach children how to recycle waste materials correctly. The results of an experiments confirm that robots can help to acquire the right recycling attitude.

In order to improve the student’s learning experience, some researches apply the augmented reality (AR) and virtual reality, in [37] for example, physical and virtual

environments have been integrated to encourage students to acquire Taiwan’s marine ecology and water resources. Also in [38] the effectiveness of an AR case study for increasing teaching and learning in the specific field of marine ecology education is presented. The study reveals that both the AR and VR applications had positive effects on the flow experience and therefore learning has been improved.

Following this trend, our research proposes to apply the multimedia technology to the sustainable education. Our planet needs children to grow up with a sensitivity towards the environment that adults have not had so far. For this reason, it is essential to promote the acquisition of knowledge about the environment in order to stimulate a radical change in human behavior since childhood.

The main contribution of the present research is the use a low-cost solution that can be adopted easily in traditional school context. As a matter of fact, both the video and the game can be viewed using a web browser, this is important for teachers who do not need any specific hardware or technical competences, as required by social robots or AR and VR. Moreover, a significant number of serious games proposed in [33] are board games that are able to attract pupils, but the technology allows to use dynamic effects that can impress them more. From the content point of view, differently to other solutions in the literature that focus on right human behaviors, the proposed solution provides some information about scientific aspects of the marine species, this is important both to improve children’s scientific knowledge and to encourage children to preserve the marine world and life in it.

### IV. THE EDUCATIONAL PATH: THE EXPLAINER VIDEO AND THE SERIOUS GAME

The main objective of our educational solutions was to promote a change in children’s behaviors by leveraging the emotion experienced both in the video and in the game. The explainer video uses the motion graphic to introduce the problem of marine litter, whereas the serious game is used to transfer information about the most common species in the Mediterranean Sea.

The marine litter, as defined in [39], [40], are any persistent, manufactured or processed solid material discarded, abandoned or lost into the sea or on beaches. The most common waste are plastic, rubber, paper, metal, wood, glass, and cloth resulting from human maritime activities. The majority of reported litter-related incidents of individual marine species are related to plastic items [40], micro- and macroplastic, that can be eaten, or which can cause suffocation of animals. To make children aware of the need to preserve the environment, it is also essential that they become familiar with marine environment and the species living in it. Thus, the serious game presents the most interesting species for the primary school kids living in the Italian seas: red tuna, great white shark, Turtle (*Caretta caretta*) and the hippocampus. For each species, the information supplied were habitat, diet, lifestyle and dangers.

The educational path is addressed to primary school children aged between 8 to 10 years old, hence the language, graphic, and interaction were accurately defined to meet users' needs and characteristics.

### A. A PLASTIC SEA: THE EXPLAINER VIDEO

An Explainer Video is a short-animated video, usually 1 to 3 minutes long, which explains a concept in a simple and engaging way. The main characteristics of such a video are a clear and concise language, appealing and attractive visuals that quickly grab the viewer's attention. The title is A Plastic Sea, its basic idea is to introduce the marine litter problem to children, to let them know what marine litter is and the consequences that can have both for human and marine life.

To make it attractive for pupils, it has been realized using a cartoon style (Figure 1) and to maximize the effectiveness of the message transmission, it lasts less than 3 minutes. The content, in terms of images, animations and words, has been carefully defined in order to facilitate the transfer of main knowledge in such a short time.

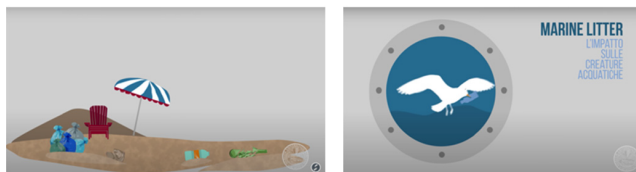


FIGURE 1. Some scenes from the Explainer Video explaining the marine litter problem.

### B. SeAdventure: THE SERIOUS GAME

To complete the knowledge transfer and to produce effects on children's behavior a serious game has been developed. SeAdventure [13], [14] is a platform game in which the player, using an avatar, swims through waste lost in the sea (Fig. 2). As said before, to allow the users to acquire knowledge about the environment they are living in, the game set is the Mediterranean Sea and the characters are the four species which currently would be at risk of extinction and the most interesting species for the children aged between 8-10. The four species are: red tuna, great white shark, turtle (Caretta Caretta) and the hippocampus.

The mechanics of the game have been defined in order to pushing the user to collect fishes rather than waste. The idea is to make the user aware of the difficulty that fishes have in avoiding all the rubbish disseminated into the sea. This concept should foster sustainable behaviour, since the children should learn that the conscious collection of waste avoids the dispersion of waste into the sea. Of course, the problem of marine litter is not only due to the direct actions of children, but the final aim of the education process is that they will grow-up becoming adults who take care of the health of our planet. Moreover, in order to support the acquisition of knowledge on Mediterranean species, for each character are spread during the game some knowledge pills about character's habitat, diet, lifestyle and dangers (Fig. 2).



FIGURE 2. Two different scenes of the game: in the first one the turtle Caretta Caretta is being guided by the player, in the second some information about this specific species of turtle is given.

The mission of the player is to help the character to swim and reach the final point avoiding junk and eating fish. The player collects healthy points if the avatar eats fish, and unhealthy points when it eats junk. In addition, to emphasize that trash is bad for the fish, the character swims more slowly for few seconds and when it eats too much trash the player loses a life in the game. The leader board is built using both healthy and unhealthy points. The score is calculated as the algebraic sum of healthy and unhealthy points collected in the game. Since in our experience in the field of educational games [41]–[43] when player is engaged by the gameplay, s/he usually skips everything that is not useful to accumulate points, SeAdventure proposes at the end of each level some quizzes to improve the player's score. Questions are related to the information scattered in the game, this pushes the user to stop the game and read carefully the information about the character.

### V. EVALUATION OF THE EDUCATIONAL PATH

Game design is a complex process that requires the involvement of different professionals, educational game design adds different other dimensions that should be carefully considered: learning objectives, domain content information, motivation, learning methodologies, and so on [44]. For this reason a software prototyping approach to develop the game was adopted. The model allows to understand customer requirements at an early stage of development, requires feedbacks from the users and helps software designers and developers to understand about what exactly is expected from the product under development. In educational software production process usability testing together with rapid prototyping will reduce the software development cycle and at the same time will increase effectiveness [45]. Following this approach, a first version of the serious game was submitted to a pilot study to measure the usability of the serious game SeAdventure, preliminary results were presented in [13], [14]. A further study was conducted in order to evaluate the users' perceived usability and learning effectiveness of the whole educational path, namely the serious game and the explainer video. Both evaluations are described in the following sections.

#### A. THE PILOT STUDY

A total of 46 pupils of two classes of the 4th grade of the 14° Didactic Circle "Re David" primary school in Bari (Italy)

were involved in the study. The goal of this first pilot study was to evaluate the pupil's perceived usability of the serious game and to collect feedbacks on specific aspects of the game, namely graphics, content, language and interaction.

### 1) PROCEDURE

Initially, was introduced the problem of marine litter and its effects on the environment using the Explainer Video, then a brainstorming with teachers was conducted to raise children's awareness on these issues. The step lasted about 20 minutes. Then children used the game for 1 hour, in the school laboratory, which was equipped with 12 PC. To get all pupils to use the game, they were divided into small groups of 2 pupils each. In each group, the pupils took turns using the game, so all 46 pupils had the chance to use the game. At the end of interaction, a questionnaire composed of 15 was administered to all pupils to investigate the pupil's perceived usefulness and satisfaction and to collect feedbacks on aesthetics. The items, through a 5- points Likert scale, were defined by the authors, starting from the standard questionnaire QUIS [46], to adapt it to children.

### 2) RESULTS

During the game session, a researcher acted as a facilitator to observe the children and to track the effectiveness and efficiency of the game [47]. The direct observation during the pilot test revealed that children used the game without any inconvenience. The help visualized in the first page of the game was useful to understand how to play and no further suggestions were required.

The analysis of the data revealed that the majority of students have appreciated the game, all users stated that the game was easy to use, the functions of the buttons were clear, and that the game was funny (Fig. 3).

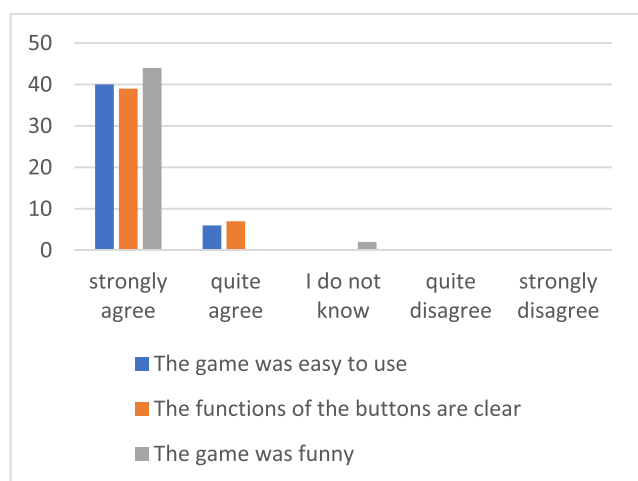


FIGURE 3. Users' appreciation of the game.

In the usability questionnaire some questions related to the complexity of text information were added, since the knowledge pills are one of the most important features of the

game, it was important to investigate the user's acceptance. Concerning to the length of texts only 8 out 46 children said that the texts in the game were too long, 38 of them declared that the texts were suitable to their reading skills. The majority of the sample, 40 pupils, said they paid attention to the knowledge pills during the game and almost the whole sample (45) think they will remember what they learned.

The whole sample (46) stated that they acquired new knowledge thanks to the serious game and the explainer video. Finally, 45 students believed that the game would be an effective learning tool to acquire new knowledge.

The first evaluation of the educational path, but in particular of the serious game, was successfully in terms of users' appreciation. Both the pupils and the teachers were enthusiastic of this new approach used and some pupils would have liked to use this approach in their daily lessons.

### B. EXPERIMENTAL STUDY

For the further investigation the same procedure of the pilot test was used. The goal of the experiment was to measure the effectiveness of the game-based approach to learning. The experimental hypothesis was "Could the serious game and explainer video promote acquisition of knowledge about sustainable behaviour and help children to change the way they act and think about it?".

#### 1) PARTICIPANTS AND DESIGN

The study involved 50 pupils (20 boys, 30 girls) of two classes of the 4rd grade of a primary school in Andria, a city near Bari (south of Italy). The data collection took place in the 2017 and a retention test was submitted to same classes in 2018. A single group, pre-test post-test study was performed, with the learning as an independent variable.

#### 2) PROCEDURE

Initially, all students underwent a pre-test consisting of 19 questions related to both sustainable behaviors and habits of Mediterranean species, namely the content of knowledge pills in the serious game. Participants had about 45 minutes to answer the questions independently. The tests were anonymous. Then, as in the pilot test, pupils were introduced to the marine litter topic using the Explainer video (Fig. 4), and then the teacher, together with an expert in environmental education Gabriella Calvano, conducted a brainstorming to let the pupils reflect about the problem of waste in the sea and how to adopt sustainable behaviors. Afterwards the game was introduced, and the actual experimental phase started. Like in the pilot test, the pupils were divided into couples and they played the SeAdventure game in the laboratory of the school for 1 hour. Each pupil has the opportunity to interact with the game.

The next day, pupils were asked to answer to a post test, that contains the same items of the pre-test. The idea was to measure if the game allows to improve the knowledge about marine species. In this view, to measure if the knowledge was actually acquired by pupils, a retention test was performed the

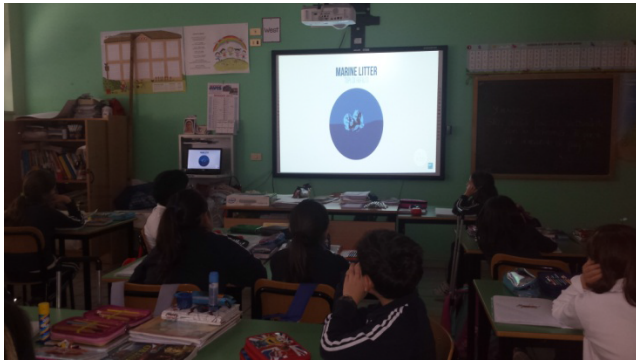


FIGURE 4. Pupils watching the explainer video.

next year to the same classes and pupils. In addition, the same usability test used in the pilot study was submitted to the pupils, in order to collect feedbacks about the aesthetics and the perceived ease of use of the game. Also some questions addressed to evaluate the user’s perceived usefulness of the content supplied by the serious game were submitted.

VI. RESULTS AND DISCUSSION

As in the pilot study a facilitator observed the children to monitor users during game session. No difficulties were reported during the gameplay, hence the game was perceived as easy to use.

A. LEARNING EFFECTIVENESS

One of the aims of the experiment was to measure whether users increase their knowledge about marine species, and they become aware of the impact that marine pollution can cause.

TABLE 1. Average number of wrong answers and learning gain.

	PRE-TEST	POST-TEST	RETENTION TEST
MEAN	6.28	3.12	2.16
LEARNING GAIN		3.16	4.12

The analysis of data (Table 1) shows that the average number of wrong answers in the post-test is overall lower than in the pre-test. The learning gain is 3.16 in post-test and 4.12 in retention test. This demonstrates that the use of the SeAdventure game is useful to acquire new knowledge. It is important to underline that between the post-test and retention test pupils did not have access to the game or to the content knowledge. Some questions were focused on bringing out reflections on the value of caring for the environment. It was interesting that for questions such as “Plastic bags and other rubbish can kill marine animals both because the animals can eat the plastic and because they can get trapped in it?” and “The waste we throw on the beach stays there, without ending up in the sea?” all pupils in the post-test gave correct answers, whereas in the pre-test some of them (10%)

thought that plastic and beach waste were not a problem for the sea and its inhabitants. This knowledge of course was confirmed the next year in the retention test. During the discussion after the retention test, the teachers asked to pupils if they change the way they act. All children were proud of the fact that they had carefully collected the rubbish on the beach during the summer to prevent it from ending up in the sea.

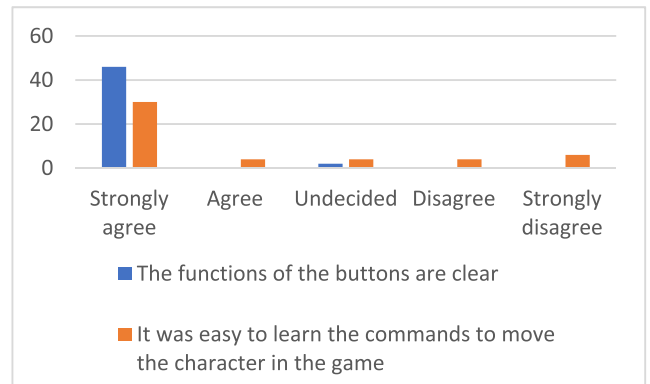


FIGURE 5. Answers to questions “The functions of the buttons are clear” and “It was easy to learn commands to move the character in the game.”

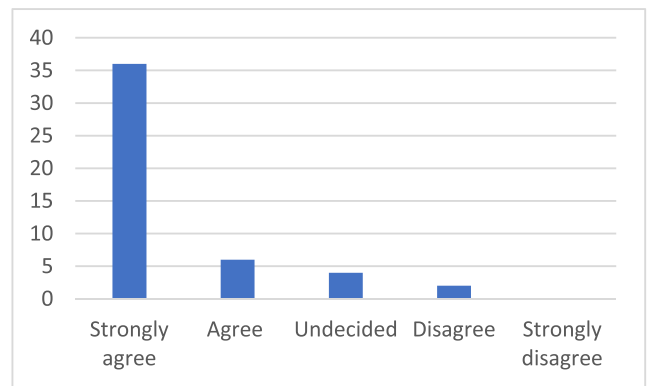


FIGURE 6. Answers to the question “I liked the colors, images and sounds in the game.”

B. USER’S PERCEIVED USABILITY

Since the development of a game is a process in continuous evolution and the perceived usability is subjective, even in the experiment, after the use of the game the usability test was administered. The majority of pupils (48 out 50) stated that the game is easy to use. The learnability of the game was quite high, 40 pupils stated that was easy to learn the commands to move the character (Fig. 5), while 10 students have some difficulties to learn the commands to move the character in the game. To move the avatar probably was not easy since younger generations have some difficulties in using the keyboard, indeed they usually prefer touchscreen. But this trait should be better investigated. All pupils said they enjoyed playing the game. For the aesthetic aspects 42 users appreciated the colours, images and sounds of the game (Fig. 6). For what concerning the questions related to

the complexity of text information the answers confirm that the text are readable, comprehensible and interesting (Fig. 7).

Finally, some questions addressed to elicit users' thoughts about the usefulness of the game were posed. Data are very promising, indeed 44 out 50 users believed that they have increased their knowledge about marine species and pollution by using the game, and 48 users stated that the game was useful to learn new information.

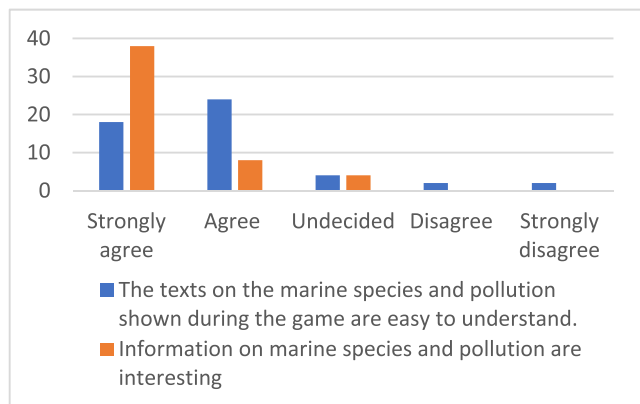


FIGURE 7. Answers to questions to measure the readability, comprehensibility and interest of texts in the game.

The only measure that seems to be in contrast to the trend is the one related to the length of the texts: 22 out 50 stated that the text were too long, and 18 were undecided (Fig. 8). This could be explained in different ways: the text interrupt the game disturbing the children's game experience or the texts are too full of knowledge that require too much attention by the children. This aspect should be further investigated.

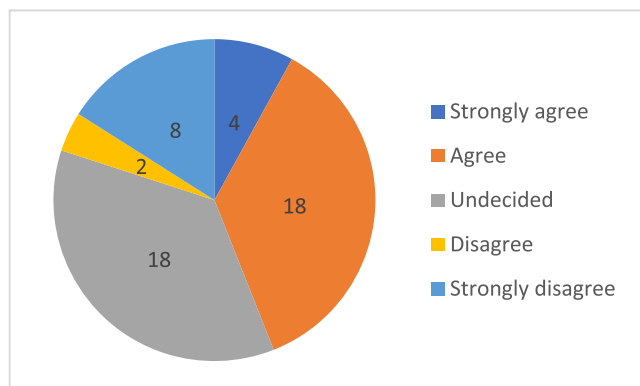


FIGURE 8. Answers to question "The texts on marine species are too long."

### VII. CONCLUSION AND FUTURE WORKS

Currently, environmental education and education for sustainability are achieving a strong international impact. Also national government are paying greater attention to education for environment, the Italian Ministry of Education in 2017, as an example, has published the National Development Education Plan for Sustainability and has introduced teaching of

civic education (Law no. 92/ 2019) in accordance with the United Nations Decade of Education for Sustainable Development (2005-2014) and the UN Agenda 2030.

Nevertheless, there is still a lot to be done, profound cultural and structural changes in society and school are necessary. But it is a complex process which requires the involvement of the whole institutional community, can only be achieved with a clear, precise and coherent educational commitment to the environment and sustainability, as stated by Sterling in 2001 [48]. Twenty years later, something is starting to change.

In addition, environment and sustainability education is much more than teaching what sustainable development is, since it demands to experience sustainability.

In other words, it is necessary to merge practice and theory in order to integrate sustainability principles in everyday life. In this view, sustainability experiences at school are more effective when supported by educational paths supported by game-based learning approach that can help in understanding how to address multidimensional sustainability challenges. Last but not least, games support engagement and motivation that are basic for successful learning and we think it can be a winning approach to getting people to behave correctly. On the basis of this assertion, an educational path composed of two elements has been designed: an explainer video and a serious game. The video aims at informing the user about the marine pollution due to marine litter, the second one aims at making the user aware of specific dangers that marine litter can cause to some marine species at risk of extinction. The knowledge about some marine species happens as side effect of this solution. The evaluation of the defined technological solutions confirms once again that game-based learning can be successful in supporting learning processes.

Both the video and the serious game were appreciated by students. The interesting outcome of this evaluation was the results of the retention test, which have confirmed that the knowledge gained has been actually acquired by children. Moreover, the teachers also reported that some children have applied the new good habits in daily practice trying to dispose of waste in the classroom in the best possible way. Another important result pointed out during the pilot study was the engagement of both students and teachers who asked if other games were available to learn other disciplines.

In the next future a larger study should be conducted in order to investigate more deeply the learning effectiveness in environmental education in terms of changing of users' attitude and actions. Even if the sample was small, hence is difficult to generalize the findings, but on the basis of the experimental evidence in the literature we can assert that the use of multimedia technologies in general, and serious games in particular, should be adopted in order to build effective educational pathways and promote sustainable behaviors.

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