Roteiro Entre-Marés: an educational app for ocean literacy promotion

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Roteiro Entre-Marés: an educational app for ocean literacy promotion

Abstract: The app "Roteiro Entre-Marés" offers digital itineraries for exploring intertidal zones, such as the rocky platform of the Avencas Marine Protected Area. As they travel through the intertidal area, several challenges emphasizing the biodiversity, and environmental issues are presented. Eighth-grade students (n=63) used this application and were challenged to identify *in situ* the marine species present in different zones of the intertidal ecosystem. Then, questionnaires and interviews were performed with teachers and students to examine the utilization of mobile apps as educational tools. The fact that they learnt a lot, autonomously, using the field guide of the app, were among the aspects that the students most appreciated, describing this app as an organized, informative, interesting, and interactive learning tool. Teachers say this is a useful didactic resource because it delivers clear and reliable information that links theory and practice. Hence, this study examines the acceptance of this mobile app as an instructional tool among students and teachers, highlighting the potential of mobile apps as educational tools.

Keywords: educational app, mobile learning, ocean literacy, science education, outdoor learning

Introduction

Mobile devices are becoming more common and integrated into our daily lives (Gowin et al. 2015; Warschauer and Matuchniak 2010). Furthermore, the application of mobile technology devices in education has been the focus of the emerging area of mobile learning, which has demonstrated its ability to remove multiple constraints in education and improve students learning (Chen and Yan 2016). Mobile learning is a subset of online learning that refers to the process of learning across several mobile devices such as laptops, smartphones, and wearable technology (Keskin and Metcalf 2011; Son, Lee, and Park 2004).

Mobile learning has become increasingly popular around the world as the number of mobile users grows daily and mobile devices become more accessible and popular among students (Saikat et al. 2021; Botha, Herselman, and van Greunen 2010; Şad and Göktaş 2014). Furthermore, following the COVID-19 outbreak, teaching and learning have been forced to shift completely to online rather than the traditional offline media and as a result, mobile learning utilization has increased, bringing a different perspective toward online education, globally, due to the large-scale use of online platforms by learners and educators (Saikat et al. 2021). Hence, there was a greater willingness among teachers to employ mobile devices as a teaching tool. Nonetheless, both teachers and students may see mobile devices as sources of distraction, which may have an impact on academic performance (Chen and Yan 2016).

In fact, the use of mobile devices has the potential to revolutionize how we learn by transforming the traditional classroom into one that is more dynamic and engaging (Sha et al. 2012). It enables educators to educate without considering the time or location, allowing education to continue after class or outside of the classroom in locations where learning naturally occurs (Huang, Lin, and Cheng 2010; Zydney and Warner 2016). It also allows educators to connect with students on a more personal level using technologies that they are already familiar with (Ward et al. 2013). Finally, the use of these technologies as pedagogical resource allows a personalized learning experience for each student/user (Chu et al. 2010).

Due to several characteristics that make it distinctive and well adapted to the affordances of mobile technology, there is potential for adopting mobile learning in the field of science education. Much of science occurs outside of the classroom and it is perhaps better studied in its natural environment, yet some science content is impossible to see with the naked eye and requires graphical depictions for students to properly comprehend (Zydney and Warner 2016). The portability of contemporary technologies, as well as their ability to present interactive, images and simulations, are ideally suited with these different characteristics of science learning

(Zydney and Warner 2016). Digital resources were created to direct students' attention to specific aspects of the environment that illustrate disciplinary concepts (Pea 2004; Land and Zimmerman 2015): text and photos to help students recognize important environmental aspects; images that revealed key visual contrasts for recognizing what is scientifically meaningful that could otherwise go unnoticed (Bransford, Brown, and Cocking 2000; Rogers et al. 2004) .

People require assistance in observation, identification, articulation, and explanation-building activities to enable them look carefully at the natural environment (Eberbach and Crowley 2009; Zimmerman, McClain, and Crowl 2013; Lehrer and Schauble 2006). For instance, previous outdoor mobile learning experiments have used technology to improve access to information, record field observations, search databases for species identification, thus personalizing the learning experience (Zimmerman and Land 2014; Chen, Kao, and Sheu 2005; Rogers et al. 2004).

Science-related dialogues about observations on the field and comparing them to observations on the app's digital resources that may explain them, are encouraged through guided involvement (Eberbach and Crowley 2009; Zimmerman, McClain, and Crowl 2013; Liu et al. 2009). So, the content of the mobile technology and the guided interactions should be tailored to specific aspects of the local area, so that learners can participate in a multisensory experience (point, look, touch) to stimulate "heads-up interactions", by questioning themselves and others about what they are observing (Salman, Zimmerman, and Land 2014; Hsi 2003).

In this context, the didactic mobile app “Roteiro Entre-Marés” offers digital itineraries, but to be implemented *in situ*, with several challenges for exploring intertidal zones, encouraging students and teachers in becoming scientific observers who can coordinate science knowledge with their sensory experiences in the outdoors and explainers of scientific phenomena connected to marine ecology.

The main aim of this educational App is to contribute to the valorisation of the natural resources of the coastal ecosystems, specifically the intertidal zone. Pressures and threats on the marine environment are growing. These include biodiversity loss, reduction of fisheries stocks, illegal fishing, tourism, pollution, sea level rise, marine litter, etc. (Ressurreição, Simas, Santos and Porteiro, 2012). A better understanding about these issues, at both local and national scales, can potentially help to minimize these threats in the future. Ocean literacy programs will be critical to accomplishing such societal goals (Santoro, Santin, Scowcroft, Fauville and Tuddenham, 2018). Ocean literacy can be considered as understanding the ocean's influence on you, and your influence on the ocean. This concept encompasses seven ocean literacy principles (Santoro et al., 2018), among which are the following "The ocean supports a great diversity of life and ecosystems" (Principle 5), and "The ocean and humans are inextricably interconnected" (Principle 6), that could be deepened through the use of the App "Roteiro Entre-Marés". As a result, the purpose of this study was to assess the acceptance of this mobile app as an instructional tool among students and teachers, and simultaneously, to assess its potentiality to raise students' awareness about these coastal marine ecosystems.

Methodology

Context of the study

This study was developed within the research project "Roteiro Entre-Marés" (FA_06_2017_011), which has as main goals to promote ocean literacy through a mobile app which offers a set of digital itineraries for didactic exploration of the intertidal zone, namely one rocky intertidal platform (Marine Protected Area of Avencas) and one of mobile substrate (National Park of Ria Formosa). These itineraries are focused on the biodiversity of these places, the characteristic adaptations of its resident species, and the impacts of the human activities in these ecosystems.

Apps' architecture: description of the itineraries

The App "Roteiro Entre-Marés" was developed as a mobile application that can be freely downloaded on any mobile technology for devices with Android operating system and is aimed to children to use in school context or a family context. The existing contents fall into the themes of the curriculum (years 7 to 9) of the 3rd cycle of elementary education. At this school level, students must understand the levels of biological organisation of ecosystems, analyse the dynamics of interaction between living beings and the environment, and explore the dynamics of interaction between living beings. However, in most schools, the majority of the examples explored in the classroom are terrestrial, not marine, ecosystems and there is a lack of resources and activities aimed at promoting knowledge about the ocean. The application incorporates a set of itineraries throughout the intertidal zone of the Marine Protected Area of Avencas and of the National Park of Ria Formosa. The geology of the area, marine biodiversity, species adaptation, and coping mechanisms to survive under harsh conditions, as well as the effect of the moon on the tides and ocean pollution are addressed while physically walking through these itineraries, drawing the user's attention to key elements.

The students were challenged to identify in situ the marine species present in the several zones of the intertidal ecosystem, namely the upper, middle, and lower intertidal zones, while estimating their abundance in each zone, through the species zonation exploitation on the biodiversity itinerary. For most of these students, all the species present in this ecosystem are unknown to them. To foster student autonomy, the biodiversity itinerary provides direct access to the field guide, which contains a wealth of information on species characterization, adaptive mechanisms, and curiosities. Thus, the challenges provided are learner-centered, encouraging direct in situ observations and collaborative work. Figure 1 shows an example of one of the tasks. In this task, the user must photograph one specific area. After that, a grid automatically appears juxtaposed to the photograph, and the user can count the number of squares filled by each species present. With this information, the App automatically creates a graph with species abundance in each site surveyed.

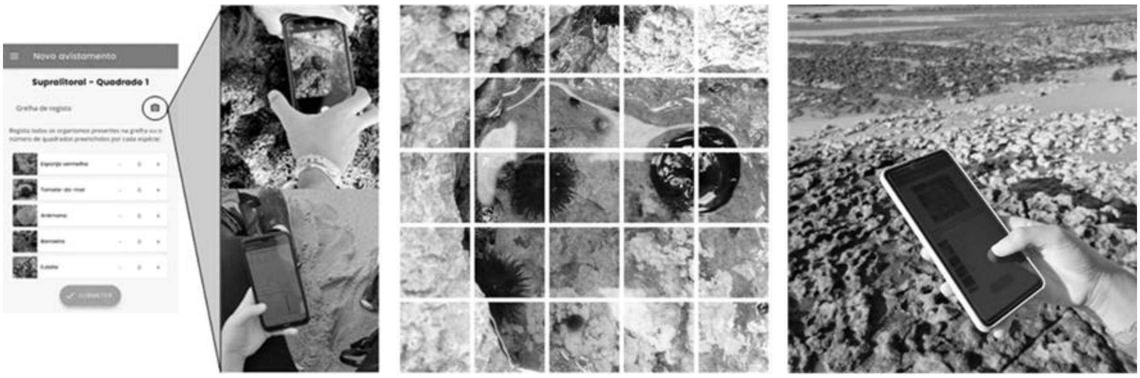

Figure 1. A diagram of the activity "biodiversity zonation" during a field trip to the Marine Protected Area of Avencas.

Participants

This evaluation study gathered a group of 63 students aged 12 to 16 from two separate elementary schools. Students came from three eighth-grade classes from schools located in the city of Lisbon. The teacher in charge of the visit was interviewed for each class, and in one case, three teachers were involved. So, 5 teachers were involved in the study: four from Natural Sciences and one from Physical Education.

Prior to the field trip, a briefing was held with the teachers to allow the children to examine the app in the classroom, which facilitated its use on field.

The itineraries were tested during the months of October and November (2021), and students were requested to work in groups of two to complete the zonation challenge of the biodiversity itinerary.

Data collection and analysis

The main goal of this study was to evaluate the perception of students and teachers of mobile devices as educational tools, as well as their opinion on the app “Roteiro Entre-Marés” as didactic resource.

All the field trips were guided by a team researcher and accompanied by two or three teachers. At the end of the activity, all students were asked to complete an opinion survey (a closed questionnaire with open and Likert-scale questions – see figure legends), which focused on the evaluation of the activity performed, in which students were asked to say whether they agree or disagree with a set of statements, taking into account the potentialities and difficulties associated with the use of the App, the aspects they liked and what did they learn from the proposed activities. In this context, the questionnaires were analysed by quantitative methods. To understand if the guided field trip allied to the app utilization had any positive effect on how students see technology as a pedagogical tool, questions about preferences for hands-on and technology-driven lessons, perceptions of everyday technology use, and enthusiasm for new technologies were assessed through the interviews.

All participating teachers (n=5) were interviewed (see appendix), as were some students (n=6), who have volunteered, with the goal of understanding the participants' perspectives on the influence of mobile technology and of the App “Roteiro Entre-Marés” as a learning and teaching resource. The interviews were audio-recorded and ranged in duration from 15 to 50 minutes. They were subsequently transcribed, and the content was assessed in accordance with Milles and Huberman (1994). In order to increase the validity of the instruments used, both data collection instruments, questionnaires and interviews, were previously analysed by other researchers, specialists on the use of technology as teaching resources, to ensure their suitability to the research aims.

The content analysis of the interviews were coded to find any recurring content mentioned by the students and teachers (e.g., enjoyment, easy-use, motivational). The coding aids in the removal of superfluous data that may be regarded noise as a result of excessive text (Norton et al. 2019). This analysis also helps to identify the overarching contents and sub-contents of the findings (Milles and Huberman 1994). This inductive analysis was performed independently by both researchers, who discussed and reviewed the analysis to assure greater reliability.

Ethical considerations

In line with the Personal Data Protection Law No. 58/ 2019, the interviewed students and teachers were informed about the project and signed consent letters. All the participants were informed that their participation was voluntary, that they could withdraw their participation at any time without any negative consequences, and that the information that they provided would be confidential and anonymized when reported.

Results

Students' perspective

General appreciation of the app "Roteiro Entre-Marés"

Most of the students (78%) surveyed (n=63) enjoyed using this app and found the information engaging. Furthermore, they believe that the tasks proposed encouraged a collective effort and discussion (81%), as well as that they gained new knowledge (82%) and motivation to learn more about this topic (70%) (Figure 2). While a small percentage (16 to 30%) disagree with such statements, they did so because they found the app "confusing and difficult to use, especially due to the species square counts".

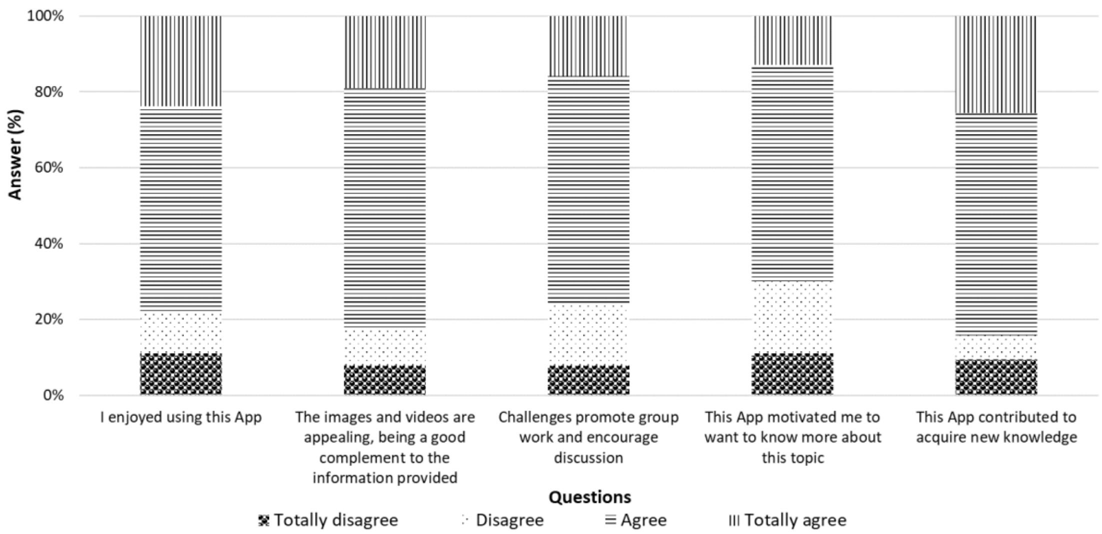

Figure 2. Students' responses (%) to the statements presented in the question "What was your general opinion about the App?" (n=63).

Positive and negative aspects of the App

What the students enjoyed most about this app was "its organized informational content in an infographic format, which made it appealing, as well as its ease of use". They also "liked to take photos of the environment and being autonomous in the species identification with the support of the field guide", just as they enjoyed being able "to take notes or saving photos on the artefacts", a digital notebook, which they can share with the classmates. But the app's accessibility, which is only available for Android users, was one of the features that students disliked (44%). Moreover, some suggested that the field guide should include more and higher-quality images (2%). Others criticized its organization (2%), suggesting that the text sections should be minimized (7%). Finally, a few students disliked the requirement to take photos (12%).

When asked to describe the app in three words, the most common responses among the students were "educational (14%), informative (12%), interesting (11%), appealing (8%), and fun (11%)", because "this digital work tool is simple to use and allows users to learn more about biodiversity in an interactive manner", thereby promoting a greater awareness about the conservation of this marine protected area. Some of them described it as an accessible (12%), and useful source of knowledge (8%). Regardless, some of them described it as hard to use, because they considered the app confusing (7%) and disorganized (1%).

In overall, the students' favourite feature was that the app's information alerted them to environmental issues (83%) and of having learned a lot (79%) autonomously (79%) during the tasks performed on the field (79%). In contrast, taking photos (30%) and registering them on the species record sheet (29%), as well as suggestions for further exploration (30%), were among the least preferred elements (Fig. 3).

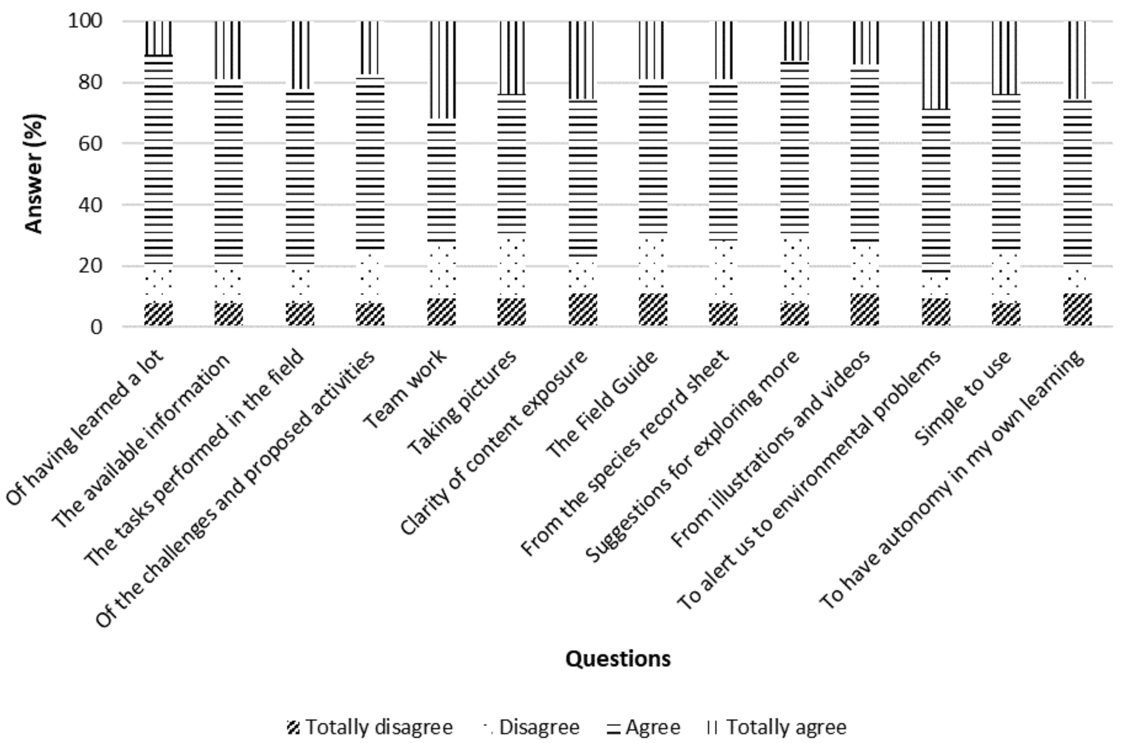

Figure 3. Students' responses (%) to the statements presented in the question "What did you like the most?" (n=63).

The App "Roteiro Entre-Marés" as a learning resource

According to the students' opinions, the app "Roteiro Entre-Marés" has in fact contributed to their learning through the challenges (75%) that the app provides in combination with the illustrations, videos (75%), and the field guide (67%) which provided an opportunity to work in groups (73%), resulting in student's engagement in the proposed activity, facilitating their learning process (Fig. 4).

According to their own words:

"This app can be a way to acquire knowledge because it offers visuals that help to understand the explanations supplied during the visit, and it also has a lot of examples that help to understand the material presented".

"The field guide made it easier to identify the species".

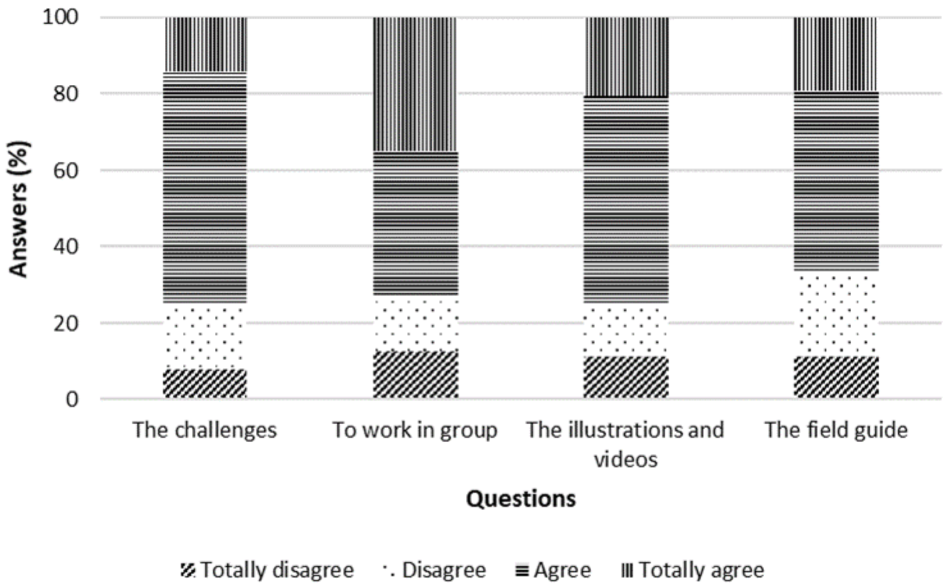

Figure 4. Students' responses (%) to the statements presented in the question "What aspects made your learning easier?" (n=63).

In contrast, the fact that there was too much written information made it harder for certain students to learn (38%). Furthermore, 29% of students considered the task difficult to complete and had difficulty navigating the application, deeming it is slow (21%).

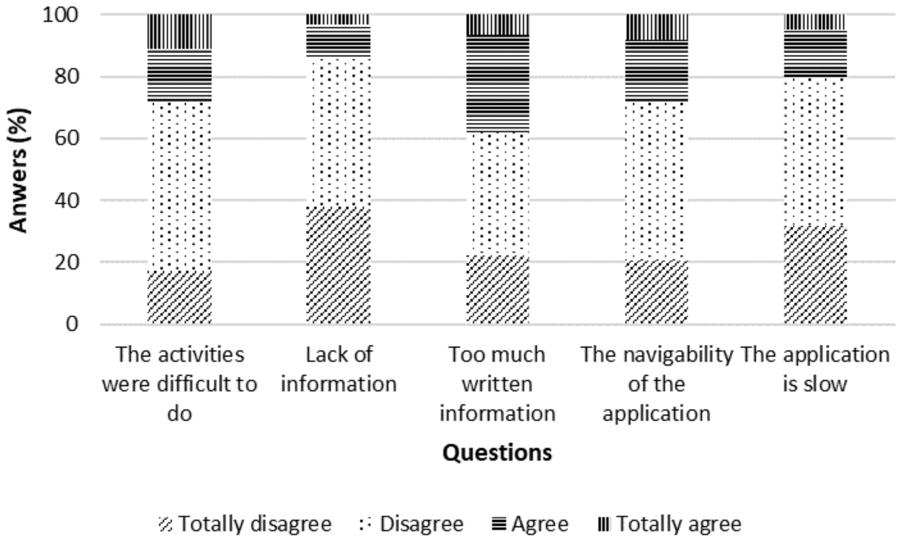

Figure 5. Students' responses (%) to the statements presented in the question “What aspects made it difficult for you to learn?” (n=63).

Some students stated that they "found the app confusing, particularly in the phase of counting the squares in which the species were present," while others stated that "the mobile device battery was a limiting problem."

Acquisition of scientific knowledge

When it comes to the main goal of this activity (Fig. 6), most of the students agreed that they learned the concepts of an intertidal zone (87%), a marine protected area (92%), and the importance of protecting these coastal ecosystems (87%). Furthermore, the goal of this project was for the students to learn more about the species that inhabits there and the variables that influence their distribution (81%) on the intertidal zone, as well as the coping mechanisms that they developed to adapt and inhabit in this harsh environment (83%).

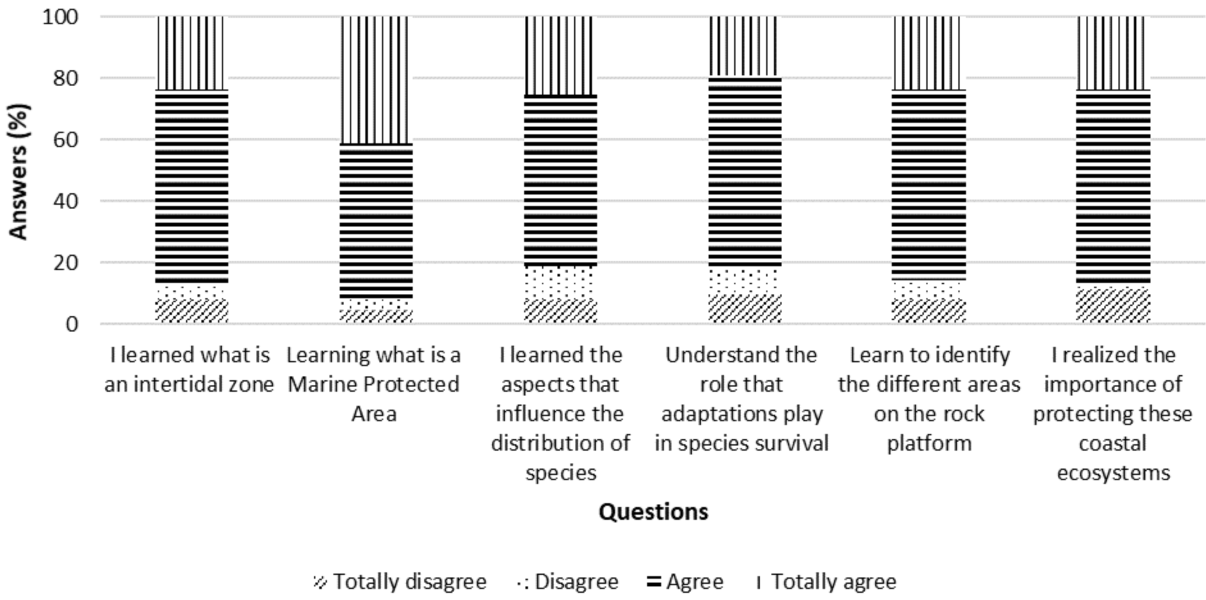

Figure 6. Students' responses (%) to the statements presented in the question "What did you learn from the proposed activity?" (n=63).

After the activity, the students reported that the app is a useful source for obtaining knowledge since it is a reliable tool that displays information in an infographic form. Using the app's field guide, they were able to identify the species autonomously, easily, and quickly.

According to some of the interviewed students:

"The activity helped to acquire scientific knowledge because we were searching for the organisms and the reasons for their behaviours".

"The activity was fun, informative, and interesting. Because it was a practical activity, it drew my interest as well as the attention of my classmates".

As a result, the students have gained knowledge of the marine ecosystem and its biodiversity, particularly about species zonation and their adaptive characteristics.

Hereby, the findings of the evaluation tools applied to the students (n=6) showed that students interviewed believe that using mobile applications as an educational tool “is an interesting, fun, and good strategy since it is a motivating, useful, and practical work tool that reinforces group work”. Furthermore, “its ease of use promotes the acquisition of in-depth knowledge and thus enhances the learning process in a sustainable manner, since there is no paper use”.

Teachers' perspective

General appreciation of the App as a didactic resource

From another perspective, the teachers interviewed referred that they see the use of digital technologies in school contexts as beneficial and positive for students' learning since they are adapted to today 's generation and are a motivating tool. Moreover, they considered that mobile technologies can be quite useful because they provide quick access to information. For these reasons, students' attention is stimulated by an engaging app that combines practice and theory with real-time feedback. However, because kids are easily distracted by other resources easily accessible by the mobile phone, its use must be supervised. As a result, if properly guided and supervised, the use of mobile devices can enable students to have access to this knowledge source, helping to develop autonomy and digital skills, such as collection and selection of information.

When we asked them to characterize this mobile app as a learning resource, teachers characterized them as an interesting, innovative, and practical tool that fascinates and motivates kids by providing them with a variety of tasks and challenges.

According to the teachers interviewed, this application is beneficial to student learning because they apply theoretical knowledge in practice, autonomously. Furthermore, the information is clear and reliable, and it can be used without screening. Above all, since it is a mobile app, it draws the attention to the students who are familiar with mobile devices and digital technology. The teachers found that this activity and the app's content fit extremely well within the eighth-grade school program as an introduction to the biodiversity and ecosystems chapter. Because it suits the tastes and competences of the students, this easy-to-use app is an intuitive and valuable tool as a teaching resource, that may be used as a learning foresight or reinforcement resource, as well as to encourage skills development such as independent study in the field. Through this app, students can develop in-depth learning about scientific knowledge, ocean literacy and build environmental awareness. Moreover, they can also develop skills, such as social and digital skills, cooperation, and autonomy.

Discussion

The result of this study suggests that the biodiversity itinerary conducted with the app "Roteiro Entre-Marés" promoted environmental awareness and the learning of specific contents regarding species identification and zonation in the intertidal zone. Because this digital work tool is simple to use and allows users to learn more about biodiversity in an interactive manner, both students and teachers described the app as educational, informative, intriguing, engaging, and entertaining. Still, each student is unique and each field experience is unique, each field experience will lead to all sorts of academic, cognitive, and social gains (Rennie 2007).

The ability of students to understand and use mobile technologies to better perceive and analyse spatially distributed characteristics of the environment is a vital component of environmental education (Norton et al. 2019). Therefore, combining mobile technologies with geographic information systems in field data gathering, may provide students with an opportunity to feel engaged in what they are learning and take control of their own learning process (Norton et al. 2019).

Therefore, it was possible for participants to act as skilled knowledge-building agents of the Marine Protected Area of Avencas and its resident species by searching diverse marine species and capturing several ecologically focused images of these species. These findings are consistent with those of Land and Zimmerman (2015), who found that using mobile technology associated with guided visits supports a learner-centred interaction in a variety of ways, including increasing student engagement by promoting learner-initiated perceptual and conceptual discussion about the species in an open learning environment (Hannafin et al. 2014; Hannafin and Land 1997; Hannafin, Land, and Oliver 2013; Land, Hannafin, and Oliver 2012; Jonassen and Land 2012) .

This evidence is in agreement with the previous research on this issue in which the utilization of mobile technology improves the development of several abilities and has a favourable impact on student learning (Furió et al. 2013; Ciampa 2014; Cagiltay, Ozcelik, and Ozcelik 2015). When we compare our findings to Norton et al. (2019), it is possible to observe student cognitive outcomes, such as knowledge and comprehension, as well as skill-based outcomes, such as making observations and developing explanations, when we transform how students learn by changing the traditional classroom to one that is more interactive and engaging.

Finally, the proposed tasks encouraged group work and *in situ* observations, which aided learning (Schwabe, Goth, and Frohberg 2005). Thus, the use of mobile phones on field trips stimulates information sharing among classmates, debate of ideas, better interaction with the surrounding environment, and more active participation in the activity of both students and teachers (Cahill et al. 2011). Thus, as already suggested by Alturki and Aldraiweesh (2022), the incorporation of this technology in this learning context, seemed to make the field trip a more dynamic and student-centred activity.

The application of mobile learning as an educational approach presents both advantages and disadvantages when compared to traditional teaching. For instance, mobile device education offers benefits such as flexibility, cooperation, engagement, availability, and mobility (Campanella 2012; Criollo, Lujan-Mora, and Jaramillo-Alcazar 2018). Thus, based on the students' answers, it was possible to conclude that they were motivated to participate in the activity and felt they had the autonomy to do so.

Still, technological constraints relating to the equipment's usability, such as the small screen size of mobile devices and short battery life, might be a barrier to student learning (Filho and Barbosa 2013; Sundgren 2017). Furthermore, some users may be unfamiliar with mobile technology, limiting their ability to interact with and comprehend mobile apps (Navarro, Molina, and Miguel 2015). As some students mentioned, the battery life of the mobile device was a limiting factor while performing the activity, as was the quality of some devices' photos, which directly impacted species identification.

Based on the concept that technologies, pedagogy, and guided participation strategies must all work in combination to connect the learners' prior knowledge, gradually build on it through interaction, and encourage learner engagement (Reiser and Tabak 2014; Tabak 2004; Zimmerman, Reeve, and Bell 2010; Jonassen and Land 2012), this type of field trip has the potential to influence students' cognitive abilities, knowledge, and interests, while also providing students with a unique opportunity to make connections that will aid in their knowledge and enthusiasm for learning (Hutson, Cooper, and Talbert 2011).

Nundy (2001) noted three significant benefits associated with field trips and students' learning 1) the fieldwork setting's memorable quality has a beneficial impact on long-term students' memory; 2) affective aspects of the residential experience, such as personal growth and social skills improvement; 3) affective and cognitive reinforcement, with each affecting the other and providing a link to higher-order learning. In overall, students are more likely to adopt new technologies if it is faster, easier, and more convenient than handwritten methods.

Taking into consideration all these results, it seems that this type of educational resource could be very important to promote ocean literacy. Indeed, although we know that knowledge is a critical factor in environmental literacy, it is not sufficient to actually promote a change in the individual's behaviour (Hungerford and Volk, 1990). Affections and emotions are also crucial for developing pro-environmental behaviours (Pe'er, Goldman, and Yavetz, 2007). In this case, the results revealed that this app created a learning environment that allowed students to deepen their knowledge about the intertidal ecosystem in a positive, enjoyable and engaging way. Moreover, both students and teachers appreciated the app's use of a nearby school area, such as the Marine Protected Area of Avencas, to introduce scientific concepts, giving students a sense of belonging to the place that elicit their understanding and willingness for conserving these marine ecosystems.

Conclusion

Field trips provide an opportunity to motivate and connect students to appreciate and comprehend scientific concepts, worked and explored in classroom, which builds students' knowledge foundation and promotes further learning and higher-level thinking skills. Self-assurance and inner motivation result from comprehension. According to students, there is wide acceptance for the potential use of mobile learning to support the teaching and learning of science education among eighth-grade students and teachers. Thus, with mobile learning, students' learning motivation can be increased. As a result, employing the App "Roteiro Entre-Marés" as an educational tool has the potential to enhance student motivation, and mobile educational apps can aid in the development of focused, centred, and creative learning environments, helping to promote ocean literacy. Nonetheless, the outcomes will be distinctive towards the students, depending on their interests, motivation, needs, and prior experiences and knowledge. Further studies are needed to allow us to understand in greater depth how the use of this type of didactic resources can in fact favour the autonomy of all students, as well as the deepening of their knowledge about the themes explored. For that, it will be necessary to develop a more interpretative study, focused on the way the activities are carried out by each group of students, during the field work, and what they felt about this type of more autonomous work.

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Competing interests

No potential conflict of interest was reported by the authors.

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