Ecological Walk: A Proposed Digital Game to Reduce Solid Waste and Safeguard Marine Ecosystems in Brazil

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1 Introduction

Marine ecosystems worldwide suffer the impacts of solid waste (SW) discharges from residential, commercial, and industrial activities, with consequences in economic, biological, and social dimensions (Chen et al. 2020; Beaumont et al. 2019; da Silva and Krelling 2019). Plastic stands out for its quantity and further durability, which causes damage to water resources and marine biota. It is necessary to properly manage SW due to its direct effects on air, water, and soil, impacting public health (Debrah, Vidal and Dinis 2021). In addition to damage to tourism, expenses with cleaning the beaches and the impact of reducing visitors' interest in local tourism must also be considered.

This scenario reflects the economic dimension perceived in several cities in Brazil, a vast coastline (Freitas et al. 2020). Cabo Frio, RJ, Brazil, one of the seven municipalities in the Lagos region, does not escape this reality, as tourism is considered a central pillar of the local economy due to the diverse historical and natural heritage. In periods of the high season, there is a considerable increase in the SW on the region's beaches caused by the large flow of tourists (Pereira et al. 2018, 2021, 2020), generating losses to the marine biota.

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Considering the impacts on marine biology in the city of Cabo Frio, de Almeida Schuindt et al. (2018) and de Oliveira et al. (2021) indicate that the Araruama Lagoon, with an area of 220 km², is one of the largest hypersaline lagoons in the world. SW is disposed into its banks, sewage and illegal effluents. To corroborate this information, the data provided by Instituto Brasil (ITB 2018) confirm this reality, by indicating that 40.3% of the population of Cabo Frio does not have access to sewage collection, which explains the current scenario that this situation entails, among other problems, damage to environmental and human health, with serious consequences for the marine ecosystem, reduction of the variety of aquatic species and even an increase in algae biomass (de Almeida et al. 2018; de Oliveira et al. 2021). The impacts of the inappropriate disposal of SW on the marine environment have consequences for the economy, marine biota and the social sphere.

In the social dimension, it is possible to perceive that the uptake of SW by marine animals, especially microplastics, has severe consequences on the food chain, threatening the food security of humans, Sustainable Development Goal (SDG) 2, when consuming contaminated fish and crustaceans (Sousa et al. 2019). These and other impacts suffered by the various social actors demonstrate the need for consolidated bases for critical environmental education, which involves individuals, the community, specialists, and the government itself (Bezerra and Iared 2019), reflecting the local socio-environmental problems (Guimarães 2016). Therefore, this chapter aims to identify the Brazilian students' perception of a High School Hosting course (HSH), about the damage to the marine environment and the proper disposal of SW, through the contents presented in the digital game *Caminhada Ecológica/Ecological Walk*, accessed via a mobile device. To achieve this goal, actions are needed to integrate the SDGs within issues involving waste management and its environment impact.

2 2030 Agenda—The Integration of the Sustainable Development Goals (SDGs)

The SDG integration actions aim to raise awareness concerning sustainable attitudes, proposed by the UNESCO Action Plan (UNESCO 2015) to implement the 2030 Agenda. Therefore, it is necessary to develop pedagogical actions (SDG 4) aimed to sensitize social actors in the protection of natural heritage (SDG 11.4) at local level, avoiding deforestation and beach pollution (SDG 14), thus integrating specific sustainable development objectives (CNM 2017).

Therefore, the digital game *Caminhada Ecológica/Ecological Walk*, available at https://play.google.com/store/apps/details?id=com.GSanchoDev.Caminhada Ecolgica, is a proposal for pedagogical action on the addressed issues. It is designed to high school students, and addresses specific SDGs, related to SW in beaches, and aims to stimulate interest and awareness among students about the

need difficulties of keeping the beaches clean. According to the 2030 Agenda (SDG 4.7), education should enable sustainable development (SD), while SDG 14.1 points to the need to reduce marine pollution in all directions, which is in line with SDG 8.9, aiming to promote sustainable tourism that stimulates knowledge of local culture and products (UNESCO 2015).

The National Curriculum Parameters (Brasil 1997; Brasil 2000) highlight the importance of developing significant environmental pedagogical actions, using information and communication technology (ICT) to sensitize citizens and lead them to reflect on the environmental problems in the community. This case refers to basic sanitation, to provide behavior, change, and thus act on the local and global reality. Pereira et al. (2020) indicate that mobile devices' use with environmental themes stimulates the focus and interaction between students searching for solutions to environmental issues.

3 Digital Games and Their Importance in the Learning Process

As emphasized by Vasconcellos et al. (2018), digital games promote the educators' attention to games, aimed at solving problems stimulating active environmental behaviors in students. To support the acquisition of knowledge, the dame authors emphasize that "gamification" is the dissemination of digital games to other fields of knowledge and not just for fun. Elements of digital games as points, medals, and rankings are adopted, thus increasing the user's interest. When developed based on reality context, the game additionally stimulates the senses and imagination and, therefore, can be applied to the teaching and learning process, adapted to the contents worked through the narrative constructions that can be performed by the students themselves or by the teacher (Hildebrand 2018). The scenario of the digital game *Caminhada Ecológica/Ecological Walk* takes place in a fictional Hotel in Cabo Frio, considering that the target audience for which the game was designed are students of a HSH Course. In the game's narrative, the hotel owner invites the player to participate in a campaign that rewards with punctuation and medals the most engaged in ecological practices. The player's mission is to collect as much SW as possible on the beach and dispose of it in the l containers appropriate to the waste type. If successful, it will reward the player. The context game was developed based on the local reality of Cabo Frio city. The contextualization makes the teaching–learning process viable by bringing theoretical concepts closer to the student's reality (da Silva and Bianco 2020). Accordingly, significant learning is developed, as it is related with the student's context inside and outside the school space.

4   Materials and Methods

The methodological procedures adopted in this study aim to offer the necessary guidelines for conducting social research in line with a specific area of knowledge (Prodanov & Freitas 2013). Therefore, the proposed strategies can guarantee the objectivity and precision in studying social facts (Gil 2008). The target audience of this investigation is 47 students, aged between 15 and 20 years old, enrolled in the HSH Course at the Federal Fluminense Institute of Campus Cabo Frio (FFI/CF). Student participation took place freely and spontaneously. It is essential to highlight that, due to the pandemic triggered by COVID-19 and the need to maintain social isolation within the 2020 classes, the year of application of this study, the application occurred remotely. However, the educational process throughout this period was carried out in a way that the link between students, teachers and other education professionals could be established, as suggested by Arruda (2020). The research participants were invited via WhatsApp by professors of the disciplines of biology, tourism and hospitality. The research is in full compliance with the objectives of the mentioned disciplines, with integrate principles of socioeconomic and environmental responsibility, the identification of practices that minimize the impacts on the environment, and the promotion of critical student awareness to develop sustainable tourism (PPC 2019). The resource used in this research is the digital game *Caminhada Ecológica/Ecological Walk* accessed via a mobile device, available on the Play Store platform for the Android system, developed by the first author. Google Forms, enabling the creation of forms and questionnaires, was used the disseminate the instrument. These digital resources are part of the Google Classroom platform, which is the most used for mediation of remote classes in times of COVID-19 (dos Santos Junior and da Silva Monteiro 2020).

This research was conducted in three stages:

Stage 1: *Convocation*. Contact was made with the students by the teachers of the course, through the WhatsApp application, for guidance and sharing of materials such as the game links and the Google Forms tool on the development of the activity phases. This application used in the educational context enables teaching and learning, as it is commonly used by people in general through the world (Martins and Gouveia 2019a, b).

Stage 2: *Guidelines*. Students were instructed to download and play the game *Caminhada Ecológica/Ecological Walk*.

Stage 3: *Survey*. Application of a questionnaire, through Google Forms, with five objective questions (**Q1** to **Q5**) using the Likert Scale, generally used for satisfaction research with questions that demonstrate the need to know the preferences and perceptions of users about social situations (Feijó et al. 2020) where the score ranges from 1 (strongly disagree), with values 2, 3 and 4 (intermediate) to 5 (strongly agree). As a result, five objective questions were presented. **Q1**: "Is it common to find SW on Cabo Frio's beaches, particularly in high season?", **Q2**: "Does the concept sensitize the player about the need and difficulties to keep the beach clean?", **Q3**: "Does the content show the importance of correct SW

disposal?", **Q4**: "Is the context of the "Government Campaign" rewarding the hotels most engaged in ecological practices related to the idea of tourism as a sustainable practice?", **Q5**: "Is the content relevant to the Hosting Course?".

Additionally, it is intended to know the students' opinion about two subjective questions. **Q6**: "How does *Caminhada Ecológica/Ecological Walk* contribute to learning the correct disposal of SW?" **Q7**: "How does the game contribute to sustainable thinking and care for the environment?".

5 Results and Discussion

Figure 1 represents the distribution of student responses for questions **Q1** to **Q5**, using the Likert scale 5 points, with variation from Totally Agree to Totally Disagree. The proportion of responses made it possible to verify the students' perception of the damage caused to the marine environment and the correct destination of SW through the contents presented in the digital game *Caminhada Ecológica/Ecological Walk*, accessed through a mobile device. On the *x*-axis are the number of participants and on the *y*-axis the percentage of responses (%).

For a better understanding, the content of the questions answered is described below:

Q1, "Is it common to find SW on Cabo Frio's beaches, particularly in high season?". **Q1** shows that the perception regarding the increase of SW faced by the city is unanimous on the part of the students. Cabo Frio experiences an exponential rise in SW, especially in the high season. Environmental education is therefore a strategy to raise awareness of behavior change (Pereira et al. 2018). This scenario is perceived across the entire Brazil. It is worth mentioning that, according to the panorama of the Brazilian Association of Public Cleaning and Special Waste Companies (ABRELPE 2020), Brazil registered an increase in SW production from 67 to 79 million tons per year between 2010 and 2019. This scenario requires great reflection on the form of high consumption is made in today's society.

Distribution of Results

	Q1	Q2	Q3	Q4	Q5
Fully agree	91,49%	78,72%	85,11%	63,83%	78,72%
Agree	6,38%	17,02%	8,51%	29,79%	19,15%
Indifferent	2,13%	4,26%	6,38%	6,38%	2,13%

Fig. 1 Answers to **Q1** until **Q5**, with more significant percentages

Q2, "Does the concept sensitize the player about the need and difficulties to keep the beach clean?" From the 95.47% of students who agree with **Q2**, it is possible to perceive that educational digital games are effective pedagogical proposals for the learning process within environmental education. Therefore, educational digital games and recreational activities enable interaction between students and expand their cognitive capacity (Costa et al. 2019).

Q3, "Does the content show the importance of correct SW disposal?", agree on the importance of the content presented in the game, and 3 responded that they are indifferent. This result reveals the need to develop pedagogical practices that can contextualize and critically analyze social relations and their economic and socio-environmental impacts to develop skills for greater awareness and socio-environmental ethics in both the local and global dimensions (Brasil 2017).

Q4, Is the context of the "Government Campaign" rewarding the hotels most engaged in ecological practices related to the idea of tourism as a sustainable practice?" 40 students responded that they totally agree, 14 that agree, 3 replied that they are indifferent. The responses indicate how relevant it is to contextualize the content to the student's reality so that learning has meaning. As a result, the pedagogical process must use different forms of language and textual genres. Digital technologies can critically and reflectively produce student's knowledge and have a role in searching for solving social problems (Brasil 2017). Also, the use of the tools available by mobile digital technologies can expand and enrich educational opportunities through different languages to reach students in different environments (UNESCO 2014).

Q5, "Is the content relevant to the Hosting Course?". It is worth mentioning, as previously mentioned, that this research was applied to students enrolled in HSH, so this is a straightforward and specific question for these students. Thus, it was found that 37 participants responded that they totally agree, 9 that agree, and only 1 student replied to be indifferent. The agreement in the responses of the total 46 students indicates the importance of implementing policies that encourage sustainable tourism, mainly since the target audience of this research is students from the hospitality and leisure sector. Thus, pedagogical practices by SDGs 8.9 and 11.4 indicate that the development of sustainable tourism promotes the creation of jobs aimed at strengthening means to protect natural and historical heritage and local culture (UNESCO 2015).

Table 1 show the students' responses, whose purpose is to present their perceptions regarding the two subjective questions. Thus, when analyzing the students' observations, on **Q6**, " "How does *Caminhada Ecológica/Ecological Walk* contribute to learning the correct disposal of SW?" and **Q7**, "How does the game contribute to sustainable thinking and care for the environment?", iIt was noticed the importance of playfulness in the learning process (de Araújo and Gouveia 2020), which in the case of this research is through a digital game, aiming to arouse the student's interest in the correct destination of SW, and in the maintenance of the marine ecosystem through actions that have a positive impact on the environment.

Table 1 Participants' responses from **Q6** and **Q7**

Participant	Q6	Q7
1	Reinforces the idea of the importance of conscious SW disposal	The game warns about selective SW collection, the importance of sustainable tourism and the need to keep beaches always clean
2	Teaches the right containers for the disposal of each object and material	The game encourages to keep a clean beach and to properly dispose of each waste so that the sea does not take, so I believe that it encourages sustainable thinking and, perhaps, initiates a conversation about the great amount of waste in the sea and the environmental impacts that this brings for us and for future generations
3	The presentation of respective containers for each type of waste, leads us to remember the recycling that is often not carried out daily	The game leads us to think about our practices and their consequences for the environment. We consider this reflection as a steppingstone for attitude changes and a better relationship and care for the environment
4	The amount of waste shows that this task cannot be left to just one person (or group), it would be easier if everyone did a little	It helps by showing us that it is very simple and easy to dirty the streets, beaches and cities, but it is more difficult, sometimes and complicated to clean everything, and thus showing the importance of not dirtying or injuring the environment
5	During the phases of the game there is a color indication where each type of waste must be discarded	The accessibility of the game is an important factor for more people to learn in a fun way, creating this sustainable thinking not only discarding waste, but preserving the beaches, the environment and that sustainable tourism is possible
6	It contributes directly to remind people of the right colors of recyclable waste containers, encourages players to always dispose of their waste in the containers and not on the beaches and streets, among others	
7	It has an influence for people to learn in a simple way about the correct disposal of waste	
8	It significantly contributed to the insertion of technology in the classrooms, as the game encompasses this practice in a subtle and differentiated way	

Table 1 (continued)

Participant	Q6	Q7
9	By identifying the colors of containers where each waste must be discarded depending on the material, which also occurs in real life	
10	The sum of these factors leads the player to reflect on his conduct through the disposal of waste	

Accordingly, the games' playful character provides a pleasant environment that enhances learning concepts that are not always perceived only in the face-to-face (f2f) expository classes (da Silva et al. 2019). Similarly, digital games developed as pedagogical resources stimulate learning, imagination, creativity, and cooperation, in addition to providing the user with appropriate and fun challenges to be overcome, motivating the learning of content, with clear objectives for achieving learning successfully (Farias and Hoed 2019; Skalee et al. 2017). Thus, the application of educational games enables the construction of learning beyond the classroom space, promoting critical thinking and care for the environment.

6 Conclusions

The inadequate disposal of SW in the oceans is a critical threat to the world's marine ecosystem, particularly in the Brazilian reality. Consequently, this chapter highlights the relevance of working with sustainable policies and practices in research that address the themes directed to the environment and health as corss-cutting issues applied to pedagogical practices. It does it in such a way that aligns with the student's background context and the objectives proposed by the student course to which it belongs, making learning meaningful.

To achieve the study's objective, dealing with the analysis of the perceptions of 47 students at the HSH, involving the damage to the marine environment, and SW disposal, the digital game *Caminhada Ecológica/Ecological Walk*, accessed via device mobile and available to Android in the Play Store, was used. The following pedagogical strategies were developed and applied to work with students, such as: (i) calling to participate in the activity via the WhatsApp application, as this work was all produced remotely due to the pandemic triggered by COVID-19; (ii) guidance, so that students could download and play the digital game *Caminhada Ecológica/Ecological Walk* and at the end, (iii) students had to fill out a questionnaire through Google Forms. 95.47% of the participants agreed that the concept worked in the game digital awakens the player for the need and difficulties to keep the beach clean and the importance of correct disposal of SW.

By the students' responses to the form, the influence of playfulness, mediated by the digital game *Caminhada Ecológica/Ecological Walk* developed by the first author, involving educational concepts and content, was noticed, arousing greater interest and motivation on the part of the students. The results thus demonstrate greater awareness and reflection by students on the issues surrounding SW and the safeguard of marine ecosystems in Brazil. They also demonstrate the ability of the mobile game tool to promote awareness towards environmental issues, throught digitalisation, an important tool within the sustainability field of knowledge.

Considering the students' more significant interest in learning educational content through digital play materials, it would be possible to develop other educational digital games involving different socio-environmental problems that significantly impact the social and tourist activities in the city of Cabo Frio, Brazil in future contributions. Accordingly, it will be possible to create pedagogical actions inside and outside the school universe that may involve the SDGs implemention within the context of 2030 Agenda.

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