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Promoting the Sustainability of Artisanal Fishing through Environmental Education with Game-Based Learning

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Abstract: Oceans provide a wide range of ecosystem services, including food and cultural ecosystem services derived from fisheries. The sustainability of fisheries is addressed by United Nations Sustainable Development Goal 14 on ocean conservation, and education strategies should include ways to achieve it. In this paper, we describe a game-based learning environmental education experience for the promotion of artisanal fishing developed in northwest Spain, in which more than a thousand primary education students (aged 6–12) participated. Following a qualitative methodology, we analyze our own generated games, their formative assessment, and the results of their implementation in schools and informal education events. Moreover, we compare the educational games generated with other game-based learning experiences on ocean literacy and the sustainability of fisheries. These educational experiences provide play-based learning opportunities in which students show great motivation and increase their knowledge about marine biodiversity, the socio-environmental effects of fisheries, and ocean conservation. Some differences were identifiable in the choice and design of the games, including their type and duration, the dimensions of sustainability analyzed, the specific learning objectives sought, the historical and cultural references used, cooperative peer learning, and the generation of shared knowledge. In this experience, the inclusion of education for responsible consumption (SDG 12) within the sustainability of fisheries represents a remarkable innovation, empowering students in their role as fish consumers.

Keywords: game-based learning; environmental education; education for sustainable consumption; sustainable fisheries; ocean literacy; ecolabels; ecosocial transition; primary education

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1. Introduction

Oceans provide a wide range of ecosystem services such as provisioning (food, water, energy), regulating (climate regulation), supporting (nutrient cycling, habitat provision, soil formation), and cultural services (recreational, cultural identity, spiritual values) [1–4]. Although the use of these ecosystem services has increased enormously since the 1950s (since the Great Acceleration [5–7]), fishing has remained too far from a state of sustainability [8–10]. Different types of fishing have different environmental impacts [11–13], with small-scale fisheries (artisanal fisheries) and their sustainability representing a new emerging issue in global ocean governance [14]. In fact, Goal 14 of the United Nations Sustainable Development Goals emphasizes the need to conserve and sustainably use the oceans, seas, and marine resources for sustainable development, something that has always been a priority for artisanal fisheries. Nevertheless, it is necessary to note that the inadequate management of small-scale fisheries may also cause unsustainability [12,15]. Therefore, it is necessary to guide the management of fisheries towards sustainable development [16,17].

In this framework, ocean literacy, i.e., the public understanding of the mutual relationship between us and the ocean and the importance of sustainable ocean use [18,19],

can contribute to improving the conservation of the sea. This type of literacy must provide knowledge related to environmental and ecosocial issues such as the pollution of the seas and the loss of biodiversity, the depletion of natural resources, and the derived socioeconomic consequences [19–24]. Formal education, which is carried out in educational centers, plays a key role in the ocean literacy process and in the urgent transition towards sustainability [25–27]. In these teaching–learning contexts, didactic materials and resources have been designed to increase ocean literacy based on ecosocial educational programs and approaches [21,26,28–31].

Among these methodologies, game-based learning has become an interesting didactic tool to promote science learning in recent years [32–34]. Educational games have defined rules for play. They pose a challenge for students. Structured in a flexible way, they allow feedback on the actions of the student/player, giving the opportunity to move forward or backward when their actions are correct or not (for example, in their answers to the questions asked). Although educational games are not intended to be won but to promote learning, they offer a result (establishing who wins the game or when the game is won). The goal is always to create a playful educational environment where students enjoy the experience while learning [35–37]. Game-based learning implies the (re)design of learning activities based on educational science and discipline-specific issues, using learning games that have applications both within the educational framework and beyond it [37]. The use of analogic games and digital simulations has increased the motivation and interest of students in learning about environmental issues [34,38–41]. Different educational experiences have been used with game-based learning on the sustainability of fisheries and ocean literacy [21,42]. It is common for these educational practices to be based on knowledge of marine biodiversity and environmental problems [19,29] or to introduce role play to analyse the perspective of those interested in the preservation of the oceans: fishermen, marketers, environmental managers, etc. [31,43–46].

Here, we show an educational game-based learning intervention from a different perspective: education for responsible consumption, considering both ocean literacy and the ecosocial promotion of sustainable artisanal fishing versus other types of fisheries. The intended purpose is to describe the games designed and to show how these games have been used to help primary school students think about the sustainability of fisheries, as well as to discuss their differences from other game-based learning experiences about fisheries.

The research questions that this work addresses are (1) What is the knowledge of primary school students about the marine natural resources fished/collected in their region? (2) What is the knowledge of primary school students about the sustainability of fisheries in their region? and (3) Can game-based learning facilitate the creation of shared knowledge about fisheries and marine natural resources among primary school students?

2. Materials and Methods

2.1. Context: Small-Scale Fisheries in the North of Spain

In the north of Spain, four autonomous communities are bordered by the Atlantic Ocean along the Bay of Biscay (the Basque Country, Cantabria, Asturias, and Galicia). Artisanal fishing constitutes a factor of cultural and traditional identity and a source of employment and income for these coastal communities [47]. In Asturias, 250 boats, grouped into 18 fishermen's associations, are housed in 19 base ports, which also have fish markets to auction off the catches. Most of the vessels are 12 m long (75–80% of the fleet) and are employed in coastal fishing for fish and shellfish (mostly mollusks and crustaceans) [48]. Inshore fishing takes place approximately 46 nautical miles from the coast (85.19 km), operating on 226 fishing grounds that occupy 984,938 hectares of water mass [49]. Our fishing fleet practices artisanal fishing using 13 minor fishing gears (some nets, hooks, traps, and others) [48].

Some interesting ecosocial characteristics that Asturian artisanal fishing shares with other artisanal fisheries are its high level of environmental sustainability, its decent hiring and remuneration conditions for fishermen, its adaptive flexibility in target gear and species,

its specialization in products of high perceived value, and its positive social impact on coastal communities [47,50]. Therefore, the Asturian artisanal fisheries practice a type of fishing that fits within the framework of the three pillars of sustainability in fishing: economic, social, and environmental sustainability [3,16,17,51]. In this sense, Asturian artisanal fisheries have seen their sustainability practices recognized with a type of label or ecolabel on their catches. Since 2015, the fish (fish and shellfish) caught by the artisanal inshore fleet and marketed at first sale in the fish markets has borne the local label *Pescado de Rula con Artes Sanos* (market fish caught with healthy fishing gear, pun in Spanish between healthy gears—Artes Sanos—and artisans—Artesanos). The fishery of local octopus has been certified since 2016 with the global MSC (Marine Stewardship Council) ecolabel.

Fish ecolabels can be a system to promote the transition towards sustainable fishing. They act as a link between sustainability-led actions in the catching of the fish and the consumers, who can choose to buy a certified product. For this to happen, fish consumers need to value ecolabels positively so that they are willing to pay a little more for the product of sustainable fishing, as well as opt to buy local fish [52,53]. Training responsible citizens to be aware of environmental problems so that they address their consumption options towards the solution of these problems and not towards their aggravation is part of Education for Sustainable Consumption [54–56] and Goal 12 of the Sustainable Development Goals established by the United Nations in 2015. The Ecos(i)Food project (https://ecosifood.com) is framed in this context, and it aims to apply scientific, educational, and management tools to the sustainability of traditional fisheries in Asturias.

2.2. Design of Educational Resources Based on Games on Sustainable Fishing

The educational strategy developed to promote education for responsible consumption and to support sustainable artisanal fisheries versus unsustainable fisheries followed an approach based on the gamification of educational content/knowledge [36,37,57,58]. Thus, three specific games (face-to-face and online board games) were designed as versatile teaching resources so that teachers in the basic education stages could apply them both inside and outside educational centers. Based on cooperative learning, these games propose a reflection on the environmental and social impacts produced by the different types of fishing, while students acquire knowledge about natural marine resources.

The online interactive cooperative game *Sustainable Fish Consumption* (*Consumo Pescado Sostenible*) was designed with the Genially application, following the style of an interactive virtual escape room [59,60]. A description of this game, and its pilot test, can be found in Torralba-Burrial and Dopico [61]. This game shows the sustainable use of marine resources through artisanal fishing, providing students the necessary training so that they have the possibility of choosing to consume sustainable fish. The learning situations are divided into three learning missions/challenges. This allows teachers to present the teaching content by tracing a narrative sequence linked to the sustainability of the ocean, seas, and marine resources. The game offers an empathic ecosocial perspective, with references to the repercussions for local fishermen facing fishing in distant seas and what this represents for the balance between their professional and personal lives. The implementation of the game in the classroom facilitates shared thinking among students, guided in the missions/challenges through the feedback provided by Octopus, the logo of the Ecos(i)Food project, who acts as a virtual hidden teacher. All students can win the game by working more effectively in a cooperative environment. This game provides an ethical context from which students can see represented the consequences of consumer choices in preserving marine biodiversity.

In another didactic proposal of game-based learning, the *Fishing Alphabet* virtual game (*Rosco Pesquero*), students had to choose the correct word related to fishing and responsible consumption to advance through each letter of the alphabet [62]. The game's word options were selected according to the curricular contents of the natural sciences in these educational stages. In this way, they were related to the gears and types of artisanal fishing, the marine

species of importance in regional fishing, the fish markets, the environmental impacts, and the basic elements that an ecolabel should contain.

The third game, unlike the previous ones, has not yet been described. Entitled *Juego de Memoria Recursos Pesqueros de Asturias* (*Fishing Resources of Asturias Memory Game*), it was based on traditional card-pairing games (downloadable in the Supplementary Materials). For its educational design, the species were selected based on socioeconomic and cultural importance (1); economic importance (2); the natural history narrative (3); threatened species of economic and cultural importance (4); and octopus fisheries with the MSC ecolabel (5). They had of necessity to be species on which a narrative could be traced about their natural history, their fishing exploitation (allowing us to talk about the differences between artisanal fishing and industrial fishing, the types of gear, and fishing quotas), and the interaction of the species with the students' own personal experience (Table 1).

Table 1. Species selection for the memory game.

Common Name	Scientific Name	Reason for Inclusion
Albacore	*Thunnus alalunga*	Socioeconomic and cultural importance. Natural history narrative
Atlantic mackerel	*Scomber scombrus*	Economic and social importance
Common sole	*Solea solea*	Economic importance. Natural history narrative
Cuttlefish	*Sepia officinalis*	Economic importance. Natural history narrative
Edible crab	*Cancer pagurus*	Economic importance
European angler	*Lophius piscatorius*	Socioeconomic and cultural importance. Natural history narrative
European bass	*Dicentrarchus labrax*	Economic importance
European conger	*Conger conger*	Economic importance. Natural history narrative
European eel	*Anguilla anguilla*	Economic and cultural importance, threatened species. Natural history narrative
European hake	*Merluccius merluccius*	Socioeconomic and cultural importance
European lobster	*Homarus gammarus*	Economic importance
Four-spot megrim	*Lepidorhombus boscii*	Economic importance. Natural history narrative
Gilt-head sea bream	*Sparus aurata*	Economic importance
Goose barnacle	*Pollicipes pollicipes*	Socioeconomic and cultural importance. Natural history narrative
Octopus	*Octopus vulgaris*	Socioeconomic and cultural importance. Part of Asturian octopus fisheries has the MSC ecolabel. Natural history narrative
Red algae	*Rhodophyta*	Economic importance. Natural history narrative.
Squid	*Loligo vulgaris*	Economic and cultural importance
Turbot	*Scophthalmus maximus*	Socioeconomic and cultural importance. Natural history narrative

Each one of the 36 cards (14.8 × 21 cm) shows a color drawing of the chosen species. The illustrations had to allow a correct identification of the species and be in the public domain. Therefore, they were selected from zoological monographs published at the end of the 19th or beginning of the 20th century by the Biodiversity Heritage Library, showing the reference on the card. The cards were titled with the scientific names of each species and their names in Spanish, Asturian, and English, considering the diversity of languages in the region. The back of the cards showed the logo of the Ecos(i)Food project.

The game flowchart is depicted in Figure 1. The game helps students to share their experiences with these fish and shellfish. They say if they know them, if they have consumed

any of these species, and what they know about the situation of the fish or their life cycles. In those moments, students learn from their own peers, generating shared knowledge from their own experiences. The teacher has a role in the game, guiding learning (although not the development of the game) and building the narrative that she/he wants to transmit. Her/his comments revolve around the natural history of fish; the characteristics that identify them; the sustainability of fishing gear; and the socioeconomic, environmental, and cultural importance of marine species. This didactic communication is provided according to the age and knowledge of the students who are playing. The previous selection of the species present in the cards allows the students to address their learning towards fishing sustainability.

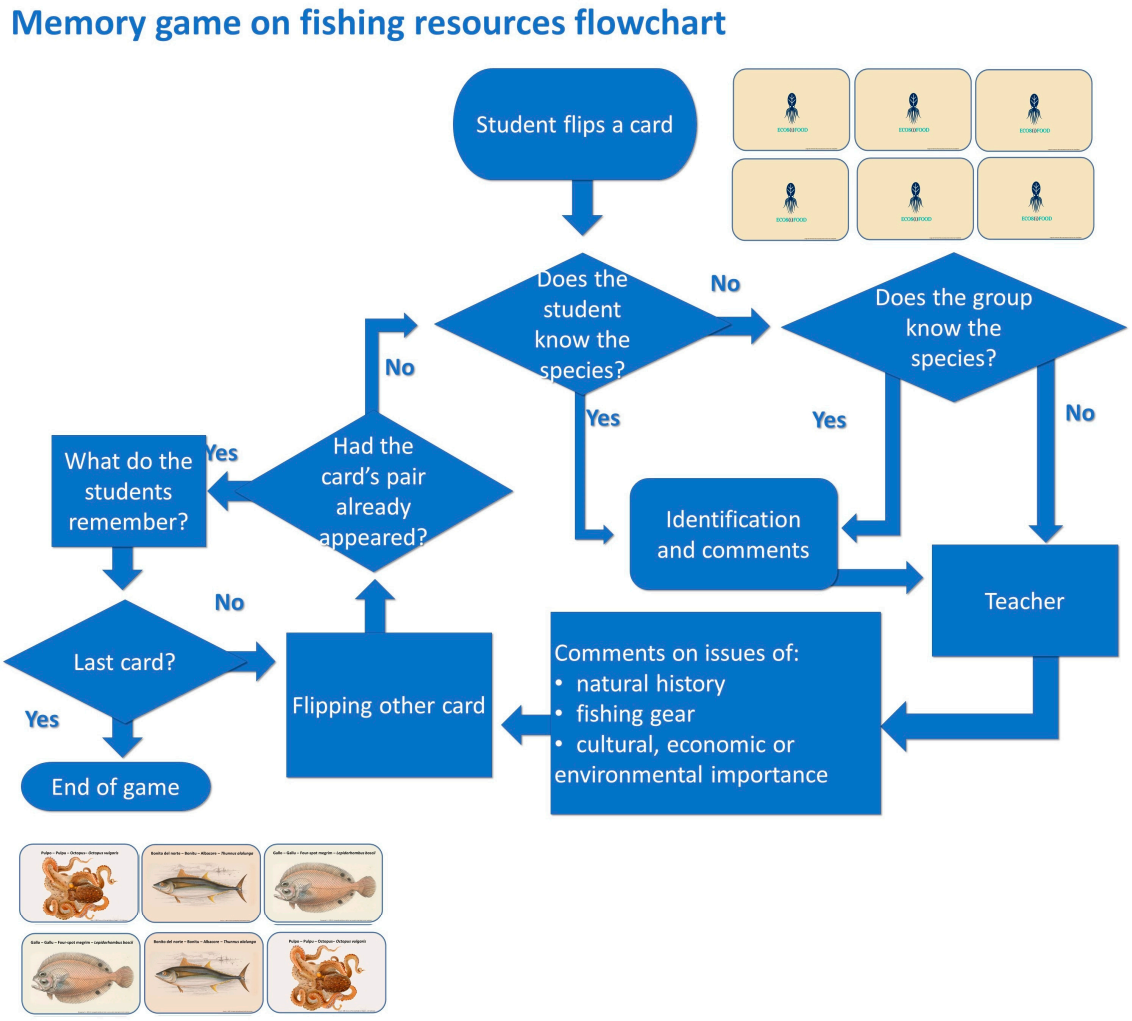

Figure 1. Flowchart of the memory game on fisheries' resources, showing the moments when students comment on their knowledge of marine species and fisheries or add their experiences (peer learning and shared knowledge), and when teacher provides feedback and addresses the learning process towards learning aims (ocean literacy and knowledge about the sustainability of fisheries).

2.3. Implementation of Game-Based Learning in Educational Centers

The game-based learning experience was designed using the learning games specifically designed for the project described in Section 2.2, and therefore it includes the previously described criteria for pedagogy and the sustainability of fisheries. The learning instructional design of the implementation in the educational centers includes as keystones formative assessment, collaborative learning by the students during play, and the generation of shared knowledge among students within a playful environment and addressed by educators associated with the project (not by their regular teachers).

Due to the pandemic caused by COVID-19 from March 2020 to September 2021, face-to-face activities in schools were not possible for people outside the teaching teams of each educational center. In this context, the students could participate in the games designed through a synchronous online connection with us. Thus, the interactive escape room on *Sustainable Fish Consumption* was put into practice in five primary schools (with students from 6 to 12 years old) during the 2020/2021 academic year [61].

In the 2022/2023 academic year, once the restrictions and protection measures were lifted, it was possible to access the educational centers with the game-based learning proposals. The gamified educational activities [63] contained in the games *Sustainable Fish Consumption*, *Fishing Alphabet virtual game* and *Fishing Resources of Asturias Memory Game* could be carried out in face-to-face sessions in 20 primary education centers, with the participation of nearly 1200 students. In collaboration with the teachers of each center, mainly from coastal towns with fishing ports (Figure 2), learning situations related to Sustainable Development Goal 14 were programmed. Following the idea of "conserving and sustainably using the oceans, seas and marine resources for sustainable development" (ODS 14), the learning games designed took on meaning and helped stimulate practical learning about fishing and fishery products and their sustainability. In addition, non-formal education activities were also carried out with primary school students during a summer festival in the coastal town of Salinas (near Avilés on the map), using the online escape room and the memory game about fishing resources.

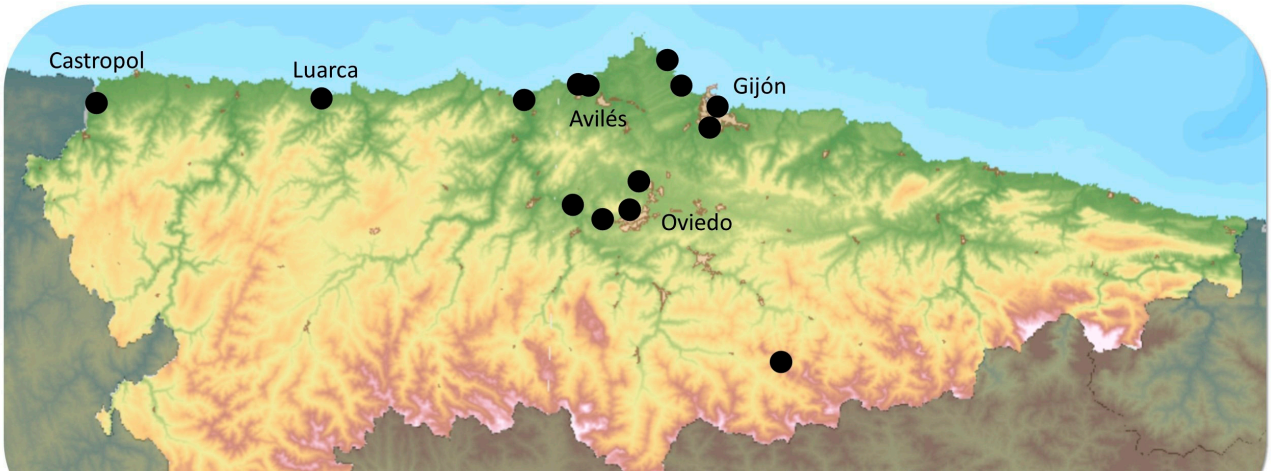

Figure 2. Location of the primary education centers where the game-based learning activities were carried out.

At the outset, a pretest instrument was devised to standardize the assessment of primary students' perceptions towards fish labels when they go to buy fish with their families. However, owing to the limited number of primary school students who accompanied their families to purchase fish, the use of this instrument was discarded in the first sessions. Consequently, it was determined that anonymous and non-traceable qualitative data would be collected in the implemented sessions. The answers of the students during the games and the comments they made about the fisheries and their sustainability, in a non-standardized way, are used in this study. This is a similar approach to that followed in the prior literature presenting environmental games and game-based environmental learning experiences on fisheries, where short-term experiences without quantitative data are described, focusing on a comprehensive portrayal of the pedagogical design underlying the game, including the processes and knowledge that are mobilized during its educational implementation [44,46].

Moreover, the game-based learning sessions included a formative assessment, understood as direct feedback on the information obtained through the dialogue with, and the observation of, the students and their comments in the game, which determined how

part of the educational experience developed (i.e., an assessment for learning according to the recent review by Schildkamp et al. [64]). This type of formative assessment allows (1) a less structured and more informal manner of collecting data (observation, dialogues) and (2) a quick form of continual feedback to steer learning [64]. Both characteristics are especially useful in the case of educational experiences in a short time frame with groups in which the interventions are not repeated, and thus it was determined that this assessment for learning should be chosen for these activities. In this study, observation of the students' comments while playing the games and the continual dialogues with the educator were used to provide immediate feedback, in accordance with the assessment for learning methodology [64]. This approach is consistent with the data provided in other articles presenting environmental games and game-based environmental learning experiences on fisheries [44,46].

3. Results

3.1. Knowledge of Primary Students on Marine Natural Resources Collected in Their Region

The formative assessment [64] on ocean literacy and fishery sustainability was carried out throughout the learning situation that each game fostered (Figure 3). During each activity, the students' answers and doubts about fish consumption, the sustainability of fishing resources, and knowledge of ocean diversity were collected. In this way, it was possible to assess what prior knowledge the students had, and how they were learning the basic knowledge contained in the gamified activities. In this continuous monitoring process, it was found that the students were used to consuming a relatively small number of fish species, which were basically the most consumed species in the region: salmon, hake, gilthead bream, and albacore. Regarding shellfish, their responses included crustaceans such as shrimp, crabs, spider crabs, and barnacles. Among the mollusks, they said they knew clams, mussels, and squid. In some of the schools, students had the expected taxonomic difficulty classifying barnacles (crustaceans) and sea urchins (echinoderms), listing both as mollusks. When they were told that this last animal was also edible, most of the students said that they would not like to eat the sea urchin (*oricio*, in the Asturian vernacular) because of its appearance (without having eaten it). In this sense, it is important to consider that sea urchins not only play a critical role in marine ecosystems but are also part of the Asturian food culture. In fact, the ones consumed are imported from nearby regions. In Asturias, the fishing of sea urchins has been prohibited since 2016 due to the decline in their populations owing to overexploitation and the changing environment [65]. As expected, the students indicated that they were unaware of this situation.

The students knew the fish consumed came from the local fishing activity, from other fisheries, and from aquaculture. But they were not clear which species came from each activity. The students had difficulties establishing the relationship between industrial fishing and some of the fish available, or identifying species caught in distant seas that were transported thousands of kilometers to reach the supermarket. In the first years of primary education, confusion was also detected in students' differentiation between sea fish and freshwater fish. This common learning error was also detected in the escape room game on *Sustainable Fish Consumption*, when students were asked about the origin of rainbow trout.

Regarding the fishing gear, there were comments during the games about nets, angling, hooks, and traps, and the students learned to distinguish one item of fishing gear from another. The issue of fish farms also arose, and they pointed out that they knew that fish or shellfish are raised there. In some cases, they knew local fishermen, or even had them in their close family.

Of the three games used, the memory game (*Fishing Resources of Asturias Memory Game*) showed more ability to activate students' prior knowledge. In this context, it is considered that this activation was greater as there were more abundant interactions during the application of the game that were observable without recording. Perhaps the very dynamic of the game, where the students had to stand around the table holding the cards, facilitated the interaction between them more effectively. Although they gave more species

of fish as known when viewing the cards, this had to do with reading the name of the fish rather than visual identification of the fish pictures. This allowed those students who did not recognize the fish to associate the names of the fish with their appearance and made it easier to reinforce that learning for those who did recognize some of them.

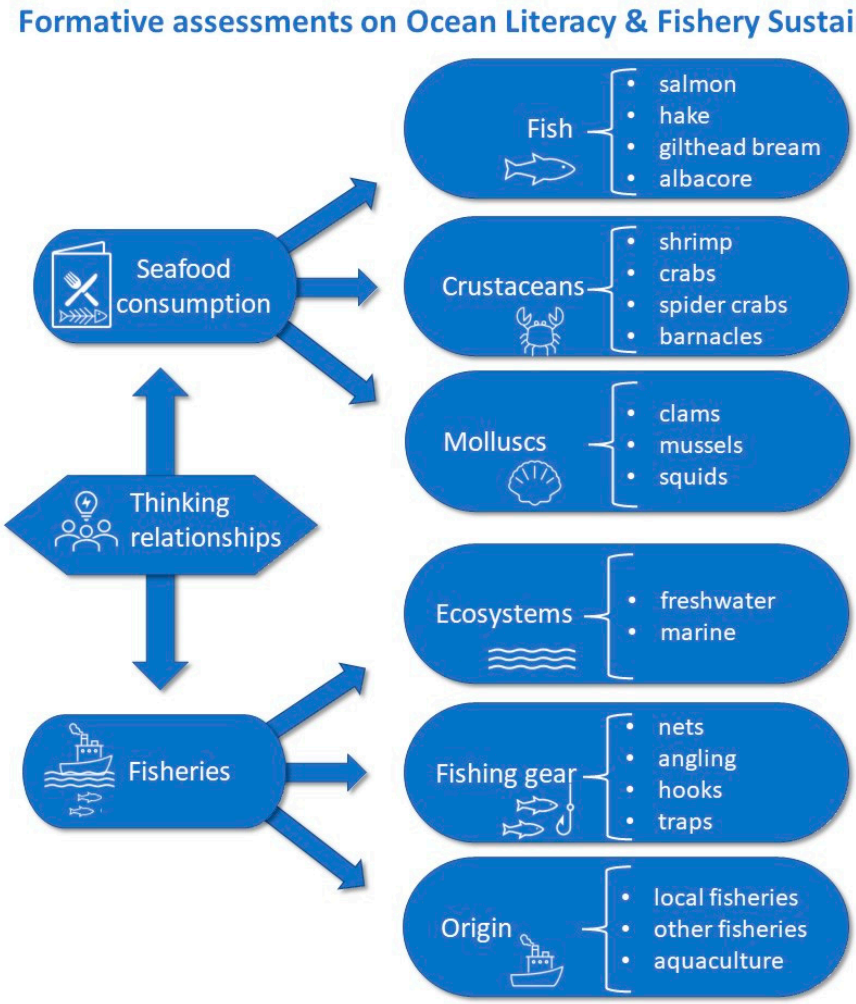

Figure 3. Formative assessments on ocean literacy and fisheries sustainability in the game-based learning experience.

3.2. Knowledge of Primary Students on Sustainability of Fisheries

The subject of fishing sustainability was known in a rather superficial way by primary school students at the beginning of the sessions. In the curriculum for this stage, fishing appears among the primary economic activities and sustainability among the ecological objectives. Basic knowledge such as the awareness that fishing more than the sea produces is not possible, that there are fishing activities that are more harmful than others for the environment, or that the exploitation of natural resources has limits was part of their action competencies [66]. However, the students could not discuss the specific situation of any species of fish or the different environmental impacts of artisanal or industrial fishing gear. Therefore, the ecosocial education approach [67] was presented to the students before playing each game. This educational model explores the interdependence between personal actions and decisions and the ecological environment, targeting an objective on which educational games revolve, especially the one entitled *Sustainable Fish Consumption*, where missions/challenges assign students/players the role that we as citizens can adopt to promote the sustainability of fisheries and the conservation of the marine environment.

As the students developed the game activities, the interaction between them to solve the challenges brought them into contact with questions about the sustainability of fisheries and the contamination of our seas and oceans by plastics and microplastics [68]. Regarding the sustainability of fishing, they assumed the role of responsible consumers who would not consume problematized species. They recognized themselves as people with the capacity to influence the sustainability of fishing through responsible consumption, stating their intention to read fish labels carefully [69] when they accompanied their families to the fishmonger's or to the supermarket. As far as marine pollution is concerned, their comments were mainly directed at not consuming products with plastics and, of course, at raising the awareness of their relatives about the importance of not throwing plastics into the oceans or the environment in general.

3.3. Generation of Shared Knowledge through Game-Based Learning

In the learning situations proposed with these game-based learning tools, students were able to build a shared knowledge [70] about the biodiversity of marine resources and the sustainability of fisheries (see Sections 3.1 and 3.2). Although it features in the curricular content of the basic education stage, this learning process was different in each educational situation. Previous experiences and knowledge already acquired by students were different. The learning response changed between the students in the first cycle of primary education (students from 6 to 9 years old) compared to the students in the most advanced courses (students from 10 to 12 years old). The teaching methodologies to which both were accustomed also collided with the one proposed by the gamified activities. Despite this, it is necessary to highlight the educational advantages of combining these games in the classroom:

- The *Sustainable Fish Consumption* game shows the sustainable use of marine resources through artisanal fishing. In a cooperative learning environment [71], the order of student interactions is regulated so that everyone can face the challenges to be answered within each mission;
- The *Fishing Alphabet* virtual game stimulates linguistic competence [72] by proposing that students choose the correct word related to fishing and responsible consumption derived from their previous learning experiences;
- The *Fishing Resources Memory* game encourages building a narrative about the natural history of fish and fishing exploitation by mixing anecdotes about the species known and/or consumed by students. Memory as a learning resource [73], although it induces short-term knowledge, should not be underestimated. Combined with the meaningful learning [74] that the other two games induce, it can contribute to strengthening knowledge about biodiversity and the sustainability of fisheries.

In all cases, the formative assessments followed during the application of the didactic games made it possible to collect evidence on the quality and characteristics of the learning that the students were acquiring. These items of evidence were key guidelines for adapting future teaching–learning processes [75].

4. Discussion

The presented game-based learning tools make it possible to understand (or reflect on) environmental and social issues related to biodiversity and the sustainability of fisheries. Similar proposals have already been addressed in different ways and by different authors (Table 2) through the design of didactic games (serious games) that seek to highlight specific aspects of the sustainability of fisheries.

Table 2. Comparison between different educational experiences of game-based learning on the sustainability of fisheries.

Name of the Game	Type	Sustainability Dimension	Observations	Reference
Apicum challenge	Digital gamebook	Climate change on coastal and marine environments using economy, environment, and society approach	Secondary education. No data included on students' comments or learnings.	[29]
	Digital role-playing game		Game Maker version. Only one role is possible: student solving a climate change problem. Data on students' outcomes scarce, used in primary education.	[76]
April 18	Role-playing game	Overfishing, fisheries depletion	Students play roles in fishing, such as industrial and artisanal fishermen, representatives of coastal communities, researchers, sharing arguments and positions on cod fisheries management.	[46]
Fishing Alphabet	Virtual alphabet games	Marine biodiversity, fish species, fishing gear, fisheries management	Students check their knowledge of artisanal fishing gear and vessels, species of regional fishing importance, fish markets, environmental impacts, and elements of the ecolabel.	[62]
Fishing Resources Memory	Memory game with cards	Artisanal fisheries on marine natural resources in Bay of Biscay	Students generate shared knowledge about marine biodiversity, artisanal fishing, and species of socioeconomic and cultural importance in the region.	This article
Fishing with Friends	Multiplayer tabletop game	Overfishing	Visitor groups (each group formed of children and adults) at an aquarium play the role of fishermen, trying to balance fishing profits in the short term with the conservation of natural resources in the long term.	[77]
Ocean Limited	Board game	Challenges to marine sustainability, motivations and behaviors of ocean stakeholders	Secondary school students assume the roles of real ocean stakeholders and develop strategies for conflict, collaboration, and social influence to solve marine environmental problems.	[44]
Sustainable fish consumption	Virtual escape room	Marine natural resources, biodiversity, fishing areas, artisanal vs. industrial fisheries and fishing gear. Responsible consumption	Through cooperative learning, students reflect on sustainability of fisheries and the contents of fish labels to choose the most sustainable options.	[61]
Sustainable Sea	Board game	Sustainability of fisheries: overexploitation, artisanal vs. industrial fishing, protected areas, fishing bans	The students become members of the artisanal fishing guild, increase their knowledge about fishing, and become aware of the sustainable exploitation of marine resources.	[45]
The Game of the Sea	Board game	Ocean literacy: marine environments, marine biodiversity, marine science, and threats, cultural approach to oceans.	Students achieve science learning objectives and raise awareness about marine conservation.	[42]

The serious games described in Table 2, analogic (board games) or digital (synchronous or asynchronous online), have been designed to promote learning about fishing sustainability. Their objectives are to increase knowledge about the ocean and marine natural resources, the differences between industrial and artisanal fishing, and the dangers of overfishing, and to raise awareness of serious socio-environmental issues such as climate change and pollution by plastics and microplastics. Naturally, the design or choice of the didactic game should be made considering the desired learning objectives and the characteristics of the proposed educational action. The quality of the learning experience achieved will depend on the methodological approach that the game takes.

Much of the game-based learning design adopts a role-play procedure [78]. These games, which ask students to play a specific role, try to develop deeper thinking or more

empathic processes than other types of games [79]. But the different prior knowledge and skills they possess can alter the development of approaches and actions when they must assume roles that are distant from their lived experience [46].

Sharing the same aims, the three games presented (*Sustainable Fish Consumption*, *Fishing Alphabet*, and *Fishing Resources Memory*) provide a new feature in the inclusion of the role of consumers, incorporating education for responsible consumption [55,80]. That is, they expand the framework of SDG 14 and include Sustainable Development Goal 12 (ensure sustainable consumption and production patterns). When used in the classroom or in online practice, they present motivating strategies that seek effective learning through shared knowledge, cooperative reasoning, and ecosocial empathy. Therefore, they propose basic knowledge about biodiversity, sustainable artisanal fishing, and responsible consumption that transcends the educational environment, transferring the learning [81] they contribute to the daily life of students and their relatives. The measure of the achievement of this horizontal learning will indicate the pedagogical value of these educational games.

5. Conclusions

Game-based learning has emerged as a promising methodology to engage primary and secondary school students in thinking about the sustainability of fisheries. It has been successfully implemented by several authors in different countries, demonstrating its effectiveness.

Game design plays a crucial role in determining which aspects of the sustainability of fisheries are addressed, the level of critical thinking required (related to the educational stage in which the activity is implemented), and the expected learning outcomes. Role-playing games, where students assume the roles of stakeholders connected to oceans, fisheries, or coastal communities, are among the most frequently chosen games for environmental education related to fisheries. Additionally, memory games, board games, alphabet games, and escape rooms have also proven to be successful educational activities.

In the described educational experience, three games were utilized: *Sustainable Fish Consumption*, *Fishing Alphabet*, and *Fishing Resources Memory*. These games introduce the role of consumers to primary school students, incorporating education for responsible consumption and aligning with Sustainable Development Goals 12 and 14.

The potential of these games to assess students' knowledge of ocean literacy and the sustainability of fisheries was found to be very high. They facilitated non-intrusive participation from the students, which is particularly noteworthy as the educational experience was conducted by individuals other than their regular teachers.

One of the key advantages of game-based learning observed in this educational experience is the high level of student motivation it engenders. Whether employed in formal or informal educational settings, games attract students to learn about ecosocial issues, foster shared learning experiences, and promote collaborative reflection.

Reviews of game-based learning in educational experiences with digital games show that there are not always positive or neutral effects from its use and that some negative effects can sometimes occur [33–35]. In that circumstance, a true relationship between game and learning objectives, and the combination of the game with other learning resources/activities, can solve some of those problems [35]. In the game-based learning experiences in fisheries included in Table 2, those negative effects are not commented on. Although some problems in its implementation are commented on due to the (scarce) time that could be dedicated to the game-based learning experience, or because of issues with the technology used [61,77], no learning problems were reported. Perhaps the explanation for this is related to the experiences being short-term ones, in which capturing the interest of the students to participate in the training action is essential, without having to maintain that attention on the game in the long term.

In particular, regarding the limitations of this educational experience, its brief application time in the classroom should be noted. Also, the low participation of primary school students in their families' fish-purchasing decisions is significant. Assessing these aspects

requires a qualitative evaluation rather than a quantitative one. To deal with these limitations, it seems advisable to facilitate access to these resources for teachers and integrate the proposed games into long-term educational programs. Obviously, we also suggest training future teachers in their use and implementing gamified activities in the different educational stages (primary, secondary, and higher education).

Overall, game-based learning proves to be an effective approach for fostering engagement, motivation, and learning in students when they explore the sustainability of fisheries. We should address the identified limitations and take strategic actions for future implementation, since this methodology holds great potential for advancing education on critical ecosocial issues such as the sustainability of fisheries and responsible consumption.

Supplementary Materials: The following supporting information can be downloaded at: http://hdl.handle.net/10651/64230 (accessed on 29 May 2023). The game is *Fishing Resources of Asturias Memory Game*.

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