

Gamifying Environmental Education: A Primary School Perspective Through a Serious Game

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Abstract: Environmental education holds significant importance for society, serving as a means to impart to new generations the principles of living in harmony with nature and cultivating social, moral, and ethical values. Research in this domain has consistently shown that the early incorporation of environmental education can yield benefits for individuals and has a lifelong impact. Yet environmental education researchers and practitioners identify early childhood, defined as ages birth to eight, as a particularly crucial time for developing environmental literacy. This paper presents the creation of a serious game designed to support environmental education in the early stages of elementary school. The developed game addresses the current trends of mobile and flexible learning, recognizing the necessity for engaging and challenging materials tailored for children. Through the assessment of the game, involving 71 users, it became evident that the developed game played a constructive role in the teaching-learning process. The evaluation encompassed aspects such as usability, accessibility, playfulness, satisfaction, and knowledge expansion, revealing the positive impact of the game on these dimensions.

1 INTRODUCTION

Digital technologies contribute greatly to assist us in our day-to-day tasks. This use has been maximized in the last years, due to the social isolation to which we have been subjected, due to the COVID-19 pandemic. In this world scenario, education at all levels and modalities have been forced to improve and innovate teaching and learning processes (Hoofman and Secord, 2021).

It was already being observed that the education system needs changes, and in this sense (Shi and Shih, 2015) warned that teachers and students have different visions and necessities.

Digital games are present in the daily life of cell phone users, whether they are adults, young people or children, combining technology with learning is a path of no return and in this future, the environmental theme has relevance and urgency that more and more

study and spread environmental education (Kudryavtsev et al., 2012).

Environmental education (EE) is not an isolated area of knowledge and action. On the contrary, the context in which it emerged makes clear its purpose of training agents capable of understanding the interdependence of the various elements that make up the life support chain, the cause and effect relationships of human intervention in this chain, of engaging in prevention and solution of socio-environmental problems and to create more just forms of existence that are in tune with the balance of the planet (Jickling and Wals, 2019).

Environmental education leaves a lasting impression throughout one's life. Researchers and practitioners in this field emphasize the significance of early childhood, spanning from birth to eight years old, as a critical period for fostering environmental literacy (Ardoin and Bowers, 2020).

Based on the context presented above, such as the precariousness of teaching and lack of tools for environmental education, this work aims to develop a serious game for EE, in order to contribute to the dissemination of environmental content. To promote the

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usage of the game, we developed a support material, specially addressed to professors, to facilitate the application of the game in their classes.

The structure of this work is divided as follows: In Section 2 the theoretical foundation approaching Environmental Education, Serious games in education are presented. In Section 3 the serious game development process, its skills, methodology and mechanisms are presented. In Section 4 the evaluation process is presented. Finally, in Section 5 the conclusions of the work are presented.

2 BACKGROUND

2.1 Environmental Education

The concept of environmental education is related to formal and informal teaching processes, where individuals build their socio-environmental values to live in harmony with nature and society.

Since the emergence of man on our planet, we have come to modify the relief, climate, soil, air and seas, in addition to even modifying other species of plants and animals, or helping in their extinction. For (Nousheen et al., 2020) nature dominated man in its beginning, between 50 and 40 thousand years ago, with only nomadism without accumulation of goods as its form of survival; with the emergence of agriculture, around 10,000 years ago, and from the mastery of agricultural techniques by community members, man became sedentary, in addition to developing concepts about social and political organization.

During the evolution and improvement of nature management practices, human beings consolidated their domain and the indiscriminate use of natural resources. Human beings need to understand and learn to live in harmony with the planet, because in our recent past, in the last 200 years, with the industrial revolution, the degradation processes of the planet have increased exponentially, on a scale never seen since the emergence of the man on the planet. The principles of environmental education do not advocate that we should stop developing ourselves economically and technologically, but rather seek a balance for sustainable development (Ardoin et al., 2020).

According to the United Nations (UN) (Fritz et al., 2019), the concept of sustainable development is one that meets present needs without compromising the ability of future generations to meet their own needs. to achieve sustainable development, which are them Eradicate poverty; Zero hunger and sustainable agriculture; health and wellness; quality education; gender equality; clean water and sanitation; clean and af-

fordable energy; decent work and economic growth; industry, innovation and infrastructure; reduction of inequalities; sustainable cities and communities; responsible consumption and production; action against global climate change; life in water; terrestrial life; peace, justice and effective institutions; partnerships and means of implementation.

These goals, as well as other global projects involving environmental issues, aim to protect and preserve life on our planet, for current and future generations. The first step, to seek this balance with the planet, is the awareness that nature has limits, also focusing on education, educating the individuals who make up society, making them sensitive to their environment, based on experiences, values and knowledge obtained and lived through an environmental knowledge (Ardoin et al., 2020).

Environmental knowledge is a political epistemology that seeks to give sustainability to life; constitutes knowledge that links the ecological potential and negentropic productivity of the planet with the cultural creativity of the peoples who inhabit it (Kopnina, 2020).

Everyone has the right to an ecologically balanced environment, an asset for common use by the people and essential to a healthy quality of life, imposing on the public authorities and the community the duty to defend and preserve it for present and future generations. Emphasizing that, the EE aims to disseminate knowledge about the environment, in the sense of its conservation and use of resources in a sustainable way. This constant process, where the whole society is consciously involved in dealing with the environment, acquiring knowledge, skills, experiences, values whose purposes are capable of acting, either individually or collectively, seeking alternatives and/or solutions to environmental problems.

Implementing environmental education in schools can pose several challenges. Some of these challenges include:

- **Resources.** Many institutions face budget constraints, competing priorities, and limited access to environmental facilities and experts. This can lead to a lack of funding, materials, equipment, time, and space for environmental education programs;
- **Alignment.** Integrating environmental education into various disciplines and levels of education, from formal to non-formal settings, can be challenging due to a lack of alignment with existing curricula and educational priorities;
- **Engagement.** Some educators may not have sufficient training, support, or incentives to incorporate environmental education into their curricula

and pedagogy. This can lead to a lack of student engagement and interest in environmental issues;

- **Changes in Demographics and Experience.** Environmental educators must address the demands of a constantly evolving social and technological landscape while ensuring that environmental education stays relevant to the needs and interests of the community. This requires continuous adaptation and innovation in educational approaches;
- **Effective Integration of Newer Sources of Information with Experiential Learning Opportunities.** With the rapid advancement of technology and access to information, it is essential to effectively integrate newer sources of information with experiential learning opportunities to provide a comprehensive environmental education;
- **Inadequate Training and Support for Teachers.** Teachers may lack the necessary training and support to effectively deliver environmental education, leading to a lack of confidence and competence in this area;
- **Overcoming Temporal Perspective.** Environmental education is seen as a permanent and continuous process, and challenges need to be considered to rethink the continued training of teachers and seek a continuous improvement in environmental education.

Addressing these challenges requires a concerted effort from educational institutions, policymakers, and the broader community to provide the necessary resources, training, and support for effective environmental education in schools.

2.2 Serious Games

The term *serious games* is used to delimit a form of game, aimed at educational or training purposes, both in schools and in civil and military training institutions. Unlike other media used in education and training, in a serious game the player is actively involved and immersed in an experience where his actions and decisions determine the course of history. In this context serious games can help with new forms of learning, for this to be effective it is necessary that serious games have objectives and consequences, as well as rules (Zhonggen, 2019).

According to (Nadi-Ravandi and Batooli, 2022) Game-Based Learning (GBL) is a pedagogical methodology that focuses on the development and use of games in education, thus being integrated within the form of a serious game, whose objective is not entertainment, but learning. Unlike gamification, where

some elements of games are used, such as disputes for points to reach a higher ranking or achieve a certain reward, then gamification is intended to make a process or daily life of a given individual more playful and interesting, so it will not necessarily have all aspects of a serious game, it is usually integrated into everyday life processes such as in schools or companies to increase participant engagement.

The development of gamification — also referred to as gamification — therefore stems from a rather obvious finding: human beings are strongly attracted to games. Over the centuries, practically all known civilizations were associated with some kind of important competition for the social structure of the community to which they belonged (Oliveira et al., 2023).

The production of digital educational games has multiplied in recent years, given the technological development that provides users with infinite possibilities of access and choice of games. In the educational area, games or gamification have been used more frequently in order to expand and provide meaningful learning. For (Yu et al., 2021) “*games can be efficient instructional tools*”, in the sense that they provide ludicity to learning, through fun and as facilitators of learning, in addition to stimulating mental and intellectual functions who plays.

Games are elements of human culture left over from the dawn of civilization, what differs from current games are the digital formats and platforms that can be used, such as: desktop, smartphones, tablets. The pedagogical practices used at school take advantage of the playfulness of the game to bring content to the student in a more dynamic and pleasant way, for (Acquah and Katz, 2020), however, it is necessary to be clear that the use of games in education as a simple adaptation to formal teaching does not guarantee learning, games alone are not protagonists of meaningful learning, there are other factors that are necessary such as didactic planning, pedagogical mediation and adaptation to the pedagogical project.

In Environmental Education, it is also possible to see a growth in the use of games as learning tools, even though it is not a formal teaching subject, it is present as a transversal theme and uses gamification resources to work on environmental themes. (Zhu et al., 2022) in a study on the evaluation of digital games with educational purposes, that is, games intended for school, elect some characteristics for a quality game, first the game needs to be accessible and easy to understand, in the sense that not all users are gamers, especially in the school environment; the game must be able to mobilize the senses, involve and provide a pleasant relationship; and finally, the game needs to present premises such as “*problem solving*,

understanding and managing one’s own learning” (Zhu et al., 2022).

2.3 Related Work

To evaluate related research, we made a systematic mapping. The search for related works started with a search for scientific articles in repositories (Science Direct, ACM DL and IEEE Xplore) using the search string:

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"environmental education" ) AND
( "digital game" OR "electronic game " OR
"gamification" OR "m-learning" OR
"serious games" OR "mobile learning" OR
"game-based learning" )
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. We filtered the results with two filters, the first being the publication date filter between 2016 and 2023, and the second only research articles, obtaining 62 articles at the end of the process. After reading the abstracts of these articles, 14 papers were selected that contained the theme that is intended to be analyzed, as shown in Table 1:

Table 1: Search filtering.

Repositories	First Result	Publication 2016/2021	Research Papers	Abstract Reading
Science Direct	97	50	42	4
ACM DL	24	16	10	4
IEEE Xplore	6	10	10	5
Total	137	76	62	14

The first analysis of the articles was the tabulation of a spreadsheet divided by repository with the articles of each one, which contained the following data: Title, Author, year, database, published in keywords and abstract. From the analysis of these tables, 14 articles were selected in the same line of work: a game under development, developed or tested by third parties, which dealt with the environment.

With the analysis of the works, we divided the works into groups such as applications based on the use of information from the Global Positioning System (GPS) with and without the use of augmented reality such as, (Lo and Lai, 2019) developed an interaction application based on augmented reality for learning about flora species on a student campus, through a mobile device with a GPS system it is possible to obtain information about the species, as well as links to nearby attractions.

(Huang et al., 2022) developed an augmented reality mobile application to be used in parks or natural environments, when pointing the camera at a plant species, the user receives information regarding it, as in (Lo and Lai, 2019). In the study by (Huang et al., 2022) the results obtained reveal that the use of aug-

mented reality technologies, the emotional impact of the participants with the proposed themes, generating a greater learning connection,

Nowadays, the use of social networks is increasingly frequent, which is why in (Pham et al., 2021), the research group developed an application based on social networks with interactions of GPS mapping applications where users interact with each other, based on posts referring to urban environmental problems encountered in their daily lives, the aim is to raise awareness of the protection and conservation of the environment. The application uses the mechanism of likes among users as an incentive to classify the most relevant posts, making the user rise in the ranking.

In general, the vast majority create games based on protagonists who must somehow perform actions, and are subject to consequences for these actions, for (Priyadarshini et al., 2021) environmental education is limited to conventional means of education such as books, documentaries, videos or animations, a few educational digital games developed to work on themes related to environmental education, the article in question addresses the development and testing of the game Carbon Warrior, which aims to teach about the carbon footprint, and how it influences sustainability . *Carbon Warrior* was developed from a pedagogical point of view for primary and secondary school children and teenagers in India, the game uses a scoring school based on user choices, more sustainable choices generate more carbon credits, the in-game currency. Among the 10 scenarios stipulated in the game, the player still has a help button for decision making and feedback after the end of the scenario.

In (Wang and Nunes, 2019) it was developed with the premise of being a multidisciplinary educational game that contains content of geography, Portuguese language, science, mathematics and environmental education, the choice of different ethnicities and genders for the protagonists, in order to promote the inclusion and diversity. The game is based on 3 phases where the player deals with different situations such as waste separation, waste recovery and the reduction of waste generation, so the game is based on the use of the 3Rs (reduce, reuse and recycle), although the levels of the phases are inverse to the logic of the 3R.

In (Chung-Shing et al., 2020) the research group used a game based on an indigenous community in the Amazon region of Peru, where users make local decisions that influence local life and the state of conservation and preservation of the surrounding forest. The user is placed in the role of deciding how ecotourism should be approached in the region, there is no mechanism for loss or victory, but with each scenario completed, the player receives feedback on the

consequences of their actions.

In (Janakiraman et al., 2021) the research group used a city construction and evolution game based on resource management, focusing on energy production issues and their relationship with the environment. The objective was to analyze whether digital games can be used to increase environmentally friendly attitudes and behaviors.

Similarly, (Tsai et al., 2020) developed a 3D computer interface game with the intention of preventing environmental disasters, within the game, the user must try to achieve the highest possible score, for this they must consider several factors that influence the game, such as money, time, personal interest and public interest, thus having to protect the city against floods in a *tower defense* game style, research has shown that the use of serious games increased learning compared to conventional methods.

In teaching, games can also be used in conjunction with other digital media resources, as in (Gaspar et al., 2020), an approach using a serious game in combination with an explanatory video could help students learn and understand marine environmental themes, more specifically on pollution of the seas, the study shows that most students liked the approach, with 82.6% reporting having learned new knowledge, and 97.8% stating that the learning approach is effective.

Another group of applications revolve around stories based on the reality of local communities, as in (Wang and Nunes, 2019) unlike the other applications mentioned in other articles, the research group developed the production in a different way, creating a collaborative design, listening to a local population of fishermen to base your game on, both in the story part, in decision-making and in-game actions. With this, the presented prototype had a good acceptance by the local community, its objective was to help in the understanding of how the individual actions of each person can affect the environment and the collective. The research carried out showed that digital games are present in Environmental Education in the form of different styles of games, with different approaches and themes related to the environment.

In general, the studies made a contribution to the future creation of digital games for environmental education, either through the different ways of approaching the themes, and also through the style of the games and the results presented. However, during the evaluation of related work, the applications shown were created or tested with a very specific public in very limited subjects, thus being a small scope within all the possibilities related to environmental education, the development of the serious game presented

here in this work has the intended to be an application available for use by teachers and students with a greater variety of work options, that is, the teacher can use it as a wildcard tool in the classroom, adapting its meaning and use as needed.

3 A SERIOUS GAME FOR EE

3.1 Game Scope

Environmental education starts with the educator, but it is necessary to promote materials for this to be possible, the educator alone, within his wide range of tasks at school, can often end up running out of ways to update himself or to produce innovative materials. and new for students. The educator is a reference in the student's education, she is the one who should transmit methodologies to be approached with the objective of enriching and building knowledge. The educator needs to be in constant renewal, updating his knowledge (Kumar Basak et al., 2018).

To guide the scope of the game, we considered the Brazilian context, which defines the environmental education must be worked on at all levels of education in an interdisciplinary and transversal way. This is a standard practice in many countries, as France, USA, Germany, among others (Ardoin and Bowers, 2020).

Even though EE is not inserted as a subject in the school curriculum, it must be approached by the educator in an interdisciplinary way. In Brazil, the *Common National Curriculum Base* (BNCC) is a document that defines a set of guidelines to establish, throughout the stages of basic education, which skills students should develop in their learning, within which the application proposed here fits in the area of Natural Sciences of Elementary School. In Table 2, the general competences are described:

In the next section, the methodology used for the development and the tools and resources used for the development of the game will be presented.

3.2 Modeling and Design

For the development of the game, the Construct 3¹ game engine was used. For the development of the game outline, diagrams were first structured containing the actions and objectives that the player must carry out during the game, based on the natural science skills of the early years of elementary school.

¹<https://www.construct.net/en>

Table 2: Examples of basic education skills related to EE, defined in the BNCC.

Elementary School Natural Sciences	
Competency 3	To analyse, understand and explain characteristics, phenomena and processes related to the natural, social and technological world (including the digital one), as well as the relationships established between them, exercising curiosity to ask questions, seek answers and create solutions (including technological ones) based on the knowledge of the Natural Sciences.
Competency 6	Use different languages and digital information and communication technologies to communicate, access and disseminate information, produce knowledge and solve problems in the Natural Sciences in a critical, meaningful, reflective and ethical way.
Competency 8	Act personally and collectively with respect, autonomy, responsibility, flexibility, resilience and determination, resorting to the knowledge of the Natural Sciences to make decisions regarding scientific-technological and socio-environmental issues and regarding individual and collective health, based on ethical principles, democratic, sustainable and supportive.

The game was designed to create an interactive experience, with simple concepts, based on planting actions with a focus on environmental education. The support material guides the user in the dynamics of the act of playing, being built with the same theme of colors and styles used in the game, in the next sections the development of the game will be specifically addressed.

For the development of the game’s music and graphics, the choice was to use online repositories such as itch.io where it is possible to find free and paid game assets packages, for the game some paid packages created by Studio ClockWork Raven and Vexed were used, having a license to use it for commercial purposes or not, and possible modifications, the credits for the game assets used are in the application menu.

When choosing the game’s background music, it was used by the artist Dieter Van Der Vesten, called Paris Gypsy Swing, the artist attributed to it the Attribution-NonCommercial-NoDerivatives 4.0 International license (CC BY-NC-ND 4.0), thus can be used within the game without modifications and giving due credit for it, the base game sounds were removed and modified from free repositories that do not have copyright. Table 3 summarizes the tools and resources used in the game development.

The choice of genre was simulator, thus allowing the player to be inserted within the environment, the view of choice was the first person with aerial view using 2D elements in Pixel Art style, in which the player must through his actions take care of planting, so when the player uses only 1 species (monoculture) the scoring system received is lower, while when using more species the score is exponentially increased. In Figures 1 and 2, the initial menu and initial screen are presented, executed in a cell phone with Android system.

The start of the game is on the game’s menu screen, which contains the start option, entering the

list of commands, ranking, credits, and the exit button, the layout starts in landscape for better use of the display device. When starting the layout, the background music starts playing, and all the buttons have sound and stand out when touched, so the player receives sound and visual feedback of their actions.

The ranking system is done through data sent within the game to Google’s firebase tool, using its database function, where through the game code, information is filtered and displayed in the ranking. As a future implementation, the possibility of logging in with social networks to share this ranking will be inserted, in the sequence the way the ranking works will be better detailed.

When starting the game, the layout is modified, a new interface appears in which the player must interact with his plantation, new buttons and mechanics are implemented and will be described separately throughout the text, the layout as well as the previous one is started in landscape mode, and cannot be changed to portrait, so it does not depend on the phone’s orientation settings; when starting the layout the background music continues to play, but it can be deactivated in the internal menu; all the buttons have sound and stand out when touched, as well as the interactions with the planting system that will be detailed in another section. The choice of colors, letters and formats for the menus was made in order to be clear and playful.

The menu button, located at the top left of the screen, opens a window with the function of returning to the initial screen, opening the command window, turning on or off sounds and effects, and has a field to type the user’s name and send your score. The score is based on the sustainability points, which will be explained in the text segment on the planting part.

The backpack and store button are fundamental for the player’s actions, in the store through the game’s currency, called money, it is possible to pur-

Table 3: Resources used in the game development.

Resource Name	Resource Type	Resource Reference
Paint.net	Image Editor	https://www.getpaint.net/
Give Your Fonts Mono	Font Editor	https://www.construct.net/en/forum/game-development/tools-and-resources-27/sprite-font-generator-v3-64038
Construct 3	Game engine	https://www.construct.net/
Dieter Van Der Vesten	Repository	https://freemusicarchive.org/music/dieter-van-der-westen/
ClockWorl Raven Studios	Repository	https://clockworkraven.itch.io/
Vexed	Repository	https://v3x3d.itch.io/
Firebase	Database	https://firebase.google.com/



Figure 1: First screen of the game – the user can select one of the elements to enter in a specific game phase.



Figure 2: Game menu.

chase 6 different types of seeds, pumpkin, beet, grape, carrot, cabbage and cherry; when buying, the money referring to the species is subtracted from the money scoreboard, a buy sound signal is still emitted, as well as a coin effect is generated on the buy button; all seeds have a specific growth time, through the backpack button, the player can select and see the amount of stock of a given seed purchased by the store and thus carry out the planting.

The order of actions needed to carry out the planting (Figure 4) starts with the prepare button, it introduces plowed land on the game screen, there are 4 beds with 11 spaces for planting in each of them, then

the watering button, transforms the plowed land into wet land, with this it is possible to select the seeds in the backpack to start planting, the game starts with 3 seeds of each type.

After the seeds grow, with the harvest button, it is possible to harvest the plants and receive a reward in coins (game money) in addition, an effect of coins is generated on the harvested plant, and in sustainability points (ranking points).

After carrying out the harvest, the wet land in which the seed was, turns into plowed land, being necessary to water it for the new planting; it is also possible to remove plowed land, wet land, or wet land



Figure 3: Bee boxes in the game. The use of pesticides minimize the presence of bees, reducing the player’s points.



Figure 4: The plantation interface – the player must choose actions to maintain his plantation that are reverted into sustainable points or decreased money.

with seed, using the remove button, but the seed will be lost and the player will not receive any reward.

For the prepare, water and remove commands it is possible with a click on the screen, or dragging with the finger, while for the harvest one click, and for the planting it is two clicks, this difference serves to avoid possible errors within the game that can thwart the player experience. The game allows the use of pesticides, but it decreases the sustainability points and reduces the occurrence of bees (Figure 4), which, when present, increase the player’s score even more.

In the upper left corner, a sun was added, which has constant animation of the sun’s rays, has five expressions based on satisfaction regarding planting, the more different seeds the player plants at the same time, the better the sun’s reaction will be. The sun has the animations detailed in Table 4.

With this visual feedback, the player notices the difference in the way he cultivates his plantation and feels motivated to maintain a plantation with a greater






diversity of species. Another important factor that contributes to the player’s tendency to make a diversified plantation is the sustainability score that grows passively and actively during the plantation.

To receive the passive score, the player just needs to plant different species, the value constantly rises every second, as each species generates an identical fixed value, this value is cumulative, so if the player plants the six species at the same time, the passive value is six times greater than with just planting one species. Active value is received when harvesting a plant, during harvesting the player will also receive a cash value, the amount received is twice the cost of the seed in the store.

4 EVALUATION

This section present the evaluation process of the prototyped game. To evaluate the prototype made, we

Table 4: Sun reactions in the game.

Reactions	Animations	Criteria
Default		No species planted
Sad		1 species planted
Normal		2 different species planted
Happy		3 / 4 different species planted
In Love		5 / 6 different species planted

used MEEGA+ evaluation methodology (von Wangenheim et al., 2020). The choice of MEEGA+ was made because it is a well documented and abroad applied methodology.

The game "Fazenda Sustentável" was published in Google Play Store and distributed to a set of educators. The evaluation was carried out with 71 participants, which are in the following profile: Educators, from public institutions, with experience of applying game-based learning techniques.

From public institutions with experience in applying game-based learning techniques, Figure 5 presents the results of the evaluation considering the questionnaire defined in MEEGA+ related to the game's usability, and Figure 6 shows the evaluation results related to player experience. We also made a qualitative analysis in the comments on the evaluation. Here we are presenting three positive analysis of the game (free translation from Portuguese):

- *I really liked the design of the game. This retro vibe is also very interesting. It reminds me a lot of games like Harvest Moon, which I liked a lot. It also has an Animal Crossing vibe but with a very focused look at the environmental issue, which I find very interesting to be worked with all audiences, but mainly with younger people from basic education. I believe it is a very valid strategy to work on environmental education and some practices that can be developed in a domestic environment. And I think it can be very well used while spending time too.*

- *Graphics are very cute and even detailed and seem to be much more filled with goals to accomplish. You not only have to take care of the farm but also care about the environment by planting trees near the river, something that until now has not been seen in a crafting game since it was never the focus.*
- *At first, I liked the game to be in the pixel style because I really like games like that. The approach to the environmental theme I also found interesting because it is an ideal model of a farm that tries to generate the least possible amount of environmental damage and bring a message behind it. The diverse elements like cattle, bees, trees, etc., also made me like the game.*

Figure 5 presents the results of the evaluation considering the questionnaire defined in MEEGA+ related to game's usability, and Figure 6 shows the evaluation results related to player experience.

We also analyzed a set of suggestions to improve the game (freely translated from Portuguese):

- *I think the game can improve on several factors, including: Improve the farm by providing mouse-dragging mechanics for planting and harvesting;*
- *Improve the composting part that needs to be better explained how it works;*
- *Assign a story with characters;*
- *Make the game playable vertically on mobile devices;*

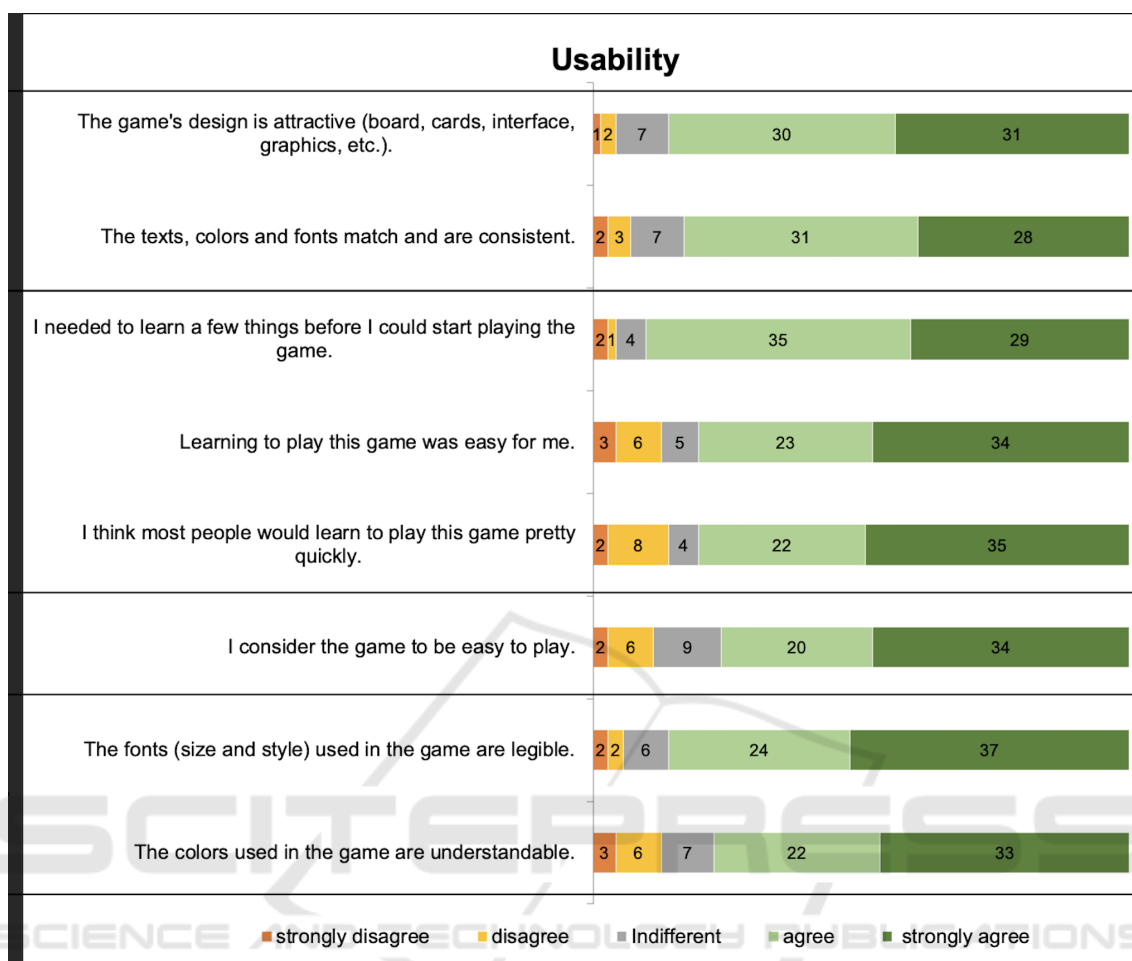


Figure 5: Evaluation of game usability.

- *Improve missions, assigning easier missions and making them more difficult as you progress through the gameplay;*
- *Improve the function of pesticides and plant enhancers so that they have a greater impact on gameplay;*
- *Assign new plants with the highest cost providing a more comfortable development.*

The analysis of the results in the evaluation process shows that the game had a general good evaluation related to the usability.

5 CONCLUSIONS

Environmental education has support from the legislature for its implementation in many countries, as for example in Brazil, but in many cases not materials or activities that generate students' interest in the sub-

ject, which is why the importance of developing environmental education games tends to help formal educators and informal games, given this scenario, the purpose of the article is to address the development of a game on this theme.

The games analyzed in this work served as a basis for the development of the sustainable farm game, the application of educational games focused on environmental education contextualized to a possible reality encourage players to assimilate information and content through their actions, thus creating a greater interest in the environmental theme.

During the testing phase, acceptance of the game was high, however, game development can be a little complex as the game project grows, both for technical development and financial issues, as future research intends to expand the game to increase activities and game modes.

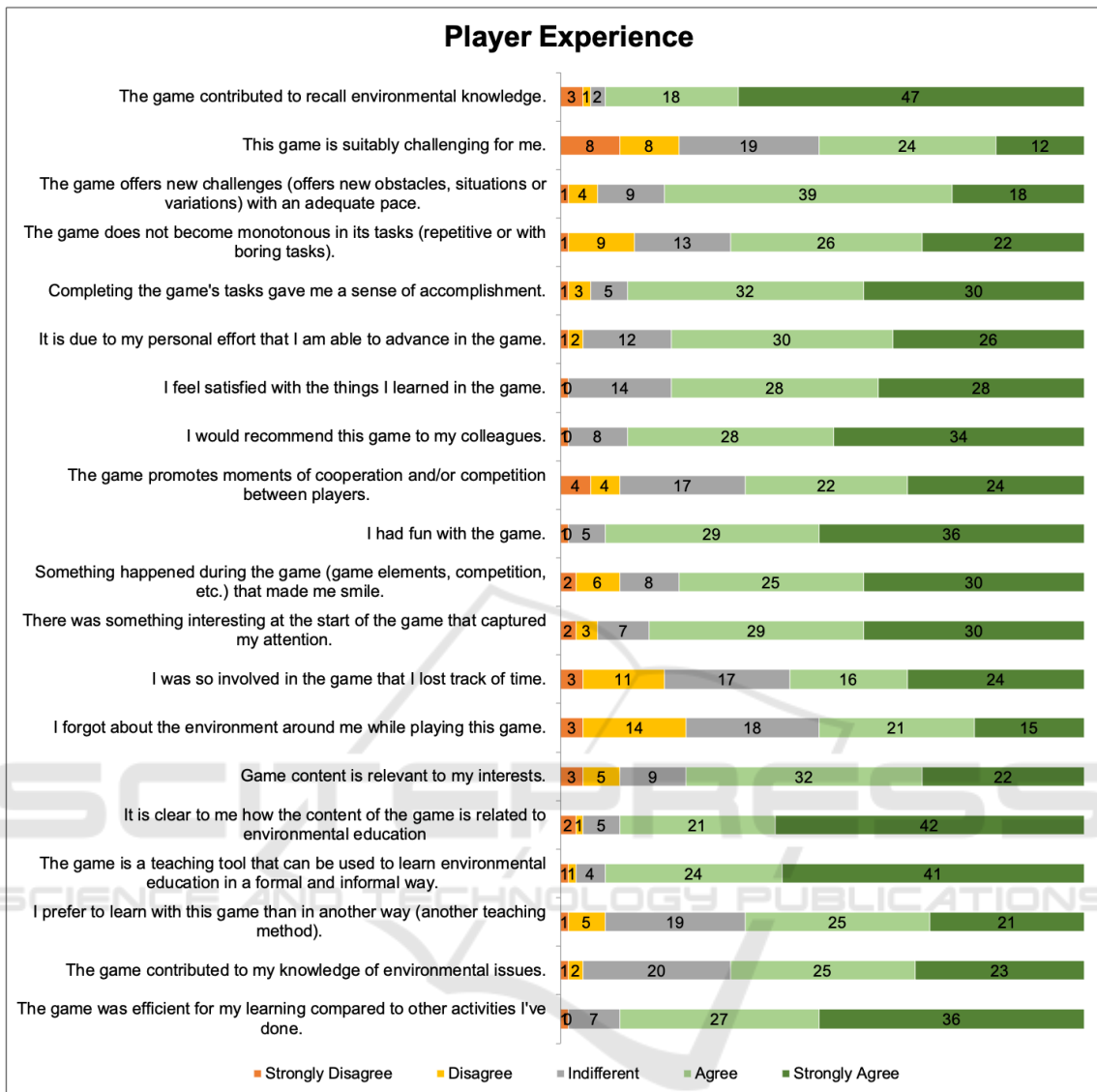


Figure 6: Evaluation of player experience.

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