Mechanical 2021: Educational Game Concept to Promote Sustainable Thinking and Cooperation in Basic Education in Brazil

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Abstract

This work aims to present the results of preliminary tests of the concept of a board game whose objective was to make people aware of the importance of their social/environmental responsibility related to the treatment and collection of plastic and electronic waste. The game is not characterized by competition between players, but cooperation, as it uses friendly social interaction to complete objectives. Based on aspects of the tabletop RPG, players must play as a team, evolve their characters and develop strategies together to overcome challenges. Two tests were carried out involving eight students aged between 12 and 13 years old, attending the 7th year of Brazilian elementary school. The purpose of these tests was to see if the idealized mechanics and rules were working as planned. As a result, some mechanics and rules were identified that were not operating correctly during the game. Another result obtained was the need to prepare an illustrative manual to facilitate the understanding of the rules. According to the tests, we concluded that the game not only addresses issues that work on cooperation and teamwork, but also involves logicalmathematical reasoning and creativity. It was found that sustainability should be better addressed in the game so that it has a greater reflective weight. As future work, we intend to adjust the identified deficiencies in the game in order to test again and see if the improvements resulted in better gameplay and cooperation between players.

Keywords: Board Game, Cooperation, Sustainability, Education, RPG



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1 - Introduction

Currently, making the right choices, from opting for sustainable consumption behaviors, whether health or well-being, is necessary for the maintenance of life on the planet (Nakajima and Lehdonvirta, 2013). Nakajima and Lehdonvirta (2013) argue that even people who develop awareness of the importance of the benefits of the right choices in their lives, have difficulty changing certain habits. And in this context, games can act as a driver of changing habits, because in this constantly changing world, gamification over time has been studied and used in several different scenarios, whether educational or business, aiming at changing situations and improvement of human sociability.

Gamification is gaining recognition not only in the sports sector, but also in other sectors such as road safety. In 2011, the Swedish National Road Safety Society and Volkswagen hosted the Speed Camera Lottery, a lottery system in which drivers participated when the speed limit was respected (Blohm and Leimeister, 2013). Another example in the metro sector is BahnSout4, which encourages Munich metro users to report damage to train stations. All examples do not represent or are games in the exact sense of the word, they only make use of possibilities that engage users in the use of products in a relationship of participation and "award" (Blohm and Leimeister, 2013).

In these attempts to use games for a specific purpose, Koster (2005) states that playing a game aimed at completing a goal is actually recognizing a specific type of pattern and playing make-believe is recognizing another pattern, that is, both although they are different in certain ways, they have the same logic, solving patterns.

It is in this context that the Mechanical 2021 project, presented in this article, aimed to raise awareness among the community and promote citizens' environmental education and responsibility in relation to the correct treatment and collection of plastic and electronic waste. This, in turn, was initially developed as a product concept for the participation in the second edition of the Electrão contest¹. The game concept is characterized not by competition between players, but by cooperation in completing objectives, as it uses friendly social interaction to complete the project's purpose. Social interaction is the foundation of the construction of the person since it is in the context of these social relationships that language, cognitive development and knowledge of oneself and others arise (Heidrich, 2020).

From this perspective, the school is an environment where social interaction, sustainable thinking and actions must be encouraged and practiced daily. Kapp (2012) infers that gamification can and has been one of the tools used in education to create an effective connection between the need and the practice of these principles so essential to life. Gamification is part of the set of active methodologies that enhance the playfulness of learning, transforming it into more collaborative and participatory issues, contributing to the integral formation of students (Paiva et al. 2019).

Having defined the introductory scope, this article develops with section 2 with a reflection on the role of games in the teaching of sustainability and social responsibility having a joint influence of gamification. Section 3 seeks to describe the methodology used in each stage of the game's development. Section 4 describes the case study in which the game was structured. Section 5 presents the concept of the game, justifying the choices and those of each element

¹ For more information about the contest visit: https://academiaelectrao.pt/vencedores/. Access at: 04/08/2022.

belonging to the game. Section 6 describes how the preliminary tests took place, ending this article with a reflection on the results obtained after the tests.

2 - Context and literature review

2.1 - Teaching through games

Currently, games are used as educational tools for adults in training and developing mental, emotional and even physical skills (Souza; Chagas; Silva, 2011). According to Pires; Hey; Teixeira (2012) the first games aimed at education and also at the development of strategic skills were war games that later evolved into business games, in which the first version of the game called Top Management Decision Simulation was developed by American Management Association in 1957.

This culture of using games for learning allows learning in an ever-emerging and everchanging environment (Borges and Sproedt, 2012). In addition, games can influence the generation of a perfect playful environment for the development of social skills capable of helping the person to face uncertain social dynamics (Borges and Sproedt, 2012). Martin; Canada; Acedo (2017) comment that scientists from all over the world whose object of study is the brain agree on the fact that games, when having the challenge/conquest/reward cycle, promote the production of dopamine in the brain, which in a way reinforces the human desire to play. In this case, Martin; Canada; Acedo (2017) say that play is something already known and at the same time common with regard to social work.

Socially, Titiev (1992) says that games are considered biocultural, because people's bodies can perform any required action and each culture says how to use it based on the rules of each game. The author complements stating that many children's games end up training them for adult tasks, presenting educational functions. Koster (2005) adds that gamification involves the educational context, so games are good teachers of something, the question is what they end up teaching. At this point, it is necessary to develop good practices, linked to issues of social importance and maintenance of life, as it is essential that games should assist in a learning process aimed at the sustainable development of human relationships and societies.

2.2 - Games and gamification

Minina and Nikitina (2012) explain that games are attractive because the development and sharing of knowledge happen concomitantly with emotional exchanges that are natural factors in human interaction. Regarding gamification, Werbach (2014) writes that it should be understood as a process, that is, the process of making activities more similar to games, and in this way we create a clearer adjustment of their perspective of academic understanding. Both operate in synergy to most of the time achieve a specific goal, and nowadays, the appreciation for games and the potential for using gamification is growing.

An example of games for people instruction can be cited the use of serious games with virtual reality to train people in the moment of evacuation of buildings during an earthquake (Lovreglio et al., 2018). The authors also claim that serious games represent a new way of investigating people's behavior to deal with building evacuations in the wake of an earthquake. An online game named "Beat the Quake!" was developed by Earthquake Country Alliance in which the game prepares people to take precautions against earthquakes (Lovreglio et al., 2018).

In terms of solving problems as a team, Schrier (2018) says that by putting players to solve problems together, it makes them start to realize that people have different skills and have different ways of helping. This ends up making players more receptive to different types of skills and experiences, helping others to feel socially included (Schrier, 2018).

As for teamwork, we can have games whose objective does not involve competition itself, but rather cooperation between players. Competition and cooperation have concepts that distinguish one from the other, because while competition occurs when a player achieves a goal that others cannot. Cooperation, on the other hand, happens when a player achieves a certain goal when all other players achieve the same feat (Peng and Hsieh, 2012).

This context is closely related to educational principles exposed in the National Curricular Common Base (NCCB)², a document that guides education in Brazil. Gamification is one of the active methodologies that are current tools used in education to develop an integral learning of the subjects. Thus, according to the introductory text of the NCCB (2017), it is extremely important for Brazilian education to present and apply diversified didactic-pedagogical methodologies and strategies, including gamification, "using different rhythms and complementary content, if necessary, to work with the needs of different groups of students, their families and culture of origin, their communities, their socialization groups, etc." (BNCC, 2017, p. 16).

Using these differentiated methodologies from a "traditional" model is to be in line with contemporary demands for the formation of the subject, not only transmitting knowledge, but actually building it with students and effectively assisting in the process of integral formation of conscious individuals for society. Where these beings are capable of sustainable actions guided by real social responsibility.

2.3 - Sustainability and social responsibility

Involving games and environmental education, Queirós and Pinto (2022) argue that gamification applied with the aim of promoting social responsibility influences the generation of knowledge and sustainable practices with regard to recycling or reducing the consumption of non-renewable energy. Since this must be addressed in society and in schools, being more than just individual attitudes but serious public policies.

This situation, until 2020, could be found in the basic education network in the city of Rolante, Rio Grande do Sul, the municipality where the game tests were applied. The municipality, both in its public and private education network, defended the insertion of elements of sustainability and social responsibility, either through the creation of school cooperatives, or in the sharp reduction of plastic waste in the school routine. The school where the game was tested belongs to a private school system, the Notre Dame network, but because it was located in the city in question, it was also encouraged to rethink some of its practices, and it did so effectively. With the change in municipal management, some of these principles were out of focus in the public network, but they were rooted in the culture of the private school, which maintains the awareness of acting in the area with its students. For this reason, the game that we present in this work showed a sense of real importance in the children who tested it, this demonstrates a factor of relevance of the study, since the greater

² The acronym of the document in Portuguese is BNCC (Base Nacional Comum Curricular).

the participation the greater the awareness of the subjects regarding the importance of sustainability and responsibility everyone's social.

3 - Methodology

For the development of the game, the seven steps of Design Thinking by Ambrosi and Harris (2010) were used to provide a quick idealization with simple steps of creation, from the first sketches, to prototyping. As for the preliminary tests, a non-participant observation was chosen, observing what worked or did not work in terms of mechanics and dynamics used in the game. For this, some observation criteria were used, which are: (1) As for the proposed objective for the game, was it completed?; (2) As for the mechanics developed for the game, were they easy for players to learn?; (3) As for the dynamics proposed for the game, does it offer fun and learning?; (4) What didn't work in the game? Our methodology as shown in Figure 1 was divided into three phases: Concept; Tests and Feedback from Participants.



Figure 1: Development Stages

In Phase 1 we idealized the game based on a case study of an educational game, having the seven steps of Design Thinking as a development framework. After establishing the game's concept, we finished Phase 1 with the prototyping of all the materials that make up the game. Phase 2 involves effectively testing the game already with the physical materials of the game so that we can verify every detail involving mechanics, dynamics and the aesthetics used in the materials that are working as planned. Phase 3 is dedicated to reflecting the information acquired in the tests, taking into account the opinions of the participants who tested the game.

For the tests in advance, parents and the school administration were asked for permission to use the image of students in recorded video of the test, for exclusively academic purposes and further analysis. Two tests were proposed with eight students of the seventh year of elementary school aged between twelve and thirteen years. Each test lasted approximately ninety minutes and served to demonstrate the functionality of the game, its rules, dynamics, etc.

4 - Game concept based on a case study

As an educational game proposal, Mergener; casenote; Bez (2020) proposed a board game concept called Conquistadores das Areias. This game aimed to act as a support tool for the teacher in the classroom for teaching specific contents of history and geography for the sixth year of Brazilian elementary school. In developing the game's concept, Mergener; casenote; Bez (2020) elaborated some design requirements for the game, these being: Capacity for four players; use of tabletop RPG³ mechanics and cooperative play.

By putting all these guidelines together, Mergener; casenote; Bez (2020) managed to design an educational game in which students (players) did not compete with each other, but played cooperatively in completing the objectives as a team. Figure 2 presents the concept of the game Conquistadores das Areias materialized for the initial tests.



Figure 2: Ultimate aesthetics of the Conquerors of the Sands game

After the tests, Mergener; casenote; Bez (2020) concluded that the design requirements used in the game concept were not only effective in completing the main objective, which was to provide the teaching of specific content in a playful way, but also can serve as guidelines for future work involving games, education and other application context. In addition, the author found that the use of tabletop RPG elements such as teamwork among players is a good alternative for working on social interaction among students.

5 - Concept used for Mechanical 2021 game

In 2020, Academia Electrão⁴ proposed the second edition of a competition that aimed to award innovative projects in the area of management of electrical equipment, batteries, accumulators and used packaging. Academia Electrão is a project by Electrão, a Waste Management Association that aims to contribute to the circular economy objective, involving various types of waste that we manage, namely: packaging, electrical equipment and batteries.

As a way to participate in the contest, a game was created keeping in mind the existing rules and categories that accepted a game to compete for the prize. Based on the design

³ The acronym RPG stands for Role-playing game. For more general information about tabletop RPGs, visit: https://www.zoom.com.br/jogos/deumzoom/rpg-de-mesa. Access at: 04/08/2022.

⁴ For more information about Academia Electrão visit: https://academiaelectrao.pt/. Access at: 04/08/2022.

requirements used by Mergener; casenote; Bez (2020), it was decided to design a game using some elements of the tabletop RPG. Likewise, it was also chosen to use cooperation between players and not competition like Mergener; casenote; Bez (2020) proposed in his game, however, designing it to be played not only in the educational context but also in the family, encouraging interaction between parents and children. Figure 3 shows the sketches for building the game board.



Figure 3: First studies and idealization of the game

The story of Mechanical 2021 takes place in a Steampunk-style apocalyptic future in which players must defeat the oppressors (zone bosses) and build recycling plants to be able to beat the game, as it is a cooperative game in which they are only players against the game. Figure 4 shows the final concept used for the game board using images only to exemplify what the aesthetics used on the board would be like in terms of design.



Figure 4: Final concept for the game board

The Mechanical 2021 game has simple and easy-to-learn rules, being a game featuring tabletop RPG features such as character creation and collaborative work between players. The game is for 4 players and each game is estimated to last approximately 45 minutes depending on the strategies that players will use during the game. It is estimated that children as young as 10 years old can play and it is a game designed to be used as an educational tool

within the classroom and as an entertainment game for the family. The objective of the game is to conquer the 4 territories and promote sustainability through the construction of recycling plants. The game ends when players have lost a territory 3 times due to death by an oppressor. Figure 5 presents the concept for the player board.



Figure 5: Final concept for the player board

We chose to use a rustic and aged aesthetic to visually provide what the game environment is like for the players, taking into account the elaborate story. Figure 6 presents the aesthetic concept of the cards that make up the support materials for players. The illustrations, as well as the images used in the aesthetics of the board, were only used to represent the closest aesthetic to the game. On the back of the cards, icons were used to make it easier for players to identify each type of card.



Figure 6: Final concept for the game cards, front and back.

The card represented by the letter (A) corresponds to the weapons or arsenal cards that players can add to their characters to facilitate gameplay when they face a challenge that requires attack or defense powers. The card with the letter (B) are cards that have defensive actions to help the player character to withstand damage caused by other cards. The card represented by the letter (C) are cards that have auxiliary or support effects, helping player characters to complete tasks more easily during the game. The card with the letter (D) corresponds to the oppressors (bosses) of certain areas of the board that players must win in battles. Finally, the letter with the letter (E) represents the treasure cards that players can find

during the game to earn extra bonuses. To help players understand what each icon designed for the game represents, a legend has been added to the board as shown in Figure 7.



Figure 7: Concept for game icons legend.

As support materials, small tokens such as game victory tokens and treasure tokens were added to promote greater immersion in the game and also to facilitate resource management during the game. Figure 8 presents the markers developed.



Figure 8: Concept of the idealized markers for the game.

The marker represented by the number (1) marks the amount of energy that the player character has in order to activate the effects of support cards. The numbered marker (2) marks the amount of life the player character has. The number marker (3) is placed on the map to indicate the location of treasures. The marker with the number (4) indicates which treasures have already been found by players on the game board. The number marker (5) indicates the position on the map of the oppressor (boss) of an area of the board. The number marker (6) indicates the oppressor that the players have already eliminated. Figure 9 shows the final render of the game concept and its components used to participate in the contest.



Figure 9: Final representation of the game and all its components

After the final result of the contest released by Academia Electrão in July 2021, the game concept won first place in the category that was entered. With the positive result, the next step was to test the game to see what was working or not in terms of proposed mechanics and dynamics.

6 - Preliminary game tests

Test 1 – The first test was carried out with four boys aged 12 and 13, students in the seventh year of elementary school, with the presence of the teacher who helped throughout the test, as shown in Figure 10. After reading the rules, the operation and the game's objectives, they drew their characters and positioned themselves on the grid of the board.



Figure 10: First test of the game

From the first moment they tried to align themselves in cooperation to fulfill the proposed objectives, the participants initially did not pay much attention to the configuration of their characters, in terms of the weapons and armor available on the cards, this made them have greater difficulty in battles, but in all of them they acted together. This demonstrated that everyone could cooperate to overcome difficulties, they were very questioning about the rules, they wanted to understand everything and have fun playing. However, they presented difficulties in making decisions as a team, sometimes they differed in the group's choices and this proved to be an assertive point of the game's proposal, as they managed to work moments of cooperation linked to having time to talk and listen, even in the difficulty they had autonomy to negotiate and argue the best paths for the group.

Test 2 – The second test was now carried out with four girls aged 12 and 13, also students in the seventh year of elementary school and also with the presence of a teacher, which can be seen in Figure 11. It was observed that the participants acted differently from the boys since the beginning. After the explanation and reading of the rules, the group already tried to coordinate their actions for the common good, while in the first test, the participants cooperated in the combat, the participants of the second test moved around the board thinking about the group and the achievement of the objectives effectively.



Figure 11: Second game test

It was noticed that they had fun with the discoveries and constantly exchanged information, helping each other, they presented a synergy of action and approached several possibilities of path and problem solving, always listening and coherently deciding what they would do. They presented a little more difficulty in the initial combats, as they were not used to tabletop RPG games. However, they quickly learned from the tips their colleagues gave even outside of their shift. They progressed through the quadrants of the board faster due to their cooperation, they always discussed everything listening and speaking logical and focused arguments.

Both groups showed ease of acting as a team, but the participants of the second test showed a more refined and more accurate cooperation in the face of challenges. While the participants in the first test helped each other at critical moments, the participants in the second test acted to minimize the critical moments. The game showed a lot of potential for cooperation and exchange of information related to sustainability and the distribution of resources. The combats were complex at times due to some participants not having explored much the system of configuration and maintenance of the characters' resources, but the participants were challenged and had fun with the challenges and their solutions created together.

Conclusions and future work

Taking the observation criteria during the tests described in the methodology, it is concluded that the objective of the game was not achieved in its entirety, since critical thinking related to sustainable awareness must be better explored. However, the objective of influencing participants to play cooperatively instead of competing was successfully achieved. It was noted that some mechanics should be rethought to give more emphasis to the theme of sustainability during the game and some dynamics should be introduced to make the game more fluid.

In technical terms, it was noticed that some game elements such as the fragments used as a bargaining chip should have their size increased to facilitate their use. It was observed that the size of the board used during the tests, which corresponds to the area of an A3 sheet, although it allowed the students to play, proved to be small for the various actions that can be taken in the game. It is believed that a board with an area equivalent to the size of an A2 sheet may present better future results. Although at the time of testing there was still no concept of a manual for the rules and operation of each element of the game, the elaboration

of a simple and intuitive manual could help players to understand the rules and dynamics of the game faster, so that in the future they do not need constant help from the teacher.

Regarding the mechanics used in the game, the rules proved to be difficult to assimilate without the help of the teacher who already had a full understanding of how the game works. It is estimated that some rules should be simplified so as not to stagnate the game due to lack of clarity for players. Another detail observed during the tests was the comment of one of the students who asked "When will this end?" The student's question revealed points to improve in relation to the fluidity of the game, which may be influencing boredom due to the players' difficulty in overcoming some challenges. A positive point related to mechanics was the constant use of mathematics, mainly in the use of addition and subtraction of bonuses and other dynamics present in the game. Another detail observed was the possibility of adding small objectives in the game to provide small satisfactions to players before completing a larger objective.

Another fact identified was that the game can not only be used within schools but can also be played with the family, promoting the approximation of parents and children and acting as a tool for teaching sustainable awareness in the new generations. In addition, the game promotes the practice of other skills such as freehand drawing and the training of creativity and strategic management of resources, which indicates a potential way to explore new dynamics during the game.

For future work involving the game Mechanical 2021, it is proposed to continue its development and implementation in the academic field in order to identify other possible application scenarios, as well as the description of the results achieved during the applications for publication and dissemination in articles and conferences. Another possibility for future work is the idea of transforming the game that is currently configured for the analog platform, as it is a physical game, to be remodeled for the digital platform, thus increasing the rate and reach of dissemination. Another idea for future work is the possibility of new games being developed within Mechanical 2021's feature which is to put players in collaborative work working together to win the game. This idea should be complemented with the development of new games with the objective of promoting social interaction, awareness and empathy between people, as behavior change can be an excellent path as an idea for new playful projects.

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