BomberKaboom: An Educational Game for Environmental Awareness Through Classic Mechanics

Vitor Ferreira[1], João Nunes[1], Anna Oliveira[1], Saymon Cassiano[1], Juliana Félix[23], Thamer Horbylon Nascimento[12], Fabrizzio Soares[2]

[1]Instituto Federal Goiano – Campus Iporá (IF Goiano)
Iporá – GO – Brazil

[2]Instituto de Informática, Universidade Federal de Goiás (UFG)
Goiânia – GO, Brazil

[3]Escola Politécnica e de Artes, Pontifícia Universidade Católica de Goiás (PUC Goiás)
Goiânia – GO – Brazil

{vitor.hugo2, joao.angelo1, anna.carlos1}@estudante.ifgoiano.edu.br

saymon.cassiano@estudante.ifgoiano.edu.br, julianafelix@ufg.br

thamer.nascimento@ifgoiano.edu.br, fabrizzio@ufg.br

Abstract. Introduction: *Environmental awareness is an urgent topic, especially among younger generations. The use of digital games in educational contexts has proven effective in engaging students and promoting learning in a playful way. In this context, classic game mechanics can be powerful allies in the educational process.* ***Objective:*** *This paper presents BomberKaboom, an educational digital game designed to raise players' awareness of environmental issues, such as wildfires and urban pollution, through mechanics inspired by the classic Bomberman.* ***Methodology:*** *The game was developed using the Unity engine with pixel art style, incorporating pedagogical goals related to environmental education. The system was evaluated by Computer Science students, who played the game and completed a questionnaire addressing usability, engagement, and thematic perception.* ***Results:*** *Participants reported high engagement and highlighted the game's educational potential. The playful approach was considered effective in addressing environmental themes, and the retro aesthetic was well received. The findings suggest that games with familiar mechanics can facilitate the assimilation of important content and foster meaningful learning experiences.*

Keywords *Educational Games, Environmental Awareness, Environmental Education.*

1. Introduction

The global environmental crisis, evidenced by phenomena such as climate change, deforestation and pollution, has generated significant impacts on ecosystems and on human quality of life. In the face of this scenario, environmental education is highlighted as an essential tool to raise awareness and engage society in the preservation of the environment, emphasizing that environmental education contributes to the development of critical and conscious individuals capable of promoting actions that support the sustainability of ecosystems[Silva e Araújo 2023].

Recent data released by the United Nations Environment Programme (UNEP) indicate that air pollution is responsible for approximately 7 million premature deaths annually, mainly due to the emission of fine particles and toxic gases from industrial activities, wildfires and deforestation[UN Environment Programme 2021]. Furthermore, the latest report of the Intergovernmental Panel on Climate Change (IPCC) shows that both the number and intensity of wildfires have increased significantly, especially in regions of tropical forests and savannas, due to the interaction between climate change and human action[Intergovernmental Panel on Climate Change 2021]. These data reinforce the need for public policies and educational strategies that promote emission reductions and ecosystem conservation.

Environmental education is essential for fostering awareness and socio-environmental responsibility, especially in times of global crisis. During the pandemic, the adaptation of educational strategies was crucial to maintain student engagement with environmental issues[dos Santos et al. 2022]. This highlights that the integration of active methodologies and technological resources in remote teaching enabled the continuation of educational practices, emphasizing the importance of training critical citizens committed to sustainability. In this context, the use of educational games emerges as an effective tool, providing an interactive experience that facilitates the understanding of environmental concepts and encourages reflection on sustainable practices.

The integration of digital games into education has been the subject of study by various researchers. [Gee 2003] argues that video games incorporate effective learning principles, such as problem-solving in meaningful contexts, immediate feedback, and the promotion of active identities among learners. These elements make digital games potential tools for engaging students in educational processes, facilitating the comprehension and application of complex concepts.

The integration of digital games into environmental education has proven to be an effective approach for engaging and raising students' awareness of ecological issues. A review of 27 studies identified 28 environmental games that demonstrated efficacy in teaching and learning topics related to the environment, with a predominance of research in Europe, highlighting the need for more studies in regions such as South America. Furthermore, the review underscored the importance of developing games tailored for early childhood education, aiming to fill existing gaps and foster environmental awareness from the earliest stages of learning[Silva 2024].

In this context, the game BomberKaboom emerges as a playful and educational proposal designed to spark ecological consciousness through interactivity. With a fun yet reflective approach, the game invites participants to tackle environmental challenges such as forest fires and the accumulation of urban waste, encouraging actions that preserve and restore the environment. The game's pedagogical design aligns with the principles of Environmental Education, using digital games as a mediating tool between educational content and player engagement, thus promoting ecological awareness in a dynamic and meaningful way.

2. Related Work

The game Explosion Math, developed by [Takita et al. 2018], exemplifies how digital games inspired by Bomberman mechanics can be adapted for educational purposes, in

this case with a focus on Mathematics learning. Its goal is to make the teaching process more engaging by combining logical challenges and problem solving within a playful, dynamic environment. Like BomberKaboom , Explosion Math demonstrates the potential of digital games as pedagogical tools, showing that classic videogame elements can be repurposed with educational objectives to provide meaningful and motivating learning experiences.

Continuing the analysis of digital games that use the Bomberman structure as a basis for educational ends, the work of [Otto et al. 2020] stands out by presenting an arcade-style game themed around the animal world. As with Explosion Math, this project relies on classic and intuitive mechanics to promote player engagement while stimulating reflection and learning. The similarity to BomberKaboom is clear, as both employ level-based designs with obstacles and strategic interactions to convey relevant content—in the case of BomberKaboom, emphasizing environmental awareness and the importance of ecosystem preservation.

The analyzed works demonstrate the potential of digital games as educational tools capable of uniting entertainment and learning. Both Explosion Math and the game proposed by [Otto et al. 2020] show how adapting familiar mechanics—such as those of the classic Bomberman—can be effective in creating meaningful experiences for players. In this scenario, BomberKaboom emerges as an innovative proposal by applying these same playful structures within an environmental education context, fostering not only user engagement but also awareness of current ecological issues. The convergence of fun and critical consciousness thus becomes a promising pathway for educational initiatives in the digital realm.

In addition to the games already mentioned, [Carneiro e Sarinho 2023] presents a casual digital game aimed at environmental awareness. The game seeks to sensitize players to environmental challenges and the importance of sustainability. Similarly, the work of [Bastos et al. 2023] introduces an educational geography game that teaches about Brazilian biomes, promoting environmental preservation through a playful approach.

Another relevant study is that of [Santos-Ferreira e Vasconcellos 2024], which conducts an exploratory analysis of the representation of the environment in digital games. The research highlights the role of games in shaping perceptions of nature and suggests avenues for future investigations in the field. Complementing this perspective, [Pereira e Rocha 2023] discuss the use of digital games as learning tools, emphasizing their educational potential and the challenges faced when implementing them in school contexts.

These works reinforce the trend of using digital games as educational instruments, aligning with the proposal of BomberKaboom. As with the games mentioned above, BomberKaboom employs interactive mechanics to promote environmental awareness, demonstrating that classic videogame elements can be adapted for educational purposes, providing meaningful and motivating learning experiences.

The integration of digital games into environmental education has shown significant potential to foster pro-environmental attitudes and behaviors. Studies indicate that such games not only convey knowledge but also positively influence players' attitudes toward the environment. For example, the research by [Janakiraman et al. 2021] revealed

that digital games designed for attitudinal instruction provide cognitive knowledge and emotionally engage students by demonstrating the consequences of harmful behaviors and encouraging corrective actions. Furthermore, [Fjællingsdal e Klöckner 2019] highlight that games like Eco can promote environmental awareness by allowing players to experience and understand ecosystem complexities in an interactive manner.

In the Brazilian context, the application of digital games in environmental education is still in its infancy, especially those that adapt classic game mechanics for educational purposes. The development of Bomber Kaboom aims to fill this gap by offering a gaming experience that combines entertainment with meaningful learning. By confronting challenges related to environmental disasters within a familiar game mechanic, it is expected that players will develop a deeper understanding of ecological issues and be encouraged to adopt more sustainable behaviors in their daily lives.

3. Game Development

The development of the game BomberKaboom focused primarily on creating a playful and educational experience that combines the classic dynamics inspired by games like Bomberman with environmental awareness. In the game, the player faces enemies represented by monsters that symbolize different types of ecological disasters. To combat them, the player uses pressurized water capsules, which function similarly to the traditional bombs found in Bomberman-style games, releasing cross-shaped bursts. However, unlike regular bombs, these capsules are designed to neutralize threats and restore affected areas by spreading water instead of fire. This approach reinforces the idea of reconstruction and environmental care, transforming the classic explosion mechanic into an act of purification and protection of nature.

Throughout the levels, the player can deploy bombs that create cross-shaped explosions in the environment, allowing them to destroy monsters and breakable blocks. However, the player is also vulnerable to the effects of their own bombs and may be eliminated by drowning if they do not move away in time. To aid the player in their journey, there are three items that enhance attributes (such as speed, explosion range, and the number of simultaneous bombs), as well as a special item that helps restore the scenario.

3.1. Screens and Buttons

The game begins with an opening screen that highlights the contrast between the two main scenarios: forest fires and urban pollution. This screen features a “Play" button and background music that aligns with the game’s environmental theme. Upon clicking “Play," the player is taken directly to the first level. During gameplay, the left side of the screen displays a joystick for movement, while the right side contains a button to deploy the bombs. Each level features arcade-style background music, enhancing the player’s immersion and enjoyment. Figures 1 and 2 illustrate the opening screen and game controls.

3.2. Environments and Levels

The game is composed of six levels, divided into two distinct thematic environments. The first three levels take place in a setting of forest fires and deforestation, featuring

Figure 1. Opening screen of the game showing the visual contrast between the two main scenarios.

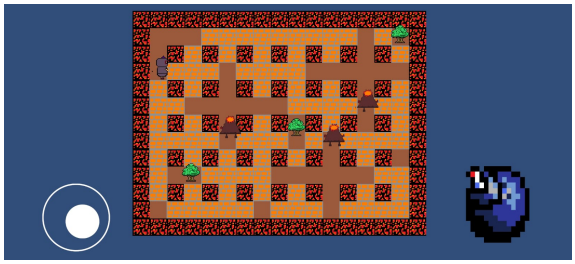
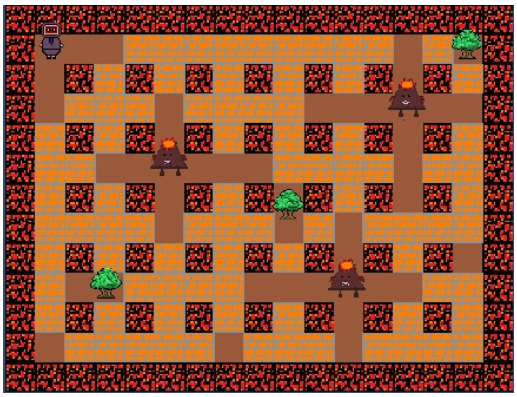
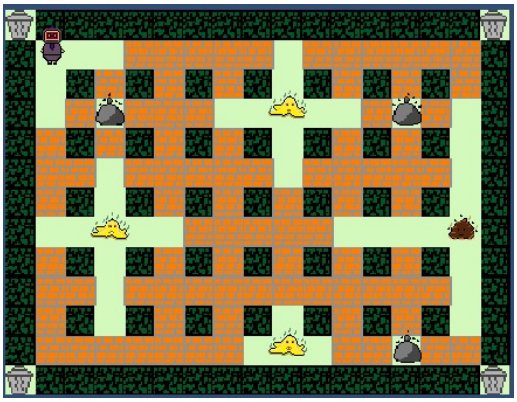


Figure 2. Game screen displaying the available player controls.

burning trees and monsters with flaming or smoky appearances. The subsequent levels are set in a polluted urban environment, filled with trash and monsters inspired by waste materials such as rotten banana peels and feces. All environments were developed using pixel art style, with 16x16 pixel tiles. The colors were carefully selected to reinforce the environmental theme of each level, contributing to the player's immersion. Figure 3 illustrates the contrast between the forest fire and urban pollution environments in levels 1 and 4.



Level 1 – Fire and Deforestation.



Level 4 – Urban Pollution.

Figure 3. Levels 1 and 4, showing the contrasts between the forest fire and urban pollution environments.

3.3. Characters and Behaviors

The protagonist of the game is a brave activist who aims to save his planet from the monsters causing environmental disasters. His pixel art appearance features brownish tones, referencing the earth and resistance. Dom Gravata can rely on three main items

during the levels: the extra bomb, which allows placing an additional bomb on the map; the little flame, which increases the explosion radius of the bombs; and the boots, which increase his movement speed. These items help make the character more effective in fighting monsters and progressing through the levels.

Figure 4. The protagonist of the game, depicted with simple pixel art strokes.

The game features a variety of six monsters, divided between the two main scenarios: forest fire and urban pollution. Each monster has been designed with specific behaviors that make the challenges unique in each phase. In the fire scenario, the Volcano Monster has a simple mechanic, acting as a stationary enemy that blocks the player's path. The Flaming Skull is a more aggressive monster, capable of chasing the player if they enter a radius of five squares and there is a clear path between the two. The third monster in this scenario is the Smoke Monster, which alternates between two forms: while in the fire form, it becomes invulnerable; only in its smoke form can it be defeated, requiring the player's attention and timing to attack.

Figure 5. Monsters from the fire scenario.

In the urban pollution scenario, the monsters are inspired by waste and contaminating urban elements. The Rotten Banana is a simple enemy, acting only as an obstacle. The Poop Monster is more complex: it summons new Rotten Bananas every 15 seconds, with a limit of up to three simultaneous summons, which can quickly saturate the screen and hinder movement. Finally, the Carnivorous Trash Can Monster acts as a mini-boss. It summons Poop Monsters every 45 seconds, with a limit of two summons, and has two lives, requiring multiple interactions to be fully defeated.

Figure 6. Monsters from the urban pollution scenario.

These enemies were created to visually represent the environmental impacts addressed in the game, using pixel art and distinct behaviors to enhance gameplay and make the experience more challenging. The mechanics of the monsters not only contribute to immersion in the theme but also encourage the player to reflect on the complexity of the environmental issues they symbolize.

3.4. Destructible and Indestructible Blocks

The game environments consist of destructible and indestructible blocks. Indestructible blocks cannot be affected by explosions, serving as fixed obstacles on the map. Destructible blocks, on the other hand, can be eliminated with bombs, clearing the path to enemies and hidden items. Additionally, there are elements such as burning trees and piles of trash that cannot be directly destroyed. To modify them, the player must collect the water item, which symbolizes environmental restoration actions.

Figure 7. Environmental elements present in the wildfire and urban pollution stages.

3.5. Items

The game features a variety of items that assist the player in their mission. Among the attribute items are the extra bomb item, which allows the player to place more than one bomb simultaneously; the fire item, which increases the explosion radius of bombs, enhancing their effectiveness; and the boot item, which improves the character's movement speed, making them more agile during gameplay.

Complementing these, there is the water item, which is highly relevant to the game's environmental theme. This item does not directly remove elements such as burning trees or piles of trash, but it modifies these objects in the environment by extinguishing flames or cleaning up trash, symbolizing environmental restoration actions. Using this item allows the player to unlock pathways and areas of the map affected by the destruction caused by the monsters. All items are designed in pixel art, with distinct visual characteristics that make them easy to identify and understand during gameplay.

Figure 8. Collectible items in the game.

3.6. Bombs and Explosions

Bombs are the player's main offensive resource. They are placed on the map and explode after a short interval, creating a cross-shaped wave of destruction. The explosions can

eliminate monsters, destroy blocks, and even affect the player if they are too close. The explosion radius can be expanded with the expansion item, and the number of simultaneous bombs can be increased with the extra bomb item. Strategy in placing and timing the explosions is essential to progress through the levels. Figure 9 shows the Game Bomb and its effect in the game.

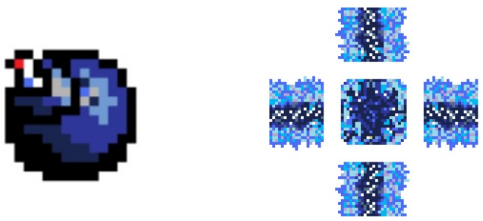


Figure 9. Game Bomb: Essential for eliminating monsters and unlocking new areas, using water to neutralize threats and restore the environment.

3.7. Tools Used

For the development, we used the Unity engine, version 2022. The creation was divided into stages to facilitate collaborative production. Initially, the character, scenario, and object artwork was developed on the Pixilart website in pixel art style. Then, the sprites were cropped, organized, and imported into the Unity environment.

The construction of the scenarios was done using the tilemap system, followed by the implementation of the main character and its collision layers. Later, the mechanics for movement, bombs, and explosions were developed, along with the programming of collisions, object positioning, and sprites on the map. Animations for both player and monster movements and deaths were also implemented. Finally, the game underwent a testing phase to verify the functionality of all mechanics and ensure smooth gameplay consistent with the proposed educational objectives.

4. Results

According to Savi et al. [Savi et al. 2007], the evaluation of educational games can be conducted by considering both technical and pedagogical aspects. This section presents the results obtained through a questionnaire administered to 15 undergraduate Computer Science students, who voluntarily participated in the testing of the game BomberKaboom: Environmental Disasters. The questionnaire consisted of eight questions addressing both technical and pedagogical elements of the game. Table 1 lists the questions included in the evaluation instrument.

Table 1. Evaluation questionnaire questions

ID	Question
Q1	Is the game easy to understand and play?
Q2	Did you feel entertained while playing *BomberKaboom: Environmental Disasters*?
Q3	How would you rate the game's level of difficulty?
Q4	Is the game's visual style (pixel art, environments, characters) appealing?
Q5	What aspects of the game do you think could be improved?
Q6	Did the game effectively convey the message about environmental disasters?
Q7	Did the game help you reflect on the impact of environmental disasters?
Q8	When collecting water to clean trash or extinguish fires during the levels, did you feel these actions reinforced the importance of environmental preservation?

Figure 10 presents the results related to the technical aspects of the game, including gameplay, visual design, difficulty, and entertainment. The responses were normalized on a percentage scale from 0 to 100% to facilitate visualization.

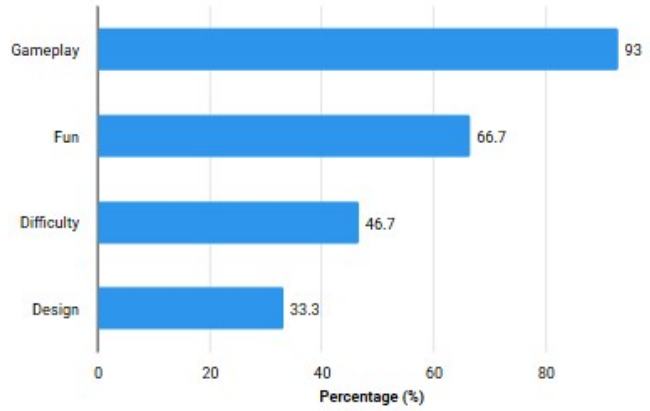


Figure 10. Evaluation of the game's technical and aesthetic aspects.

Figure 11 presents the results of the questions related to pedagogical and environmental aspects. The data reflect the participants' perceptions of the game's environmental message and the impact of its actions.

The results indicate that the game was well received in terms of usability, with 93% of participants stating that the gameplay was easy to understand (Q1), and 66.7% reporting that they found the game highly entertaining (Q2). Regarding aesthetics, 33.3% considered the visual style to be very appealing, while another 33.3% found it appealing (Q4). In terms of difficulty (Q3), 46.7% rated the game as easy, while the remaining participants considered it moderate or difficult.

With respect to pedagogical aspects, 53.3% of participants indicated that the gameplay could be improved (Q5). Regarding the transmission of the game's intended message, 53% reported partial understanding, while 40% indicated clear comprehension (Q6). Furthermore, 46.7% stated that the game encouraged them to reflect on how small actions can impact the environment (Q7), and 53.3% felt that the actions of collecting water and cleaning reinforced the importance of environmental preservation (Q8).

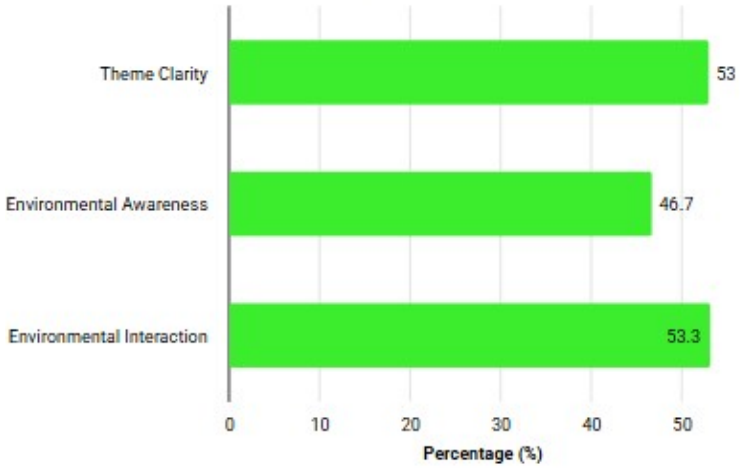


Figure 11. Evaluation of the pedagogical and environmental aspects.

5. Final Considerations

This work aimed to develop a digital game that, through a playful approach inspired by the classic Bomberman mechanics, promotes environmental awareness among players. BomberKaboom was conceived as an educational tool that combines entertainment and reflection, addressing themes such as wildfires and urban pollution through accessible and engaging mechanics. Throughout the development and evaluation process, the goal was to understand how the gaming experience contributes to the construction of knowledge and attitudes related to environmental preservation.

The analysis of the data collected from users showed positive results in various categories. Gameplay was one of the main highlights, with 93% of participants stating that the game is easy to understand and play. Regarding engagement, two-thirds considered the game very fun, while 33,3% rated it as moderately fun, reinforcing its potential as an educational tool. In terms of difficulty, 46,7% found the challenge easy, while 26,7% considered it moderate or difficult. Regarding design, 33,3% found the visual style very attractive, and another 33,3% found it attractive. Improvement suggestions mainly focused on gameplay (53,3%) and the storyline (20%). Although 40% stated that the environmental message was clear, 53% perceived it only partially, indicating the need to strengthen this aspect. Still, 66.7% of participants showed some level of environmental awareness through the playful experience.

Considering these results, the next steps of this work include direct improvements to gameplay, such as adjustments in the pacing of the levels, the behavior of enemies, and the difficulty curve. The development of new environments and enemies is also planned, increasing the complexity of the game and exploring other types of environmental disasters. Additionally, special attention will be given to the narrative and how the ecological message is conveyed, ensuring that players better understand the impact of their actions in the virtual environment and their relationships with reality. Thus, it is expected that BomberKaboom: will evolve into a more complete, challenging, and impactful educational resource.

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