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DEVELOPMENT OF THE GAME AERNUM

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Abstract: This work aims to record the methodology and development journey of an educational game that combines fun and engaging mechanics with the learning and practice of mental mathematics. From planning to the production of the alpha version of the project, development notes were made and then transcribed into this article. The production process proved to be the most complex compared to planning. Overall, the experience of developing this project brought a lot of learning and work ethic.
Keywords: Godot development. Digital games. Reasoning. Mathematics

INTRODUCTION

"Digital games are experiences that present a paradigm to the player", a set of rules, tools and interactions between them that then offer an objective to be achieved from this paradigm that is taught in an organic way while the player is interacting with it (SOUZA SANTOS; ALVES, 2021, p. 5).

In keeping with this line of reasoning, when we look at mathematics and the content it brings, we realize that it can also be seen as a set of rules, tools and interactions that can be learned and used to achieve a meaningful goal. Therefore, it would be possible for a digital game to be used as an aid to educational learning, transforming the articulation and memorization of the content covered into an intuitive and fluid process (FERREIRA; ROCHA, 2024).

A "subgenre" of digital games are educational games that seek to merge the immersion and engagement of the audiovisual elements of digital games with practical value and the learning of educational topics. These games have great potential to be used as alternative or supplementary methods of practicing mathematics, when it cannot be done with paper and pen, taking advantage of the time we dedicate in front of the computer it is possible to create this connection between the student and an environment that offers the player a network of numbers and calculations that are used to progress in the session being rewarded for their speed and accuracy of their mental calculations (SILVA et al., 2021, p. 12).

Based on this, the aim of this article is to report on the development of an educational game that seeks to encourage the practice of mental resolution of mathematical calculations from combat situations that require precision and proper positioning to succeed in combat and to shed light on a possible alternative means of practicing mental mathematics from a computer game, encouraging the player to improve their math skills through interaction with the game.

To program the game, the GDScript language will be used, which is a modified version of the Python language. To create the visual elements, the Krita drawing program will be used and to take notes and monitor the development of the game, the Obsidian application will be used.

THEORETICAL FRAMEWORK

The use of digital games in the teaching of mathematics has proven to be an effective pedagogical strategy to make learning more dynamic, interactive and motivating. Souza Santos and Alves (2021) point out that digital games offer a paradigm to the player, consisting of rules, tools and interactions that lead to a goal, allowing learning to occur organically during interaction with the game. This characteristic is especially relevant for mathematics, a subject that can be understood as a system of interconnected rules and tools that can be learned through playful and meaningful experiences (SOUZA SANTOS; ALVES, 2021, p. 5).

Digital educational games, as a subgenre of digital games, combine immersive audiovisual elements with clear educational objectives, enhancing student engagement and facilitating the learning of mathematical content. Sil-

va et al. (2021) point out that these games can be used as alternative or supplementary methods to traditional teaching, especially when the use of paper and pen is not possible, promoting the mental practice of calculations and the development of logical reasoning through challenges that require speed and precision (SILVA et al., 2021, p. 12).

In addition, the literature points out that incorporating digital games into math classes contributes to increasing students' curiosity, attention and motivation, making classes more enjoyable and effective. As highlighted by Menezes and Alves (2020), games facilitate the fixation of content in a dynamic way, help students with specific difficulties in the subject and promote socialization and collaboration between students during playful activities (MENEZES; ALVES, 2020).

Empirical studies reinforce these benefits. For example, research carried out by Prodanov (2013) and cited by authors such as Diniz (2008) and Massa and Riba s (2016) shows that mathematical games promote more interesting teaching and more dynamic learning, stimulating the development of students' logical reasoning and creativity. Chiummo and Oliveira (2016) also highlight the role of games in intellectual development, social relationships and the playful nature of mathematical learning.

Andrade (2017, p. 56) emphasizes that playfulness, when properly understood and applied, can develop knowledge for personal and professional life, enabling a pleasurable and dynamic interaction with the social environment. Oliveira (2018) adds that the game, inserted into the educational context, acts as a socializing element and minimizes the difficulties faced by students in understanding mathematical content, as well as reducing emotional blockages related to fear of mathematics (MENDONÇA, 2017).

In the current context, the integration of digital games in math teaching is also in line with the demands of 21st century society, marked by technological advances and the need to develop digital and cognitive skills. Recent studies indicate that interaction with digital games can demystify mathematics and open up new ways of thinking and producing knowledge, making it an essential tool for contemporary teaching and learning (BRASIL, 2009; 6).

Finally, systematic reviews of the literature show that digital educational games and gamification have great potential to motivate and engage students, stimulate creativity, promote collaboration and enable more meaningful and autonomous learning at different levels of education (FERREIRA; ROCHA, 2024; 5). This finding reinforces the importance of investing in the development and application of these pedagogical resources to improve the teaching of mathematics.

METHODOLOGY

The free game engine Godot was used to program the game, the free software Krita was used to produce the visual elements and Obsidian was used to take notes and monitor development progress

COLORS AS A LANGUAGE

The aim of the game is to mix 2 practices, mathematical calculation and interaction with the game world such as running, shooting and punching. The player will need to be proficient in both to progress in the game, as they are intrinsically related. Solving calculations will be necessary to overcome the challenges and knowing how to position yourself and act when, how and where necessary is integral. In order to guarantee this interaction, the game needs to be presented in such a way that it takes the player as little time as possible to recognize the steps needed to ensure victory. To this end, the colors used in the game are given a treatment that makes them tools for directing and recognizing the challenges that the player will need to overcome.

LIMITED TONE AND SATURATION

As a measure of organizing the game's visual palette, the possible color tones and saturation levels were limited to 16 and 6 respectively, as shown in the figure:

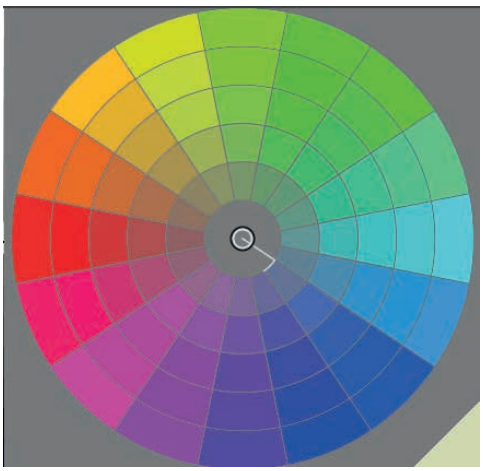

Figure 1: Color wheel

Source: Printed from within Krita

All the visual elements of the game (scenery, enemies, player, interface and the like) will use this color wheel as a way of standardizing the visuals to ensure that the player can easily identify each distinct element in the game.

CONTRAST AS DIRECTION

To make it easier to prioritize, the contrast of the elements in the game will be used intentionally to guide the player's gaze towards the most important elements in the game. As an example, the character representing the player has a higher concentration of detail and contrast in the torso, wrists and head, which are the most important elements in the game, while the feet are made up of just one color and don't have high-contrast details because they aren't as important as the other parts of the player's body.

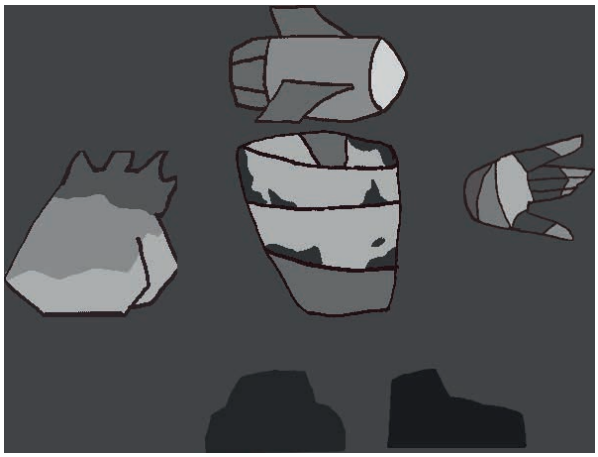

Figure 2: Player Sprite

Source: Printed from within Krita

LUMINOSITY AS A DEGREE OF IMPORTANCE

After recognizing which elements are present in the game, it will be necessary to define which elements are given more priority over others, for example during combat the player's priorities should be where he is, which enemies are nearby, which enemy is the most dangerous, whether there are obstacles in the scenario. To do this, the brightness of the elements will be used to highlight them in relation to others, where brighter elements will be intrinsically more important than others.

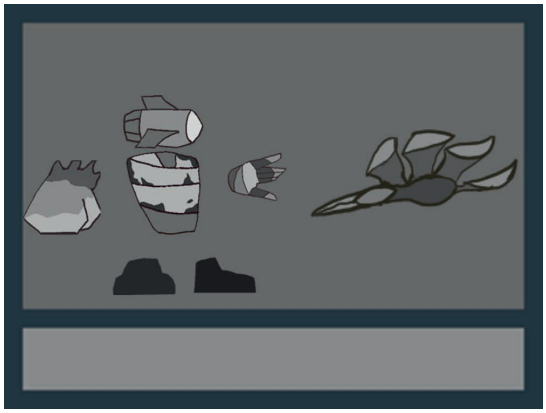

Figure 3: Player and enemy in the scenario

Source: Printed from within Krita

ENCOURAGING LEARNING

The aim of creating the game is to provide the player with an environment in which to experiment and practice mental mathematics in the context of various combat arenas, and from this premise arises the problem of how mental practice can be integrated into arena combat.

ENEMY LIFE SYSTEM

The player will have three types of attack at his disposal, shooting, punching and running, these attacks inflicting a random number of damage during the match. Before each enemy appears during the match the following process will be followed:

1. The damage values of the player's shot, punch and run will be collected
2. 1 to 3 of these values will be selected
3. If the number of values collected is greater than 1, they will be added up to a single value.
4. The resulting value will be the enemy's maximum life

With this life selection system, each enemy will require a specific sequence of attacks so that their life reaches a value less than zero and they are eliminated from the fight. In each match, the player will encounter enemies whose health adapts to the amount of damage their attacks cause, so they will always be faced with challenges that require quick calculations and efficient decisions in order to succeed in the game.

POINTS SYSTEM

The game can be divided into two parts, mental math practice and arena combat, and the player will be required to master both in order to succeed in the game. However, it is not possible to accurately measure both the player's mental math skills and combat skills, so the game's standard difficulty level can prove frustrating for players who are not adept at math calculations or combat skills, or both.

Based on this, a system of points has been implemented which are acquired when the player efficiently performs mathematical calculations or precise attacks. These points can be used to bring advantages to the aspect of the game which brings the player the most difficulty and to implement more challenges in the aspect which the player has the most skill. This system allows the difficulty to be adjusted dynamically by the player regardless of their initial skill and the rate at which their skill evolves during their gameplay.

DEVELOPMENT JOURNEY

The development process began at the end of November 2024, and continued until May 2025, thus reaching its Alpha version.

PROTOTYPE

The main priority at the start of development was to create a prototype of the game as quickly as possible, so that as soon as possible the gameplay could be tested, corrected and refined through iterations as more elements were added to the project. The player-controlled character was the first to be made, consisting of a movement system, a life system, then he was given the ability to punch, shoot and run.

Then an enemy stalker was implemented, soon after which an arena system was integrated into the game whereby if a condition is met the game will change the arena in which combat takes place. The last part of the prototype was the damage system for the player's attacks and the enemy's life, which is made up of the sum of 1 to 3 numbers chosen by the player.

ALPHA VERSION

For the Alpha version of the game, concept art was created to define the game's visual style, color composition and levels of contrast between the game's elements, including the player, enemies and game interface, in order to define an art base for the rest of the game.

Figure 4: Concept art

Source: Printed from within Krita

Then 2 types of enemy were introduced, a sniper and a bomber enemy who plants explosive mines around the arena. Then various arenas were introduced.

RESULTS AND DISCUSSIONS

The project was developed from conception, design, programming, proofreading and artwork by me alone. The development process proved to be more complicated than expected, taking longer to complete than expected due to adapting to new tools and solving problems. The game's testing processes provided information that allowed significant changes to be made to the overall project. This project was developed with the following steps in mind:

1. Offering fun and engaging learning: Through the game's mechanics I hope that the player will at least enjoy the game experience regardless of whether they play for just 3 minutes or 3 hours.
2. Reducing barriers between learning and practice: Through the game's mechanics that require the practice of mental math, it is hoped that this project will be effective in exercising and familiarizing anyone who wishes to improve their mental math skills.
3. Sparking an interest in learning: By blending game mechanics and math practice, I hope that the player will reflect on the way they view studying, not seeing it exclusively as a dull and methodical process, but as something that, with the right perspective, can offer fun and leisure.

The ultimate goal of this project is to enable anyone, regardless of age or previous experience, to interact with mental mathematics in a new and engaging way.

FINAL CONSIDERATIONS

The process of developing the Aernum game proved to be an experience rich in challenges and learning, requiring the continuous acquisition of new technologies and methodologies to meet the specificities and limitations imposed by the game's design. The construction of the prototype was fundamental to making it possible to integrate the practice of mathematics with the elements of engagement typical of digital games, enabling an approach that organically combines learning and fun.

The decision to restrict the color palette and saturation tones in the visual elements, as well as the way the enemies were implemented, made it possible to establish a clear direction for the gameplay, favoring a focused gameplay and facilitating quick and effective iterations for future refinements. This choice contributed to the creation of a cohesive and intuitive experience, which enhances the player's interaction with the proposed mathematical content.

Throughout the journey, various demands that were initially underestimated in terms of time and complexity turned out to be more challenging than expected, requiring greater effort and dedication to overcome. This recognition is a valuable lesson that should be incorporated into the next stages of the project, guiding a more realistic and efficient management of time and resources.

In summary, the development of Aernum not only enabled the team to advance technically and creatively, but also reinforced the im-

portance of flexible and adaptive planning in the face of the difficulties inherent in creating educational games. In addition, it highlighted the potential of digital games as pedagogical tools capable of promoting engagement and the effective practice of mathematics, contributing to more meaningful and motivating learning.

REFERENCES

ANDRADE, M. Ludicidade e desenvolvimento de saberes: uma abordagem para a educação. **Educação, Ciência e Cultura**, v. 3, n. 1, p. 50-60, 2017. Disponível em: https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/article/view/1234. Acesso em: 06 jun. 2025.

BRASIL. Ministério da Educação. **Parâmetros Curriculares Nacionais: Matemática.** Brasília, 1998. Disponível em: http://portal.mec.gov.br/pcnmatematica. Acesso em: 06 jun. 2025.

CHIUMMO, M.; OLIVEIRA, A. O papel dos jogos na educação matemática. **Revista Educação**, v. 10, n. 2, p. 15-30, 2016. Disponível em: https://revistaeducacao.com.br/artigos/jogos-na-educacao-matematica. Acesso em: 06 jun. 2025.

DINIZ, M. **Metodologias de pesquisa em educação**. São Paulo: Editora XYZ, 2008. Disponível em: https://editoraxyz.com.br/livros/metodologias-pesquisa-educacao. Acesso em: 06 jun. 2025.

FERREIRA, J. N.; ROCHA, A. L. Jogos digitais como auxílio no aprendizado educacional. **Foco**, v. 10, n. 2, p. 1-15, 2024. Disponível em: https://ojs.focopublicacoes.com.br/foco/article/view/2193. Acesso em: 06 jun. 2025.

FERREIRA, S. S.; ROCHA, A. C. B. Contribuição de jogos digitais no ensino de matemática. **Foco**, v. 10, n. 2, p. 1-15, 2024. Disponível em: https://ojs.focopublicacoes.com.br/foco/article/view/2193. Acesso em: 15 maio 2025.

MASSA, F.; RIBAS, R. Jogos matemáticos e desenvolvimento do raciocínio lógico. **Educação Matemática**, v. 5, n. 3, p. 20-35, 2016. Disponível em: https://educacaomatematica.com.br/artigos/jogos-matematicos-raciocinio. Acesso em: 06 jun. 2025.

MENDONÇA, R. Superando bloqueios na aprendizagem da matemática. **Educação e Pesquisa**, v. 7, n. 1, p. 40-55, 2017. Disponível em: https://educacaoepesquisa.com.br/artigos/superando-bloqueios-matematica. Acesso em: 06 jun. 2025.

MENEZES, E. C.; ALVES, E. Jogos Digitais e Gamificação na Educação. **Educação, Ciência e Cultura**, v. 2, p. 10-30, 2020. Disponível em: https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/article/view/7169. Acesso em: 06 jun. 2025.

OLIVEIRA, P. O jogo como elemento socializador na educação matemática. **Revista Pedagógica**, v. 8, n. 2, p. 45-60, 2018. Disponível em: https://revistapedagogica.com.br/artigos/jogo-elemento-socializador. Acesso em: 06 jun. 2025.

PRODANOV, C. **Pesquisa exploratória e bibliográfica**. São Paulo: Editora ABC, 2013. Disponível em: https://editoraabc.com.br/livros/pesquisa-exploratoria-bibliografica. Acesso em: 06 jun. 2025.

SILVA, A. P. et al. O uso de jogos digitais educacionais como ferramenta para o ensino de matemática. **JIEEM**, v. 5, n. 3, p. 1-22, 2021. Disponível em: https://jieem.pgsscogna.com.br/jieem/article/view/8506. Acesso em: 06 jun. 2025.

SILVA, M. A. et al. O uso de jogos digitais no ensino da matemática: um estudo baseado em revisão sistemática. **JIEEM**, v. 5, n. 3, p. 1-22, 2021. Disponível em: https://jieem.pgsscogna.com.br/jieem/article/view/8506. Acesso em: 15 maio 2025.

SOUZA SANTOS, L. E.; ALVES, E. S. Jogos digitais e o paradigma educacional. **Educação, Ciência e Cultura**, v. 1, p. 1-21, 2021. Disponível em: https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/article/view/7168. Acesso em: 06 jun. 2025.

SOUZA SANTOS, W.; ALVES, L. R. G. Jogos Digitais: um level up para a Educação Matemática brasileira. **Educação, Ciência e Cultura**, v. 1, p. 1-21, 2021. Disponível em: https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/article/view/7168. Acesso em: 15 maio 2025.