

A SERIOUS GAME AIMED AT TEACHING MULTIPLICATION TABLE

UM JOGO EDUCATIVO VOLTADO AO ENSINO DE TABUADA

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ABSTRACT

Teaching new skills for children involves sharing tasks in smaller steps and repeating them several times in order for the child to absorb the knowledge. Some researchers have concluded that the use of technologies as teaching tools can provide the necessary resources to develop such activities, facilitating the child's learning using an interactive approach. Based on these facts, it was proposed in this work the creation of a digital 3D educational game and RPG elements for the Android, Linux, Windows and Mac platforms, whose main objective is to teach the tables for children of the 3rd and 4th years of elementary school. The validation of the game was made through interviews with students of the pedagogy course after watching the demo of the game. The result of the interview demonstrates the potential of the game to serve as a tool to support the teaching of tables for elementary school children.

Keywords: Digital Games. Educational Games. Serious game. Game Design.

RESUMO

Ensinar novas habilidades para as crianças implica dividir tarefas em etapas menores e repeti-las diversas vezes a fim de que a criança possa absorver o conhecimento passado. Algumas pesquisas concluíram que o uso de tecnologias como instrumentos de ensino podem fornecer os recursos necessários para desenvolver tais atividades, facilitando o aprendizado da criança usando uma abordagem interativa. Baseando-se nestes fatos, foi proposto neste trabalho a criação de um jogo digital educativo 3D e com elementos de RPG para as plataformas Android, Linux, Windows e Mac, que tem como principal objetivo ensinar a tabuada para crianças do 3º e 4º anos do ensino fundamental. A validação do jogo foi feita por meio de entrevistas com alunos do curso de pedagogia após assistirem a demonstração do jogo. O resultado da entrevista demonstra o potencial do jogo de servir como uma ferramenta de apoio ao ensino de tabuadas para crianças do ensino fundamental.

Palavras-chave: Jogos Digitais. Jogos Educativos. Jogo Sériio. Projeto de jogos.

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Introduction

It is very common to observe children and teenagers using smartphones and mobile devices in their daily lives, including in classrooms. These technological items are common to new generations, who grew up having access to such devices. These technologies are not new in classrooms, there is a wide field to be explored, allowing new media and methodologies to be inserted in this environment. As an example, we have the digital educational games (GRUNFELDT et al., 2018).

According to Anetta (2008) the current teaching system is outdated, trying to teach new generation students with old methods and tools, causing students to lose interest in studies and disperse attention.

Educational games can be used as tools for teaching. This type of game brings several features that stimulate learning and reasoning, as it allows the user to interact with the game world, creating new experiences and concepts, thus generating knowledge. It makes them great pedagogical tools (SENNA et al., 2016).

There are some problems with the insertion of digital games in educational institutions. Games are tools that require a great deal of time and investment for their development. Moreover, among some teachers, there is the bias with the use of some technological tools within the classroom, which also hinders the use and dissemination of educational games (GRUNFELDT et al., 2018). However, this scenario already shows signs of change. In some parts of the world, many professionals in the area adopt the use of games for teaching children and adolescents. According to Lofgren (2016), 74% of US teachers use digital classroom games in elementary education.

A study by Senna et al. (2016) shows that with the increasing availability and use of videogames in general, a greater investment is needed in the area of educational game creation, given that potential users of this type of game are also users of other games segments developed by large companies. This implies in reducing the immersion present in the games used in classrooms, which are generally simpler and focused on a single goal.

1 General objectives

The general objective of this work is to build a digital educational game of easy access and gameplay for diverse platforms and with focus on mathematics, targeting the children of the 3rd and 4th years of elementary school.

This game should help the child to learn a tablet. This choice is due to the breadth of the theme, as it is a common theme in different media, as well as being essential for future years of children's studies.

1.1 Specific objectives

- Create different levels of difficulty for the game, with progressive difficulty so that the student can observe their progress, both in the game and in the studies;
- Use an attractive color palette, with characters and objects elaborated in a simplistic way, allowing the game to work on less robust devices.

2 Theoretical reference

In this section will be presented some works where we can find the application of games in education, as well as the elements necessary for the creation of these games.

2.1 Educational Games

Educational games have as main proposal the practical teaching, through experiences and interactions. Therefore, it is important that these games meet pedagogical requirements, which sometimes make the games a little fun, and it is necessary to find a balance between the fun and the pedagogical side (FORTUNA, 2000). However, finding this balance is not always a trivial task (RAVI; ULBRICHT, 2008).

The use of educational games in classrooms is not only different for the student, but also for the teacher, who also adopts the role of mediator and not only that of an information transmitter (GEBRAN, 2009). This increase in function, as well as the conflict between the different generations, can bring problems to the implementation of this teaching technique, and it is up to the developers to mitigate this damage, inserting

within the manual games and training, in order to help both students and teachers (MATTAR, 2010).

It is also possible to use educational games as an auxiliary study material outside the classrooms. For this, one can use the methodology of the inverted classroom, in which the study material is available to the student before the class itself. In this way the student can know the subject at home and use the class time to practice, discuss the content of the subject with the other students and also ask questions (LORENZI et al., 2018).

2.2 Meaningful Playful Interaction

One of the biggest challenges in the area of game design is to create a good experience between the player and the developed world for the game. This type of interaction, called Significant Play Interaction, is the player's ability to understand what is happening within the game environment and respond to it with actions that make sense within this environment (SALEN; ZIMMERMAN, 2012).

Having said this, it becomes necessary for any type of game developed to contain clear feedbacks on the actions taken during a game match. If this return is not shown, the player gets the feeling that he is simply pressing buttons randomly, and all the immersion and interactivity effect to the game is lost (LORENZI et al., 2018).

2.3 Development

The main tools used to develop this project were the Unity3D game engine¹ and the Visual Studio 2017 development environment².

Unity3D (version 2018.26) was selected because of its great versatility in creating programs and applications for different platforms, such as Android, IOS, Mac, Linux, Windows, Xbox One, Xbox 360, Playstation 3, Playstations 4, among others. . This tool also has an active community, contributing with the availability of Assets (games components), online training, and the clarifications of the various doubts that may arise during the development of the project. Figure 1 illustrates the Unity3D development interface.

¹ <https://unity3d.com>

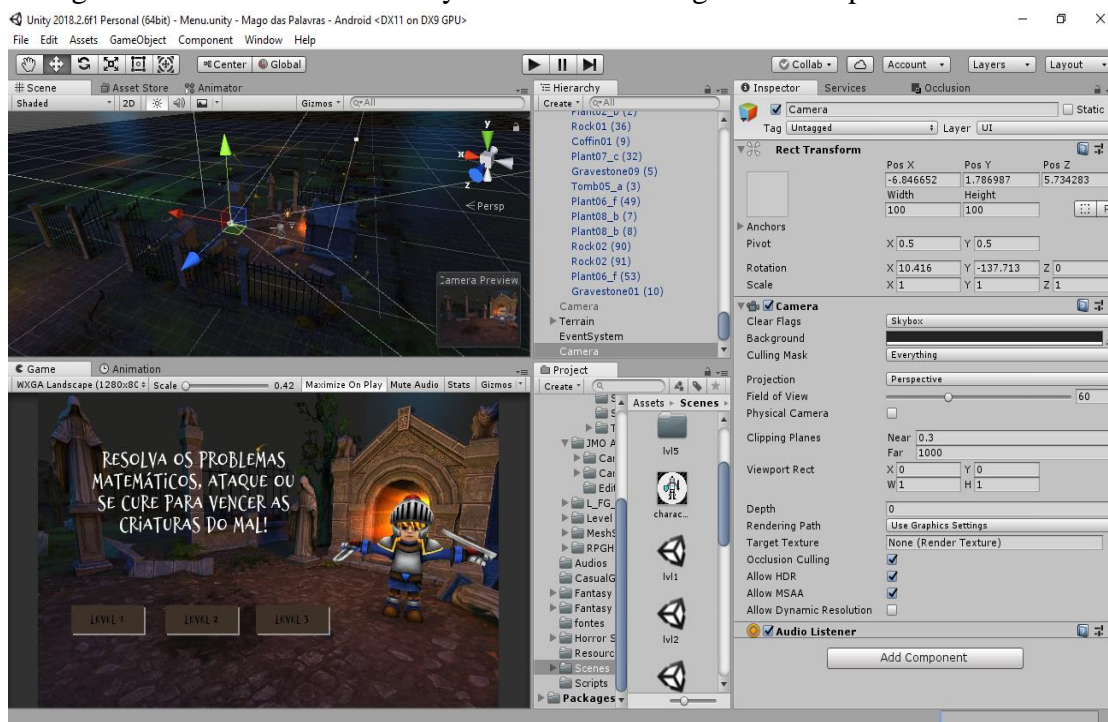
² <https://visualstudio.microsoft.com>

Most of the assets used in the proposed game development (3D models, audios and special effects) were acquired by the Asset Store³, an online asset sales and distribution store, also owned by Unity Technologies.

Of these assets, the scenario was made available by XIAOLIANHUASTUDIO⁴, a 3D modeling studio that offers low-poly design (few polygons) optimized for mobile devices. The textures used on the ground, the fog effect present and the lighting used in the scenes were also made available by this studio. The package used was Make Your Fantasy Game - Lite⁵.

Most of the enemies entered in the game have been made available by PI ENTERTAINMENT LIMITED⁶, as the models are also optimized for mobile devices and meet the requirements initially proposed. The package selected was the Level 1 Monster Pack.

Figure 1. Overview of the Unity3D interface during the development of the work



Another studio used for the enemies was the MESHSMOTH, specifically for the last character of the third level of the game. The package selected was Toon Rock.

The main character was created by DUNGEON MASON⁷ studio, and was chosen for the same reasons previously mentioned. The package selected was the HP Hero RPG.

³ <https://assetstore.unity.com/>

⁴ <https://assetstore.unity.com/publishers/2752>

⁵ <https://assetstore.unity.com/packages/3d/environments/fantasy/make-your-fantasy-game-lite-8312>

⁶ <https://assetstore.unity.com/publishers/10960>

⁷ <https://assetstore.unity.com/publishers/23554>

All the animations of all the characters were made available by their respective studios of origin.

The audios used in the game were made available by the LITTLE ROBOT SOUND FACTORY⁸, DUSTYROOM⁹ and TYLER CUNNINGHAM¹⁰ studios. These audios include special effects and music. The selected packages were the Horror Sfx, FREE Casual Game SFX Pack and Fantasy Battle Music Free Pack, respectively, to each studio mentioned above.

The special effects chosen were studio JEAN MORENO¹¹ (JMO), specifically the effects of the Cartoon FX Free package. In this case, the package was selected for having an excellent note from other users of the sales platform, and the support needed for design.

Visual Studio 2017 was selected as the development environment because of its compatibility with Unity3D and ease of use. Support for the C# language, a programming language selected for project development, was one of the key factors in choosing this software.

The C# language was selected for its integration with Unity3D, as well as being a modern, object-oriented language and having broad support of your company. In addition, because it is a widely used commercial language, training and forums about this language are easily found on the internet. Figure 2 illustrates part of the code developed in this work.

Figure 2. Code development interface

```

60         trigger = true;
61     }
62
63     if (trigger)
64     {
65         StartCoroutine(wait());
66
67         if (triggerT && enemyLife.value > 0 && enemyTime != null)
68         {
69             enemyTime.value -= Time.deltaTime;
70             panel.SetActive(true);
71             pre1.gameObject.SetActive(false);
72             pre2.gameObject.SetActive(false);
73         }
74         //else
75         //panel.SetActive(false);
76         if (enemyLife.value > 0)
77         {
78             if (enemyTime.value == 0 && !anim.GetBool("die"))
79             {
80                 if (player.GetComponent<Desloca>().myLife.value > 0)
81                 {
82                     player.GetComponent<Desloca>().myLife.value -= Random.Range(ataqueMin, ataqueMax);
83                     player.GetComponent<Desloca>().anim.SetBool("hit", true);
84                     player.GetComponent<Desloca>().GetComponent<AudioSource>().clip = player.GetComponent<Desloca>().
85                     player.GetComponent<Desloca>().GetComponent<AudioSource>().Play();
86                     anim.SetBool("atk", true);
87                 }

```

⁸ <https://opengameart.org/users/little-robot-sound-factory>

⁹ <http://dustystudio.com/>

¹⁰ <https://assetstore.unity.com/publishers/31102>

¹¹ <http://www.jeanmoreno.com/>

2.4 Design of the game

The project was divided into 5 phases of construction. During the first phase, the entire scenario of the game was built using previously quoted components. Each item was organized in such a way as to leave the environment as immersive as possible, with the use of mist to reduce the processing required to render the whole environment.

At this stage, "rails" were also built, where the character and the camera move. It was defined that the main character will walk only in a straight line, leaving the camera in a fixed position showing the environment from right to left, generating an effect similar to 2,5D.

The Heads-up display (HUD) was developed in a style whose coloration stands out from the background, leaving these elements in evidence. The lighter colors, and simple buttons have been selected to be visible, but without distracting the player, allowing their focus to remain in the game's action.

In phase 2, it was defined how the gameplay would be and how its challenges would be built.

During phase 3 of the game construction, with the attributes of the enemies already defined, the attributes of the main character have been configured, so that the combat is dynamic and challenging to the player. Then the game menu scene was built, which is used to navigate between levels and gives a short description of how the game works.

After the three phases of construction, some tests were carried out to refine the project. At this stage the need for change in the positioning of the game camera was detected in relation to the initial idea. In the Updates phase, the camera was positioned over the right shoulder of the main character, still focusing from right to left, but now highlighting the 3D effect of the project.

It was also observed a deficiency with the mathematical problems initially proposed to the player. Taking into account that mathematics has a broad scope, in the first version of the game the problems generated involved summing, subtraction, division, multiplication, and also combinations of these elements. However, in the upgrades phase, the mathematical problems were restricted to the table, making the game simpler to be understood and played by the target audience.

2.5 Gameplay

The game was built with progressive difficulty. Initially, in the menu screen, the user can view the main character of the game, as well as part of the scenario and a list of levels available to play. This can be seen in Figure 3.

At the beginning of the game, the player observes the main character moving by the scene alone, until he meets his first enemy. At this moment, the battle between the two begins.

Figure 3. Game menu screen



As can be seen in Figure 4, there is a mathematical problem on the right side of the screen, and a HUD with a numeric keypad on the opposite side. The user interacts with the game solving the math problem and selecting an action for the character.

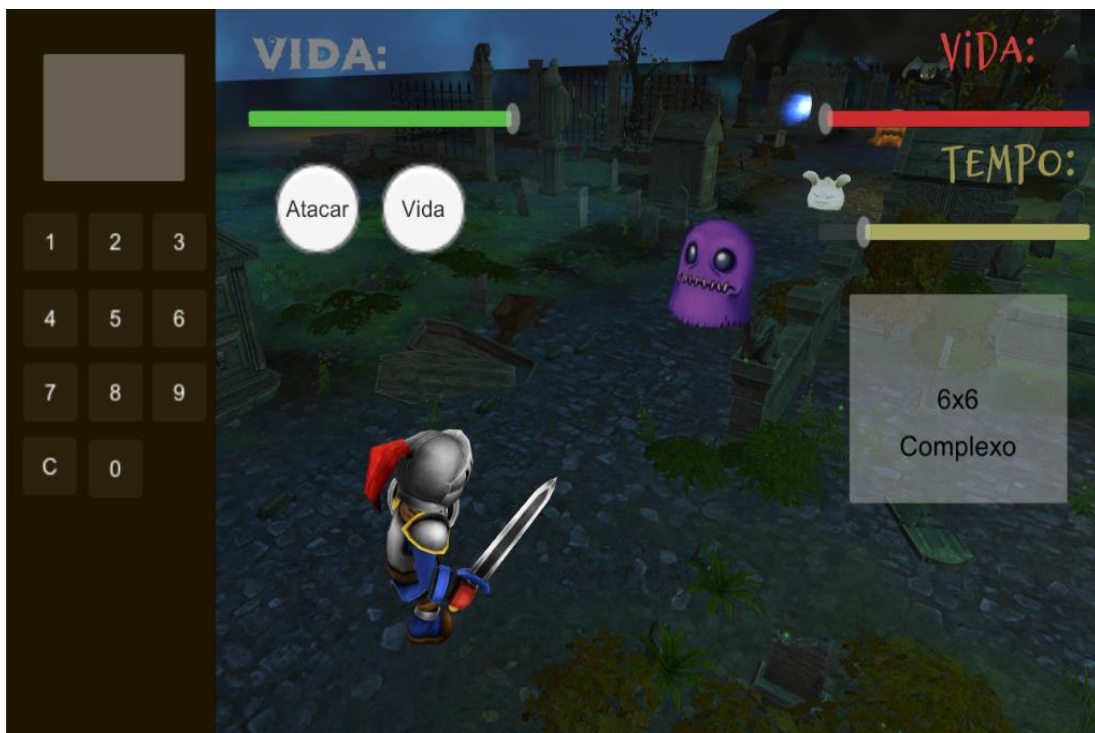
The available actions are: "Attack" or "Life". There are also three different difficulty levels for each question: "Simple", "Normal" and "Complex".

As an example, by choosing the "Attack" action and the proposed mathematical problem is a "Simple" problem, the player performs a simple attack, and causes a small damage to the opponent's life. If the problem is of "Normal" difficulty, the damage done

is greater, and the character's animation is also different. A "Complex" difficulty problem causes significant damage, and also comes with a specific animation.

If the player selects the "Life" option, a special effect is shown on the main character, and a certain amount of life is gained by the same. The amount of life to be gained, as in the previous case, depends on the difficulty level of the mathematical problem currently proposed.

Figure 4. Mathematical challenge shown to the player



If the player misses the proposed problem, the simple attack animation occurs, but with a different sound signal, showing the user the error committed. The effect is the same, both in the case of the choice of "Attack", and in the case of the choice of "Life". No punishment is generated directly to the player in case of error.

Both the amount of damage done on enemies and the amount of life restored depend on the difficulty of the proposed question, but the exact number is generated randomly, within predefined values. This element adds the luck factor to the game, an effect found in all RPG style games, giving more playfulness and immersion to the project. Figure 4 shows the challenge display and the HUD that displays the virtual keyboard.

The main character also suffers attacks of the creature that fights, according to the time. Each enemy has unique animations and attributes based on life, speed, and damage. The creatures present in this project and their specific attributes can be found in Table 1.

Like the player, the only absolute attribute of the enemy characters is life. The time of each attack, as well as the damage caused by it, is generated randomly, within values previously defined according to the quality of the specific attribute of each enemy.

The time of each attack can be observed according to a yellow bar at the top right of the screen, and the life of the enemy character can be seen in red, above the time bar. The player's life is shown in the upper left, being represented by a green barred.

Table 1: Attributes of the characters in the game

Name	Velocity	Life	Damage
Slime	Slow	Big	Moderate
Phantom	Moderate	Moderate	Moderate
Rabbit	High	Small	Small
Bat	High	Moderate	Small
Golem	Slow	Big	Big

When you select an action, the mathematical problem is replaced by another. This occurs regardless of the chosen action, whether or not the player hits, or misses the problem. The new problem is generated randomly, but always a multiplication problem, with numbers varying from 1 to 10.

If the player loses the battle (get life equal to zero), a panel appears leading you back to the Menu and selecting levels. If he wins the battle, he will go on to the next fight, with another enemy.

The number of enemies in each level is different, and in level 1 there are 4 enemies, in the second level 5 enemies and in level 3 there are 6 enemies, the latter a stone golem representing a "big boss". If the player wins all enemies in a level, a panel appears congratulating the player, and taking him back to the Menu.

3 Validation

In order to validate the game, a questionnaire was elaborated on some characteristics of the game. This questionnaire was applied to pedagogical students from

several semesters of the FATECE (faculty of Pirassununga). For this stage, a questionnaire containing 6 questions (Q1 to Q6):

- Q1. From 1 to 10, what is the chance for a child to learn math with this game?
- Q2. From 1 to 10, how much do you rate a child would be attracted to this game?
- Q3. Would you use this game to teach math for a class of students?
- Q4. Do you consider this game gender neutral?
- Q5. In what age group does this game fit the best?
- Q6. Is the complexity present in this game in accordance with the age group proposed in the project?

Firstly, a demonstration of the game was made to the research volunteers using an Android mobile device. Subsequently, physical questionnaires were given, where they should answer the questions, give suggestions to the project and fill in some personal data.

4 Results

The built project resulted in a didactic game, fun and functional on several platforms. To validate these results, a field survey was carried out, involving 31 students from the Pedagogy course of the FATECE (Faculty of Pirassununga). The students interviewed are from the 2nd, 4th and 6th semester of this course, predominantly women, with different age groups. Table 2 summarizes the results of field research.

Through the results obtained with the field research, it is possible to observe that there was a great adhesion between the volunteers regarding the use of the developed game as a further teaching tool in the classroom. All interviewees marked this option by showing that, grammatically, the game is acceptable by the standards of the students involved in the research.

It is also possible to observe that the design of the game was adequate from the point of view of complexity and issues addressed. Again, all respondents agree that the complexity present in the game fits the originally intended age groups (9 to 10 years of age).

Regarding the mean values of the suggested age groups, the value obtained was 10 years of age. These values had a great variation, but their average is within the values initially proposed in the project.

When questioned about the project's gender neutrality, most volunteers responded that the game would be equally attractive to both boys and girls. However, approximately 16% of respondents said the game is more aimed at the male audience. In the field of suggestions, many comments were observed encouraging the addition of a female character to the game. This has been incorporated into future work.

Regarding how much a child would be attracted to this game (on a scale of 1 to 10), the highest grade was 10 and the lowest grade was 8, with an average of approximately 9.5. With these values, it is demonstrated that the students interviewed believe that this game would be well-liked by children in classrooms.

Table 2. Volunteers' responses to the questionnaire presented

Q1	Q2	Q3	Q4	Q5	Q6
10	9	yes	yes	8 years	yes
10	9	yes	no	9 years	yes
10	10	yes	yes	8 to 9 years	yes
10	9	yes	no	9 years	yes
10	10	yes	yes	10 years	no
10	10	yes	yes	8 to 9 years	yes
10	10	yes	yes	8 to 9 years	yes
10	10	yes	yes	7 to 10 years	yes
10	10	yes	yes	7 to 10 years	yes
10	10	yes	yes	9 to 10 years	yes
10	10	yes	no	9 to 10 years	yes
10	10	yes	yes	9 years	yes
9	9	yes	yes	9 years	yes
8,5	10	yes	yes	9 years	yes
8	10	yes	yes	8 to 10 years	yes
8	10	yes	yes	10 to 12 years	yes
8	9	yes	no	10 to 11 years	yes
10	9	yes	yes	12 years	yes
9	10	yes	yes	11 years	yes
9	10	yes	yes	9 to 10 years	yes
10	10	yes	yes	9 to 10 years	yes
10	9	yes	yes	9 to 10 years	yes
10	9	yes	yes	10 to 11 years	yes
9	9	yes	no	8 to 9 years	yes
9	9	yes	yes	8 to 9 years	yes
10	10	yes	yes	9 to 10 years	yes
10	8	yes	yes	8 to 12 years	yes

10	9	yes	yes	8 to 13 years	yes
10	9	yes	yes	8 to 12 years	yes
9	10	yes	yes	11 years	yes
10	10	yes	yes	10 years	yes

The question that measures the possibility of a child learning mathematics with this game (on a scale of 1 to 10) the highest result was 10 and the lowest was 8, with the overall average being about 8.9. Talking with the volunteers, it was said that the pressure imposed by the time issue on children might hinder their performance and that this game would be best applied as a form of review rather than teaching itself.

5Conclusions

This work showed how the development of a digital educational game was developed with the aim of teaching tables for children in the 3rd and 4th years of elementary school. A field research was also carried out to validate the ideas of the project, a research that was carried out with 31 students of pedagogy spread across several classes of the course.

The results obtained in this work show how the idea of putting this type of game in classrooms can help in teaching new materials and how future professionals in the area appreciate this idea.

This type of technique is still little explored in Brazil, but in other countries it is already common. It will require a great investment so that this delay is corrected, but the possible results obtained from this methodology can be very impacting for the new generations.

Future Works

The game currently has only 3 levels, and was done thinking only in the teaching of tables for children of 9 and 10 years of age. However, the project can be expanded by creating more levels, adding more mathematical operations, and increasing RPG elements.

In the future, a female lead character will be inserted into the game in order to increase the diversity of player choices. Also new enemies and scenarios can be added.

The idea present in the first game version with more complex mathematical problems was also not ruled out. In a new version, each enemy will have a specific problem as a form of combat. For example, the enemy X will always be fought with sum problems, while the enemy Y will be fought with multiplication and divisions.

This scenario also opens the possibility of greater customization for the game, allowing a teacher to select the phase and also the enemies in it, making this project a more complete tool.

The use of larger RPG elements during combat will also be included in the game. You can also insert new elements, such as a second bar (magic, for example) that allows special movements. With this, the game will be even more immersive and playful.

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