

Matemática: a role-playing game to reinforce the teaching of the four basic mathematics operations in a playful way

Juliane Silva, Liliane Fonseca, Adelmo Oliveira, Carlos Saraiva, Reili Santos

Faculdade Nova Roma

Recife-PE/Brazil

[julian3, lilianesheyla, ad3lm0, emailcarloscadu, reiliamon]@gmail.com

ABSTRACT

According to the PISA 2015 report, the Brazilian school performance in mathematics presents unsatisfactory results. A strong aggravation to this scenario is the mathematical anxiety, the fear of mathematics. This work aims to create an electronic game as a tool to support mathematics teaching. The methodology used includes bibliographic research, to collect information present in the literature on existing educational games, focusing on the role-playing games and the approach to mathematics. Through the use of a specific tool, the RPG Maker, a game was created to reinforce learning in a playful and stimulating way. Finally, this work presents a playful tool to stimulate the learning of the four mathematical operations, in an attempt to diminish the mathematical anxiety in elementary school students. Assessment studies are being applied through case studies in public and private schools and soon the results will be published.

Category and Subject description

K. 8.0 [Personal Computing]: General-games.

K. 3.1 [Computer Uses in Education]: Collaborative Learning.

General terms

Documentation, Performance, Design.

Key words

Mathematics. Educational electronic game. Role-playing game. RPG. Learning

1. INTRODUCTION

Mathematics are present in the development of children early on, but it is quite common to find a certain level of contempt and reluctance towards this discipline in school-age children. This barrier clearly causes a negative influence on the learning of mathematics.

Since 2000 the Programme for International Student Assessment (PISA) has been analyzing the performance of the Brazilian students and the negative results, in respect of mathematical knowledge, draw attention. According to the 2015 report, the students in Brazil are below the average of the students in the other countries of OECD (Organisation for Economic Co-operation and Development) in sciences (401 points, compared to the average of 493 points) and in reading (407 points, compared to the average of 493 points). In mathematics a more alarming number stands out, reaching

113 points of difference (377 points, compared to the average of 490 points).

The lack of knowledge in mathematics is emphasized by a cultural reflex that states that mathematics are difficult and complex [13]. According Felicetti and Giraffa [2], this reflex generates a psychological disorder, called mathematical anxiety, which prevents learning and interferes in the intellectual equilibrium of these students.

In face of these scenarios, it's necessary to propose an alternative that can contribute to the teaching of mathematics. An alternative with a more playful and fun approach turning the learning process enjoyable and removing the possible presence of mathematical anxiety. At this point, the educational game shows as an ally.

According to Tarouco, et al. [14], it's observed that all games, from the simplest to the most complex, have a certain degree of learning that is acquired while playing it along with the capacity to recognize and understand the rules, and to identify the context in which they are inserted and invent new contexts to rebuild them.

For the educational process of children to evolve, it's needed to upgrade the teaching methods through the use of technology and the insertion of games as an alternative educational tool. It's necessary to understand the positive side of using games – in a beneficial way – to transfer knowledge to children and increase their chances of absorption of past knowledge.

It is also necessary to invest in the production of attractive, complex and content-rich games that allow children to practice the skills learned through the school curriculum and many others. The children of the new generation signals for a change in the form of teaching of schools and, as Prensky says, parents and teachers are able to initiate this change [9].

In this way, this work presents an role-playing game called “*Matemática*”, whose objective is to enhance the learning of the four basic operations of mathematics, using a playful and fun approach, in an attempt to reduce the indices of mathematical anxiety in children from 3rd to 6th year of elementary school, in addition to stimulating interest – on the part of these children – in the learning of mathematics.

The remainder of this article is presented as follows. The Section 2 presents a review of the literature on the use of educational games as a learning tool, as well as an overview

of context-related works. The Section 3 describes the research method used. The Section 4 reports the development of the proposed game, including the tools used and the structure of the game. The Section 5 introduces the proposals for future works. Finally, the Section 6 reveals the conclusions of this work.

2. LITERATURE REVIEW

This Section presents a brief review of the literature on educational games. In the Section 2.1 an approach to educational games is displayed describing their concept and function in society. In Section 2.2, the contextualization about role-playing games, its mechanics and which characteristics stand out for the teaching-learning environment are reported. The Section 2.3 presents a review of the proposed context-related works.

2.1 – Educational Games

Children develops their intellectual capacity when they imagine situations, problems and their solutions. Piaget states that such development is what we call “learning” [8]. The educational game focuses on teaching of certain content, taking advantage of the playful motivation so that the children who plays it, imagine its context and absorb the content in the form of learning.

According Prensky and Retondar, the educational game is a fundamental element in the formation of students, as a tool that shapes skills; teaches respect and understanding of social rules; stimulates the search for more knowledge while keeping them interested, motivated and excited [9, 10].

There are different types of games. Caillois, classifies the games into four distinct groups, they are *Agôn* (Competition), *Alea* (Lucky), *Mimicry* (Simulation) and *Ilinx* (Vertigo) [1]. However, it's entirely possible that games have one or more of these classifications in their concept and all of these types can be applied to achieve educational learning objectives.

2.2 – Role-playing Game and Education

The RPG¹, is a simulation game, responsible for working the player's imagination and make-believe, where a game is interpreted and narrated, requiring that one of the participating players interpret the role of the master (narrator), controlling the NPC² and the enemies, while the other players interpret their characters, created specifically for the game, with their emotions and actions directly influencing the way that the game develops [12].

The interpretive feature makes the RPG environment, where the player feels the sensation of having been transported to a parallel world and can “live situations” which not always happens in real life. Another feature is the rich social interaction between players, where they will need to mediate conflicts and make a game decision.

The electronic version of the RPG corresponds to the role of the master being interpreted by a computer. In this version the player controls his character and/or other characters partially needed in the plot. No other players participate in the same game context.

When analyzing the application of the RPG in the educational environment, one can imagine a scenario in which students discuss, among themselves, what is the best strategy to advance through a particular obstacle in the game that addresses a content presented in class. These students would be fixing the learning at the same time they explore ways to optimize it and is entirely possible to perceive the positive impact – of the RPG – on teaching.

The design of the game “*Matemágica*” results from the interest in exploring the curiosity of the child that immerses in the playful universe of the game, making a reflection on the dialogues experienced, as well as, the interest of trying out the different roles of interpretation existing in the electronic RPG.

The use of a context of action, of duels and battles, with moments of relaxed and entertaining dialogues, is to help the child to overcome the barrier of mathematical anxiety and, desirably, feel stimulated to overcome the duels, reinforcing its ability to solve the calculations of the four basic mathematical operations.

2.3 – Related Works

It's possible to find in the literature, several researches involving the use of electronic games as a tool to support teaching-learning, which demonstrates the growing interest in studies related to the use of electronic games for the teaching of contents experienced in the classroom.

Among the educational games found in the literature, stands out *Caféboo* [5], *GeoEspaçoPEC* [4], *Final Product* [11], *Alius Educare* [3], *Taultun* [15] and the *Educational Software Applied to Teaching of Environmental Chemistry* [6], by the similarity to the context discussed in this work. The following is a brief description of each of them.

Caféboo is a daily simulation game, where the main character lives the role of a coffee shop attendant. The objective of the game is to become a tool to support the teaching of basic financial mathematics.

GeoEspaçoPEC, in turn, is a role-playing game, in which the character is an elementary school student studying, for a mathematical test, in a library that will be the target of the actions of a group of thieves of rare pieces of Leonardo da Vinci. The game aims to help learn about spatial geometry.

Final Product comprises a role-playing game developed with RPG Maker, where the objective of the game is to approximate the financial education of the students' school

¹Role-playing Game abbreviation.

²Non-player character (Non-playable character)

routine and introduce the concept of currency/money in a playful and investigative way.

Alius Educare features a role-playing game, also developed with the RPG Maker tool, in which the goal is to establish environmental awareness.

Taltun is a role-playing game, developed with RPG Maker, where the game aims to address content of the disciplines of Natural Sciences, Geography, History, Portuguese language and Mathematics.

Education Software Applied to Teaching of Environmental Chemistry is a role-playing game, developed using RPG Maker, where the objective of the game is to educate students about the impact that chemical waste has on nature, generating pollution in the air, soil and water.

Finally, it is possible to observe that there is plenty of room for the inclusion of new tools and new studies involving electronic games for education. In a brief analysis, it's possible to observe that the game "*Matemática*" presents itself similarly in terms of its entertaining and captivating approach, which results from using the RPG Maker tool.

Although the role-playing game style points to a fairly common game script, which the character is inserted in a particular context, where he encounters a problem-situation and develops the plot of the game dialoguing and seeking clues to the solution of this problem, as it's observed in the games *GeoEspaçoPEC*, *Final Product*, *Alius Educare*, *Taltun* and the *Educational Software Applied to Teaching of Environmental Chemistry*, the game "*Matemática*" presents the mathematical problems like enemy attacks, stimulating the player to defeat them and increasing the child interest in mathematics gradually and seamlessly as they get more powerful in the game and face more challenging foes.

Another similar feature refers to the ambiance. In *Caféboo*, *GeoEspaçoPEC* and *Alius Educare*, the ambiance of the game points to our real life, however, there is a "minor detail" that changes all the perception on the part of the player. The "*Matemática*" brings in this approach, the playful element, when the character is "plucked" from the classroom to an unknown dimension, where the four mathematical operations are also guardians of the four elements of nature.

About the context of the conflicts, or battles' system and duels, it's possible to perceive the lack of this context in the games *Caféboo*, *Final product* and the *Education Software Applied to Teaching of Environmental Chemistry*. In turn, the game *GeoEspaçoPEC* presents this context in the form of a pastime. The *Alius Educare* addresses the battles without direct relation to the content and *Taltun* and the *Educational Software Applied to Teaching of Environmental Chemistry* don't present any battles, while the "*Matemática*", presents a battle system developed exclusively to involve duels that depend on mathematical calculations.

Finally, observing the external references involving the first PhD woman in mathematics in Brazil and the relationship

that the characters have with the universe of mathematics, one understands that the game "*Matemática*" – as a tool – have a unique, playful, fun and stimulating context.

3. METHODOLOGY

The development of this work comprises an applied and descriptive research, presenting as purpose the creation of an educational electronic game, consisting of 6 steps.

1) Realization of the literature review

The first step is the revision, of the literature, performed for a better understanding and knowledge of the existing needs for the development of the game. Next, we present the approaches to how the literature was revised for this work.

a) Problem choice

Reviewing the indexes of school performance in Brazilian education a very negative scenario was perceived in relation to the mathematical knowledge.

b) Identification of aggravating factors

In depth the research and revisions focused on the low performance index in mathematics. It was identified the presence of mathematical anxiety, the difficulty of text interpretation and the demotivation to learn mathematics on the part of the students.

c) Search about the Game Engines

The problem and its aggravating factors acted as a motivation for the choice of a game engine that offered a cozy, stimulating, playful and entertaining platform. The RPG Maker tool presented itself as an excellent option, because of the ease resources for the development and the simplicity offered to the end user, as to its use.

Viewing this scenario in the literature, the following research question arose:

How to increase interest and willingness to study mathematics of School-age children using an educational electronic game?

d) Search for existing games

In this step, were searched mathematical games developed through RPG Maker tool brought us games focused on financial education, mathematical logic, spatial geometry and basic mathematical concepts. Finding space to the reinforcement of learning of the four basic operations of mathematics.

2) Collecting data of the main elements of the game

It was collected some fundamental elements for the development of the game, aiming to preserve its originality and direct attentive eye at a tool with differentials. It was established the use of a communicative language rich in local terms and slang, in order to facilitate the interpretation by the player, as well as elements that reinforce the characteristic of an educational game in role-playing game style: The will to

play, where the player can battle as many times as wanted for the desired time and autonomy in making decisions, in which the player acts in the way they feel more comfortable with.

3) Implementation of the Game

In this step, a functional version of the game “*Matemática*” was implemented, in order to confirm the logical, dramatic and playful functioning of the game. Functional requirements were collected and during the development stage concepts of usability and validation about the user experience were applied.

4) Execution of tests

Alpha tests were carried out with the researchers involved in this work and with a potential user of the proposed age group, in order to validate the established criteria, identify bugs, as well as analyze variables of time, difficulty, effort and satisfaction during the action of playing.

5) Planning for case studies with students

A detailed and careful planning is being implemented to analyze the game from real users in different scenarios existing between public and private schools in the metropolitan area of Recife.

6) Game evaluation, adjustments and improvements

The evaluation of the game, from the point of view of Beta testing, will be briefly applied in the real context that the game is proposed, and the data will be collected and analyzed. The improvements will be implemented and, if possible, re-evaluated. Soon the results of this evaluation will be published.

4. THE GAME “*MATEMÁTICA*”

This paper presents in Section 4.1 the tools used for the implementation of a functional prototype of the game. Section 4.2 describes the playful script prepared. Section 4.3 reports on the existing characters. Section 4.4 presents the elements that reinforce the unique, playful and relaxed characteristic of the game. Finally, Section 4.5 revises the proposed goal of the game: to reinforce teaching.

4.1 – Development tools

The main tool used was the RPG Maker MV³ software, version released in 2015 that brings the possibility of developing RPG-style games for various devices such as Android smart phones and IOS; MAC/OS, Windows and Linux operating systems; and Web, regardless of operating system or device used.

Another detail that highlights the version used the other is the use of JavaScript – for creating plugins⁴ – as a programming language, instead of using the Ruby language. The algorithm responsible for the structure of the duels was developed exclusively for the purpose of the game, being linked to the project as a plugin. The format of the generated files, in the creation of the games, is of type *JSON*⁵, which makes these files light and easy to manipulate. To assist in the process of version control and persistence of the source code was used *Git*⁶ in conjunction with the *Github*⁷.

The tools used for graphic development comprise the use of the *Photoshop*⁸ for general image editing, and the graphic suite of the *Corel Draw*⁹ for the creation of a logo, initial and final screens. Finally, the characters' drawings (main graphics icons, battle icons and faces) were developed through the character generator, made available as a plugin for RPG Maker or as standalone software.

4.2 – Gameplay

The reality of “*Matemática*” is set in our everyday universe. The game starts in a classroom. The teacher presents herself during a small dialogue and then highlights the relevance of mathematics to people's lives. At this moment, the teacher shows excitement in affirming that mathematics has a “*Matemática Energy*” that is responsible for keeping the universe in harmony or in imbalance.

For an instant another student – called *BJ* – initiates a parallel conversation with the player. The conversation is soon interrupted by the teacher, who changes the subject to the awareness of how essential mathematics is for life, exemplifying with some situations in which students would never be able to solve without the help of mathematics.

Unexpectedly, the player finds themselves in a disastrous scenario. The school is destroyed; the classmate is on the floor and hurt, asking for help to find the teacher. A search for the teacher begins.

A mysterious creature comes out of nowhere and presents itself as *Bash*. The creature doesn't seem to remember how she got there but tries to explain that to the player in a short dialogue. After a bit of dialogue between the player and the creature, they decide to look for the teacher. At this point the player will have the freedom to search for the teacher across the map.

³RPG Maker, *Make your own role-playing games*. Available in <<https://www.rpgmakerweb.com/>>. Accessed on 09/20/2018.

⁴Tools that add new features to larger programs. They are usually small and light, often used on demand.

⁵*JavaScript Object Notation* is a lightweight format for computer data interchange.

⁶It includes the distributed version control system, in conjunction with a source code management system, with an emphasis on speed. It's free software.

⁷This is the source code hosting platform through *Git* version control, allowing any user registered on the platform to contribute to projects from anywhere in the world.

⁸Software characterized as two-dimensional image editor, developed by company *Adobe Systems*.

⁹Software of two-dimensional vector drawing to design graphic developed by company *Corel Corporation*.

When the player encounters the Teacher and tries to approach her something mysterious happens and another very suspicious creature shows up, this time seemingly hostile. The teacher tried to escape unnoticed.

Unfortunately, the creature notices the teacher's presence and charge at her. The player attempts to reach them, but the creature disappears carrying the teacher. *Bash* approaches after hearing the cries and noises and talks about what just happened. Then the player is presented with the magic artifacts *Bash* found while searching for the teacher and adds some new information she was able to remember.

The real adventure begins. *Bash* and the player leave for a journey through the dimensions of “*Matemágica*” in search of the teacher, hoping that in finding her all this chaos would be explained and possibly solved. This adventure is characterized by a journey between elemental dimensions (water, fire, earth and air) where the player is going to have the opportunity to face the creatures under the control of the Guardians of Addition, Subtraction, Multiplication and Division, in scenarios contemplated by mazes and challenging experiences.

4.3 – Characters

The game counts with the option of choosing the main character among eight predefined models, allowing from the beginning to exercise of autonomy by the student player. Another important detail about these models corresponds to the fact that they are equally divided between the male and female genders and a fair range of skin tones, bringing some basic characteristics of representativeness¹⁰.

The character BJ was chosen to honor the 9-year-old son – Bernardo Justino – of the author of this article. The Teacher emerged from the interest in valuing the role of the education professional and the idea to prestige the role of a relevant woman in the history of Brazilian mathematics as presented by Pereira [7].

The guardians of the four operations – addition, subtraction, multiplication and division – refer to the four natural elements – water, fire, earth and air – contemplating the same idea that opposite elements maintain balance.

Finally, the characters *Bash* – which accompanies the player throughout the game's adventure – and *Karah*, malignant creature that sets the chaos in the dimensions of “*Matemágica*”, were born of the idea of creating a character that had a direct relation with mathematics, in this case with the popular name of the formula that solves second degree equations. Thus, *Bash* and *Karah* have opposing identities that complement each other to create the *Bhaskara*.

4.4 – Elements of the game

The game “*Matemágica*” was designed to assist students in the process of learning the four basic operations of

mathematics (addition, subtraction, multiplication and division). Given this, four elements have been addressed in the game, an explicit element consisting of indirect teaching of the mathematical content, where the student will need to have a sense (minimum knowledge) of the content and use it in the correct way so that it has the capacity to proceed and advance in the game, that is, the learner will not have the power to decide not to learn the content, consisting of a linear process of learning, according to Horta and Almeida [3]. This is done so that the student who has taken the class on the subject and has not mastered it, has the interest in learning. This element comprises the duel where the player needs to correctly answer the question in a set of possibilities, also the player must answer correctly to be able to strike the opponent otherwise his character will suffer damage.

The dramatic element consists of the interaction that the player develops with the non-player character (NPC). This element, in turn, acts in situations or events – that the student player loses the focus of the game – transferring to the NPC the control of the game. According to Horta and Almeida [3], such action causes events to move forward, and so continue the history.

The historical element is the approach responsible for moving the plot, bringing the conflicts unfolded by the development of the plot and that maintains the connection with the proposed mathematical teaching always present.

Finally, the attitude element comprises the freedom that the player has in certain events of the game, where questions and dialogues of the plot occur that require intervention through multiple choice responses and which can subtly change the perception about some characters but does not change the linearity of the game's history.

4.5 – Reinforcement in teaching

As presented earlier, the game proposed aims to support the learning of mathematics through explicit elements addressed in the design of the plot. The proposed teaching of the four operations develops progressively in the action scenarios – characterized by mazes where possible duels with enemy creatures – in which the player must win the duel by selecting the correct answers in the proposed calculations.

In case the player is unable to win the duel, the game will end, and the player must try again starting from the beginning or his last saved progress point. In addition, as the player progresses along the scenario, the difficulty of calculations increases with higher values in the composition of the terms of operations.

The final duel of the scenario – represented by the Guardian of the operation – comprises, at random, the exposure of the simplest calculations to the most complex ones, besides the need for a greater number of problems to be solved to

¹⁰ It means to represent politically and socially the interests of a particular group, social class or a people.

overcome the duel, compared to the common creatures of the scenario.

In these moments in which the player needs to solve the calculations to advance in the game, the teacher has the opportunity to take advantage of this desire to continue in the game – on the part of the student – to stimulate it and to lapidate it in the content of the operations.

The proposal still extends to the non-linear scenario of the game – a hidden room, known as Easter Egg¹¹ – addressing questions of mathematical logic, with humorous character, in the form of charades or pranks, such as Fibonacci sequence and prime numbers. The proposal also works on developing the player's ability to interpret text.

5. CONCLUSIONS AND FUTURE WORKS

This paper presents an educational electronic game for mathematics learning processes to elementary school students. It has a RPG-style, focusing the four basic operations of mathematics.

Developed with RPG Maker, the game brings a playful, fun and stimulating proposal to encourage learning. This proposal also acts in the attempt to diminish the mathematical anxiety, psychological disorder that causes fear and repulsion by the mathematical discipline and its alike.

The elements presented in the context of the game point to a satisfactory result regarding the degree of incentive and playfulness presented as the problematic of this work. Although the proposed game has been evaluated through alpha tests, we intend to apply the game “*Matemágica*” in the real context in which it is proposed to act, that is, in schools – both public and private – and after collecting and analyzing the data obtained, present the final results of this work, validating this tool and identifying a set of improvements to implement this game.

As a future work, it's also intended to separate the stages of the game into independent modules, so that it is possible for the teacher to act directly in a single mathematical operation, as well as the implementation of difficulty selection, so that the player feels more challenged and motivated to face the problems proposed by mathematics.

With the proposed tool by this work, it's hoped to stimulate the learning of mathematics, demystifying its complexity, making the student understand the mechanics of calculation. To attract students' interest in the discipline, pointing to the use – of in everyday life – outside the school. Reduce the presence of mathematical anxiety, through playful, fun and relaxed contact with mathematics. Finally, modify the performance indexes in mathematical knowledge to a positive scenario, bringing a benefit not only for the student himself, but for society as a whole.

¹¹ Easter Egg is something hidden in any kind of virtual system, including music, movies, websites, video games, etc.

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