Mathematics Teaching Based on a New Pedagogical Tool for M-Learning

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Figure 1: (a) Menu screen of the game Dimus. (b) Dimus Phase with questions related to geometry.

Abstract

The integration of educational process with digital technology is a trend and may greatly enhance the teaching-learning process. Electronic games can be considered educational teaching resources, due to its dynamic and engaging characteristics, allowing also the learning and fun process together. In the current educational context, the use of technological resources is already a reality. When considering that education in the Information Society is realizing the need for a change, we propose a novel process for the usage of mobile devices in educational terms. This article proposes and evaluates an application for mobile devices with the aim of contributing to the elementary school Mathematics teachers.

Keywords: mobile, educational games, teaching and learning of mathematics.

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1. Introduction

Currently the technology is being used by a range of users, including children who have early interact in the world of digital technologies. Because the computer is a great means of entertainment, they give off a lot of time in this activity, according to [Silva et al. 2010]. Furthermore, the computer is considered as a new way to acquire knowledge, and therefore can become a teaching tool. However it must be well instructed by the teacher or someone more experienced so that this function takes effective [Mousquer and Rolim 2011].

It is important to be highlighted that the age of childhood and adolescence is the stage that develop concepts essential to the formation of the individual. The knowledge gained in this stage are essential for their integration into society and a friendly social life [Silva et al. 2010].

According to [Filho 2010] cited in [Prieto et al. 2005], "The games must have a pedagogical aim and its use should be placed in a context and a teaching situation based on a methodology to guide the process, through interaction, motivation and discovery, facilitating learning of a contents.". Thus, the researchers, to create this type of software, looking to integrate fun and interaction with educational content, causing the student has an interest to learn in an active, dynamic and interactive [Filho 2010].

About the prospect of using mobile devices in education, [Batista et al. 2010] states that: "Mobile learning (m-learning) is a research field that seeks to analyze how mobile devices can contribute to learning. The development of teaching resources for these devices are essential for the effective application of m-learning.".

Our objective is to present a game which covers mathematics course content according to the Parâmetros Curriculares Nacionais (PCN). The proposal arose on the complexity of the exact area of the discipline. Many games with this goal already exist, but the work of this paper seeks to combine a new media technology into the teaching-learning process. To do this we developed a new application for mobile devices, exploiting the full potential in terms of usability. Their use could happen in school with the

guidance of a mediator or informally outside the school environment. Thus the child will be performing activity that raises interest, pleasure and, at the same time, develops his intellect.

2. Related Work

2.1 Development of Logical Reasoning Math

A major difficulty encountered by students is a matter of understanding and reason which exposes a problem and then seek the solution. This context emphasizes the importance of working this issue from the earliest stages of learning, because knowledge construction is performed at all times [Escolare et al. 2007].

According to [PCN 1997], "It's part of life for all people in the simplest experiences how to count, compare and operate on numbers. In the calculation of salaries, payments and consumption, the organization of activities such as agriculture and fishing, mathematics is presented as a great knowledge of applicability.".

The proposal for teaching mathematics in elementary school is to get the student to be able to solve problems of everyday life and also serve as an instrument for other curriculum areas [PCN 1997].

Despite its importance for the development of the student, mathematical contents are complex to be taught. Because so many students in this age group have little ability to abstraction. The [PCN 1997] describes that "an important aspect in the games is the genuine challenge they bring to the student, which generates interest and pleasure. It is therefore important that the games form part of school culture, whereas the teacher to analyze and evaluate the educational potential of each game and aspect of the curriculum that he wants to develop.".

Given the importance of mathematics in human life, it is necessary that his basis in the teachings of Elementary School is very strong and profitable for years to come and to his everyday life. Thus, this paper developed and evaluated a new educational tool for the discipline of mathematics.

2.2 Technology X Education

According to [Nogueira et al. 2010], alphabetization is one of the most important steps of the whole educational process of an individual, and any way to facilitate his learning is widely welcomed. The fun is something natural for the child and should be exploited to assist in the transmission of knowledge between the educator and the student.

The activity of play is already part of everyday life of the human, because this action is exerted from the earliest times. Thus arises the importance of intertwining games with educational content, benefiting and facilitating the acquisition of knowledge in any predetermined area [Machado et al. 2011].

Through technological developments in the modern world, the adoption of the Internet as a research and communication enabled a new educational context, especially on the way to acquire knowledge. This advent spurred the school and teachers to rethink their practice. For some time that the traditional pedagogy "where the teacher was perceived as the ultimate authority, an organizer for the content and teaching strategies and therefore the sole responsibility of the educational process." [Cabral and Martins 2009] became obsolete due to new social demands.

As described by [Silva et al. 2010], the school has the challenge of contributing to the process of cognitive development of students. And, given the current context, there is a need to seek other ways to contribute to this process. According to this concept the teacher can rely on features of digital culture to make the teaching-learning process more attractive to the student [Oliveira and Medina 2007].

New technologies in education and the teaching-learning process not only contribute to the cognitive process, but also to the emotional, as stated by [Souza et al. 2011], "in the games we see the influence of other elements such as design, aesthetics, plot, as well as attitudinal and behavioral values that are internalized and disseminated more easily and subtly through a language domain increasingly widespread among children and adolescents."

As example, the puzzle and memory games are used for educational construction for both children and adults, since the game can be used as a means to learn the contents and develop the skills of the human.

Electronic games are educational resources arising from the digital culture. And if well designed involves the student, because this activity generates a personal achievement as interest increases as they develop their skills and reasoning [Silva et al. 2010]. Os autores [Nogueira et al. 2010] ainda fortalecem que os jogos educacionais são formas lúdicas de ensinar às crianças de maneira muito menos cansativa.

[Filho 2010] describes in his work the main positive aspects of using games in education. They are: motivator, facilitator of learning, development of cognitive skills, discovery learning, experience new identities and motor coordination.

Mobile devices, according to [Mousquer and Rolim 2011], can be used within the classroom as educational support, causing development of autonomy, creativity, curiosity and socialization, thus contributing to the child's knowledge.

Following the aforementioned technology, [Oliveira and Medina 2007], advocate the use of M-Learning, which is widespread in education by making use of the wireless network. As cited in [Mousquer and Rolim 2011], tablets, smartphones and PDAs (Personal Digital Assistants) are examples of mobile devices that encourage students to work their creativity, awakens their motivation, contributes to the learning process and assists in resolving problems that may be addressed both individually and collectively.

[Silva et al. 2010] cited in [Moita 2007] claims that technology along with education are major contributing factors to build the ideal and character formation of every human, because these approaches have dynamic and flexible characteristics. Thus, the technology has developed significantly and positive aspects are huge.

2.3 Educational Electronic Games for Teaching Math

Because the need to innovate teaching methods and adopt different ways of working with mathematics, new tools emerge. The games are a good example, because there are many of them addressing mathematics content. The objective of this modality is to minimize the difficulties encountered by students in understanding the logical concepts of the discipline [PCN 1997].

The "Trilha Matemática" application submitted by [Rieder et al. 2004], is a board game based on mathematics expressions. If answered correctly, the player moves the squares of the board to enable him to reach the end point of the map. Its structure is client-server, other words, connectivity allows the sharing of the game to multiple computers, making it multiuser. Designed for computer experiments showed satisfactory acceptance of the game, but there were difficulties in setting the structure. With regard to aspects of usability was perceived failure with respect to the absence of bright colors.

[Rieder et al. 2004] developed the game "Memória Matemática". This has the classical mechanics of a memory game, but the pairs (to be found) are the mathematical expression and its result. The subjects covered are mathematics and exponentiation operations. At first, the user can select the degree of difficulty, rails blocks, animation, and how many terms will have the expression. There was a great satisfaction of users, but there were difficulties in solving calculations with more than one operator and suggested a greater use of color and the adoption of sound.

[Lopes et al. 2011] developed an application similar to the previous, this time with the aim of creating relationships between geometric figures and their respective classifications. The game has 8 stages and at the end of each is given the amount of errors and time spent to finish it. The target audience were children between 6 and 10 years. The prototype used the navigation keys of remote control, the button "enter" to select the cards through a platform for TVDi.

In [Batista et al. 2011] was presented a pedagogical structure called M-learnMat in order to direct activities of m-learning in Mathematics in Higher Education. They conducted the experiment with the MLE-Moodle, whose installation requires internet. This editor allows the teacher to draw up, for example, quizzes and other educational materials for students to exercise their knowledge of mathematics. In the experiments positive results were noted, as the adopted model contributed to planning of strategies and to performing actions.

The idea of [Silveira et al. 2012] was to create a playful environment consists of educational games. Their goal is to develop the logical and mathematical thinking player. One of the games is named "Jogo do General", which is based on levels, that first proposed the user to form the largest possible sequence of numbers within the same pre-defined rules. The next levels are based on the first, but there are changes in the rules causing greater difficulty in the game. In "Bingo Dos Dois Dados" game, each player selects a card, and each round is randomly selected two data. The player who has drawn on the card the sum must respond. If the answer is correct the card color change and is adding a point to it. If the player loses points incorrect. The game ends when someone meets all your card numbers. Both games were developed for aged 6 to 10 years and were also validated by a group of elementary school. The results showed the "Jogo do General" more attractive, but the two were considered fun. The items suggested were: use of sounds according to the actions, display the corresponding number of data and increase the font size of the game.

Our work proposes a tool to support the teaching of mathematics like [Lopes et al. 2011] and [Silveira et al. 2012], using 10 stages with a gradual increase of difficulty of the curriculum. Likewise, the target audience are children of 8 years. Its basic function and development platform are similar to [Batista et al. 2011], whose application uses the quiz mode. The difference related to this mode is that the options appear in animated form, requiring the ability to response selection, which is characteristic of the action genre games. Another feature of our application, which was called to attention by [Rieder et al. 2004] and [Silveira et al. 2012], is the approach of bright colors and sounds for each interaction.

2.4 Benefits of Using Mobile Devices in the Classroom

According to [Oliveira and Medina 2007], the use of mobile devices, especially mobile phone, has grown significantly due to the gradual decrease of its price and also the technology to offer easy access to the internet. The portability of the device allows access to

content at any time, both the time spent waiting and in locomotion.

The [Mousquer and Rolim 2011] advocates the use of mobile computing for the teacher, for children treat technology as a toy and then become interested in it. In addition to learning, students can exercise skills as fine motor coordination and wide, laterality, visual and auditory perception, notions of planning and organization and logical reasoning. Therefore, children who are in pre-literacy can enhance their knowledge of letters, learn their usefulness and text through this technology. They stress the importance of educational mobile system designers know the issues that children should exercise. The aspects are: autonomy, creativity, curiosity, sensorimotor development, without fear making mistakes, interdisciplinarity, motivation, logical reasoning, mobility and socialization.

Society is slowly leaving the desktop computer to use such devices, [Bottentuit 2012], cited in [Moura 2009a], quotes about it: "For years, the number of mobile phones surpassed the number of personal computers, converting in the communication system." And so arises the need of creating new educational applications for this technology so pervasive.

3. A proposed Tool for M-Learning Applied to Teaching Mathematics

3.1 Covered Content

The education guidelines of many countries adopt a curriculum organized by ability, but since mathematics is considered a tool that allows a better understanding of the environment where the child lives, we need new tools to help build educational [Pastells 2009]. For this we have educational electronic games, meeting the expectations of consolidating the knowledge.

Aiming to contribute with a tool that is a resource for teaching ludic mathematics course, were selected were selected program contents of 3rd year of elementary school suggested by the Parâmetros Curriculares Nacionais [PCN 1997].

With reference to studies cited by Piaget [Barros, 1988] in his theory of stages of development, at the age of 8 years the child is at the stage of concrete operations, ie, the stage more conducive to acquire knowledge, assimilate and save them. Especially at this stage the child begins to develop the skill of abstraction that is a prerequisite for working with calculations.

Our application aim to work and consolidate some content that the child has learned or are learning in school about mathematics. Content covered by the game content are provided in the curricular structure of this series with some others that should be consolidated.

According to [PCN 1997] and [Sanchez and Liberman 2010], this cycle students learn about the natural numbers and their uses in everyday life, they know also the decimal numbering system, they get to know some geometric solids and flat shapes identified in the figures. Children also are replaced notions of time measurements, such as seconds, minutes, hours, days, months and others. Measurements of length and measures of capacity and mass, although it is only an introduction. Strengthen the knowledge of mathematics operations as addition, subtraction, multiplication and division operations units and also learn with tens and hundreds, but this has become more complex for students [Sanchez and Liberman 2010].

Thus, the context of the quizzes was formulated as in [Sanchez and Liberman 2010] and [PCN 2007]. Seeking to take questions for the game that enriches and strengthens the student's knowledge. Figure 1 (b) and 2 illustrate the type of question that the game works.

Figure 2: Phase Dimus with issues relating to the sum.

The contents of mathematics covered in Dimus game (our proposed application), inspired by lists of exercises taken from [Pastells 2009] and in accordance with [PCN 1997] were: addition, subtraction, multiplication and division of natural numbers, concepts of numerical sequences, double, triple and quad-dozen, dozen and drive. Also geometric solids, flat shapes, successor and predecessor of natural numbers and time measurements. The questions designed to characterize the action genre (which requires skill and speed of thought) had to be objective and short, examples can be highlighted in Table 1:

Table 1: Questions examples.

Question	Correct Answer	Area
Continue: 10, 12, 14...	16	Numerical Sequences
Solve: 53-3	50	Subtraction
Number with 4 tens and 4 units.	44	Tens and Units
Two months have how many days?	60	Measures of Time

Therefore the developed tool allows the student "play" with content that he learned in school. It also helps the student to practice mental arithmetic and develops the reasoning.

3.2 Application Development Tools

For application development we used the Corona SDK compiler and simulator. That tool is a software development kit that uses the Lua programming language, created in 2008 by Walter Luh. Today the company that develops is called Ansca Mobile. The engine generate codes through a server, it simulates the application as if it were running on the mobile device and still has a terminal command to debug [Corona Labs Inc. 2009].

The executable made by Corona SDK run on devices with Android operating system and iOS [Corona Labs Inc. 2009]. The application Dimus was developed for Android because, according to [Silva et al. 2011], this platform is enriched due to its characteristic to be free software and open source, allowing easy modification and creation.

The corona SDK has libraries that allow easy construction of images, vector drawings and texts; physics simulation using gravity and collisions, animations and transitions, audio processing and execution of up to 32 channels; maps and location, integration with social networks and accelerometer (feature that identifies the slope of the unit). However the engine does not compile (for security reasons unspecified) [Corona Labs Inc. 2009].

To install and run the application Dimus need a smartphone or tablet with Android operating system with at least version 2.2.

3.2.1 The Lua Language

Lua is a programming language designed, implemented and developed in Brazil by PUC-Rio [Ierusalimschy et al. 2006]. The scripting language has the following characteristics: variable declaration, which is dynamically typed, the possibility of having more than one return and automatic memory management with incremental garbage collection. Lua is not an object-oriented language, but has the meta-mechanisms for the construction of classes and inheritance. Thus, the language is kept small, but can be expanded in several ways [Ierusalimschy et al. 2006].

The execution of a Lua program is called by the main file ("main.lua") and it can be called from other files by completing all external features of the game. [Ierusalimschy et al. 2006].

The Lua was chosen for implementing the game Dimus for being lightweight multi-paradigm programming language, also widely used for game development [Nogueira et al. 2010].

3.3 Educational Game Dimus

Dimus is an m-learning application developed to assist educators in teaching mathematics. It was a name chosen based on the creatures that were designed for the game. Its shape is based on geometric shapes, but with custom eye, mouth, arms, wings and hat. Very colorful and attractive. In order to encourage students to become interested in the geometry.

Initially, the game displays an animated menu screen (Figure 1 (a)). The user has the option to play games, read the game instructions and start. When he start the application, the question of mathematics will be exposed to awaken, as an effect on the player's attention. Soon after, the about four Dimus will move on the screen each holding one possible answer. Meanwhile the player will read it and think fast to get to the answer. And so the child must select the number chosen by means of a touch screen on the corresponding Dimus.

When the player scores a correct answer, plus five points is the scoreboard. Case he scores a wrong option or does not check any options, he loses a life. The player has three lives. Both the scoreboard and the number of lives are displayed at the top of the screen.

The application consists of ten stages, each with six random quizzes according to the database default. At the end of each one is a screen with information if the player managed to win the stage or not, your scoreboard and the max score of this level. This information has been added to help the teacher on the maximum score of the stage and also to challenge the student to acquire a higher score. Figure 3 shows an example of when playing win.

Figure 3: End Screen of each stage.

The design of the Dimus game was made to encourage and tranquility for those who are playing. As shown in Figure 1 (a), the strong colors in the menu screen, such as blue, yellow, red and green, objective look confident, alert, action and balance respectively. During the phase, Dimus come in various colors in order to engage, enter and capture the imagination of the player into that environment.

The soundtrack was also thinking worked to awaken the attention and feelings of the player and also away from something dull and silent.

Dimus game is belonging to the genres: action, puzzle and educational. The action games characteristic have been used to improve the performance behavior in a wide variety of perceptual tasks that require effective allocation of attention on the visual scene, to require the successful identification of briefly presented stimuli [Green et al. 2009]. Puzzle are more likely to affect spatial cognition. Fans of this genre are likely to exercise memory, problem solving, planning, reasoning and decision making [Spense and Feng]. The educational games are intended for educational purposes, are important because they promote the teaching-learning situations and an increase in the construction of knowledge through the introduction of recreational and pleasurable activities, developing the capacity of initiation, active and motivating action [Moyles 2002].

Our game has characteristics of action games, because at any time the Dimus change position on the screen in order to force the student to take great care and skill to not lose the opportunity to respond. Puzzle can be considered by the requirement of logical reasoning. Finally, the application is found in a learning environment, it is a fun and motivating activity that encourages students to exercise their mathematical knowledge.

4. Evaluation of Developed Software

By the evaluation standards of mathematics' software as a pedagogical game [Gladchef et al. 2001], the game Dimus got the following analysis:

a) Educational Purpose: This thread checks whether the game has an educational objective mathematical; working aspects necessary for this purpose if its language is clear to the student, and if the embedded mathematical concepts are correct.

The Dimus game has the mechanics of quiz and was made with only the content of mathematics. The vocabulary is easy to understand and also the concepts are correct, since they have been reviewed by a teacher.

b) Content: This verifies that the game takes into account what the child can (or not) know, in the age group proposal, the ability to select what the teacher wants to work at the time, awakens the student's interest in mathematics, and presents a summary of what was working after the end of each session.

In Dimus, the questions were prepared exclusively for children aged 8 years, but the game is restricted in the matter of the teacher can choose only the phases of interest. This requires a programmer to adapt the database. The student's interest is aroused, it shows the game challenging for the student because of its dynamic.

c) Usability: Here are verified if the set goals and milestones to be achieved are clear and are at the level of student understanding. Here are verified if the set goals and milestones to be achieved are clear and are at the level of student understanding. Allowing "sessions" are interrupted started from the "stopping point", if the user wishs.

The objectives and stages of the game are clear, because it is based on the same quiz and the answers are not in motion makes it difficult. But the player can only return from break point to leave the application on to the next move. However, as a casual game characteristic, the phases are quick and small, requiring no checkpoints.

d) Interactivity: Checks if the game has a great interaction with the student and has "details" in which children can explore mathematical knowledge.

This question cannot answer, because experiments have not yet been done.

e) Challenge: This topic evaluates whether the game is smart and does not underestimate the child; if there are gradual difficulties adequate; if it has internal logic challenging that after discovery, is easy to be mastered by the student; and the presentation of the challenges, verify that the game uses the most out of the machine and allows the student to develop action strategies that facilitate him to win more often.

The game of this study does not underestimate the child, because the quiz was prepared for the specific target audience. The contents follow the sequence of the book written by [Sanchez and Liberman 2010] and the books usually start with content of the most basic to more difficult. There is no answer on evaluating if the student will be able to formulate a strategy, because the experiments have not been done.

f) Playful Aspects: They are assessed if the system provides realistic situations related to mathematics, so natural and playful, if mathematics is connected to the subject of the game in an intrinsic way and not superficial.

Dimus does not work with real situations, but it makes the player think about how it actually is. The subjects covered are essential and clear.

g) Psychopedagogical Aspects: Analyzes if the game somehow, encourages questioning the child, stimulates their imagination and curiosity.

We need to perform experiments to answer this question.

h) Feedback: It is checked if there is return error; if children's responses are scanned correctly, providing positive reinforcement at appropriate times; if the feedback allows the student to reflect on his mistake

and try to fix it without overt intervention of the teacher.

Feedback is nice, because the environment remains the same, very relaxed. The responses of the quizzes are corrected with enough integrity. The correction made by the student can only take place if he plays the stage again and he missed the question appears again in this cycle.

i) Performance of Student: This topic verifies that the game provides feedback of student progress during their use and offers a summary of your overall performance at the end of their use.

This feedback is showed at the end of each stage with the performance, which is represented by the game scores.

j) Exercises: If the game offers exercises, it should check whether the game is actually representative of the student; if allow students to understand what is being asked; if there is a relationship between activities / runs performed during play and exercises.

This question cannot answer, because experiments have not yet been done.

k) Submission of Issues: If the game deals with the mathematical knowledge in order to be applied in solving routine problems should verify that the game offers so engaging and challenging, according to the age group that is intended; proposes significant problems and allows the formulation of hypotheses for the student; if allows multiple paths to the solution; and if the scheme used to guide the child to the resolution is appropriate.

The Dimus application does not simulate routine problems.

According to our evaluation the application meets the requirements Educational Purpose, Content, Usability, Feedback, Performance of Student, but some of others can just be confirmed by practical experiments.

5. Conclusion

Technological advances and the invasion of digital culture boosted a new model of society. The actual information society with its dynamic interactivity is redefining the course even of education. The school faces a new generation of students that requires other forms of education, considering that traditional educational process lost the supremacy of teaching.

Today, digital media, internet and mobile devices provide opportunity to learning anytime and anywhere. It is perceived in this context the need for new tools to support the teaching programmatic contents.

Electronic devices are widespread among the new generation of students and from this reality comes the possibility of integration between technological devices and education.

The educational electronic games have shown great potential to support education. Whether developing skills such as attention, concentration, problem-solving ability, motor coordination or even helping to strengthen the fun way the knowledge acquired in school.

Dimus game was developed with this educational goal and as the results of the various aspects of evaluation of educational software for mathematics proposed by [Silva et al. 2011], we conclude that the application can positively contribute to the teaching and learning of mathematics.

For future work, experiments will be done with students from 3rd grade of elementary school.

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