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GAMIFICATION BASED LEARNING ACTIVITIES IN ELEMENTARY BRAZILIAN PUBLIC SCHOOL

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ABSTRACT

This work presents an iterative method which is based on the serious games development in elementary and high school classes, focusing on the students and teachers experiences from Brazilian scholar reality. Furthermore, it does not require strong background in game development and it is planned to be introduced any area of knowledge. It has been considered as a motivational method to engage the teachers and students' in-depth discussions. It follows some Agile Methods practices, such as the Extreme Programming (XP) and Scrum Agile Methods to guide them along the continuous exploration of game design in classrooms. This method also considers the design patterns techniques to reuse (re-guise) some well-known digital games engines and educational concepts, as example a guided game design based on the spaceships battles to associate electric charges concepts. The results obtained in experiments occurred in public schools show successful acceptance and they contribute to improve the students' academic performance.

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This method is now introduced in some undergraduate and graduate practices to analyze its impact in entrepreneurship courses.

Keywords: Computer Aided Design (CAD); serious games; Software Engineering; XP; Scrum

1. INTRODUCTION

The Brazilian primary and secondary scholar level reality has been improved by some governmental programs that aims to introduce computers and other digital medias in their daily practices, being similar in many countries around the world. However, almost all of these technologies have just been introduced without any training or tutorial to teachers (FROTA; FINKELSTEIN, 2013).

The adoption of games in the learning process have been a widely discussed theme around world by a large number of researchers from different areas of knowledge. They usually associate technologies available and cultural aspects to design fruitful tools to attempt the teaching-learning process, where digital games being one of the most adopted (KOLKO; RACADIO, 2014).

In this context, this work presents educational application of systematic procedure to introduce gamification concepts and their necessary requirements. In Section 2 a brief referential theory associated to the prospective Brazilian scenery conditions, followed by the Section 3 where the herein method proposed is presented. The Section 4 presented some landmarks results important to be discussed and reviewed in critical conclusion presented in Section 5.

2. EDUCATIONAL SERIOUS GAMES AND EXPERIMENTAL EDUCATIONAL SCENERY DESCRIPTION

The educational games are recently and usually designated by serious games, which can be defined as software or hardware approach that applies interactive electronic games principles that aims to stream content with educational characteristics for the gamers (PRENSKY, 2005; GE; IFENTHALER, 2018).

In this context, it is also possible to define the serious game as a mental dispute between gamer and game, aiming to promote the human-machine interaction to combine the learning efforts for some didactic techniques in training, communication and ludic information, previously specified by rules for their entertainment interests (ZYDA, 2005; KIAN; CLARK, 2016).

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Prensky (2001) also emphasizes that digital technologies in a teaching-learning process, including serious games, proportioned complex tasks that promote a struggle between digital native and digital immigrant generations by communication under the same language. For this reason, a comprehensive method to introduce game design should be considered. The individual and institutional diversities and the possibility for application to many areas of knowledge, being flexible enough to attempt this wide number of unknowns (FARASHAHI; TAJEDDIN, 2018).

The Information and Communication Technologies (ICT) in Brazilian public scholar environments are commonly introduced under an entertainment point of view and the computational laboratories are sporadically used by tasks that are regularly disassociated to the pedagogical programs. Furthermore, teachers from primary and secondary scholar levels, usually, are not able to develop educational practices using any computational approach, by the absence or low level of knowledge (DE ALMEIDA, 2003; MARCELINO; MARCELINO, 2018).

In order to elucidate these brief review and to estimate real demands and remarks associated to the insertion of ICTs, especially the digital games, in classes and didactic practices, some tutorials were offered in four different trials, totaling a group of 75 high school students and 78 teachers from elementary and high school levels. Henceforth only a small set of samples were possible to perform initial statistical analysis and describe the evaluated scenarios. The Figure 1 shows a graph describing teachers experience and Figure 2 the weekly number of classes taught by them.

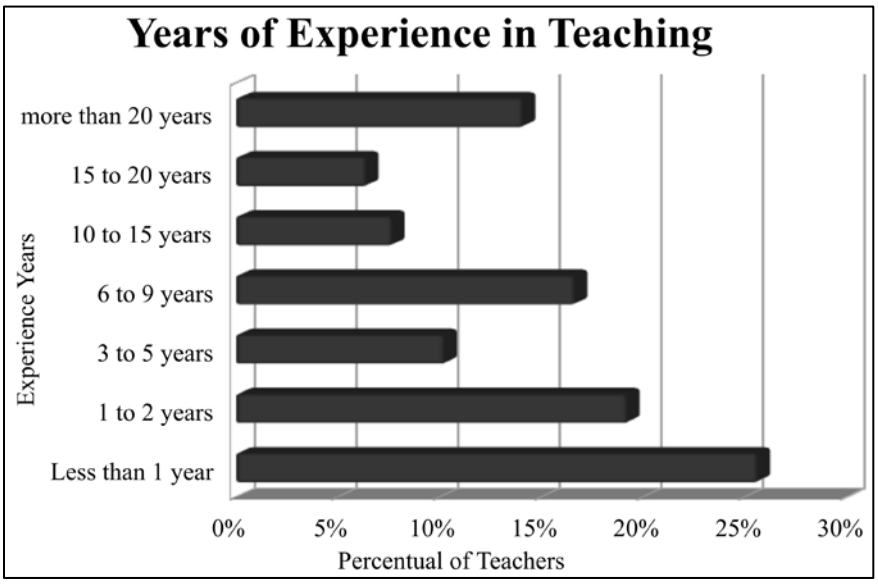

Figure 1: Teachers years of experiences.

ISSN: 2236-269X
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It is a heterogeneous group of teachers that work in different schools in one of the poorest regions in São Paulo State. A wide number of their scholar institutions have computer laboratories and other multimedia resources, such as spotlight and smart TV. However, as presented in Figure 3, just a small number of these teachers adopted these technologies in their didactic practices.

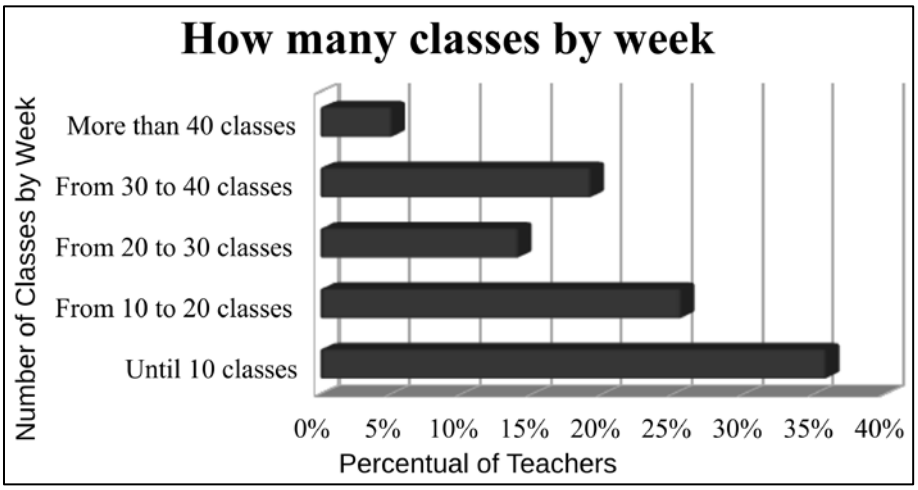

Figure 2: Weekly number of taught classes by teacher.

This group of teachers were questioned about the possibility to adopt digital games as alternative tools to support their teaching-learning processes, where 84.62% agreed with, 15.38% partially agree and none of them disagreed whit computational games.

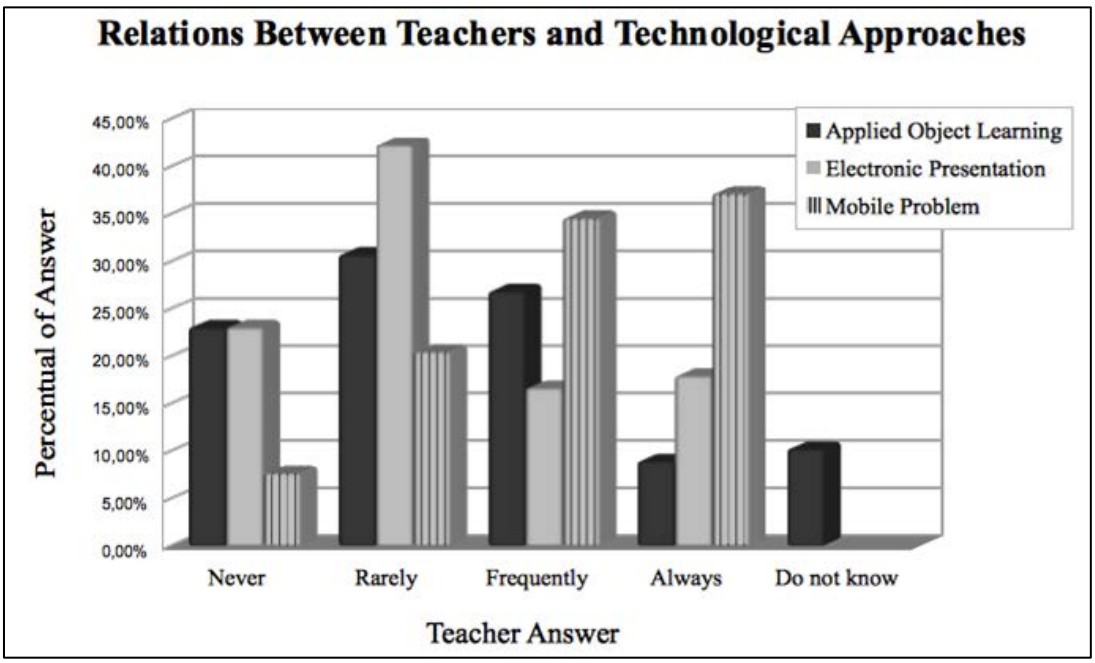

Figure 3: Percentage relations between teachers and media approaches.

ISSN: 2236-269X
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The adoption of the digital serious games are not a reality between the teachers samples (Figure 4), being an interesting motivational reference to proceed with this educational research. At this point, it was also interesting to understand the students' point of view.

The students were first questioned about some didactic practices, where in the graphic of Figure 5 the work groups have greater percentage. It is well suitable under the XP Agile Method perspective.

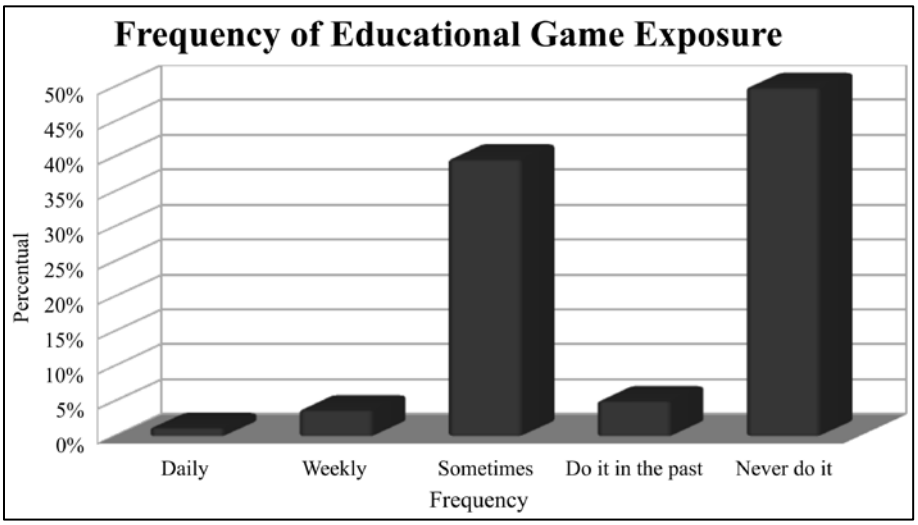

Figure 4: How frequently they use educational games.

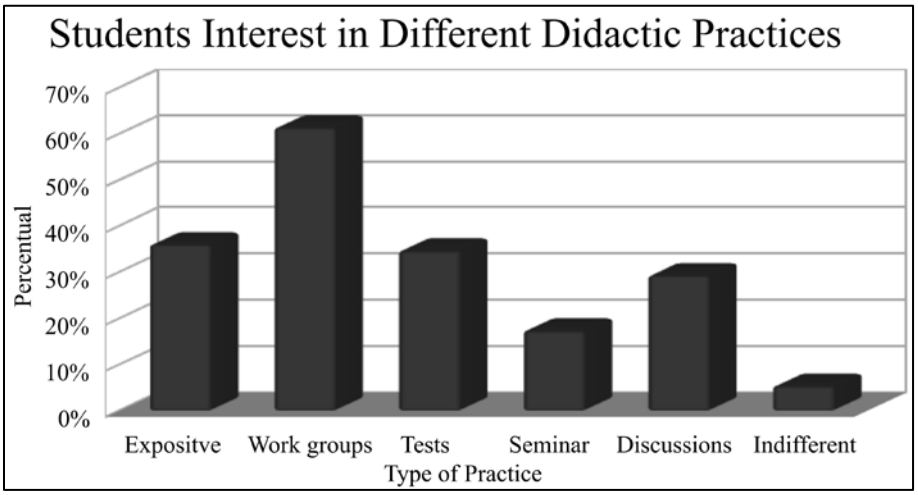

Figure 5: Students practices interesting.

Secondly, they were questioned about the possibility to insert the game usage and development in their daily educational practices, where a majority group was interested in this procedure, as presented in Figure 6.

This graphical data summarizes the relation between the actors interested in the adoption of the serious games in their educational environment by their knowledge and experiences in them.

ISSN: 2236-269X
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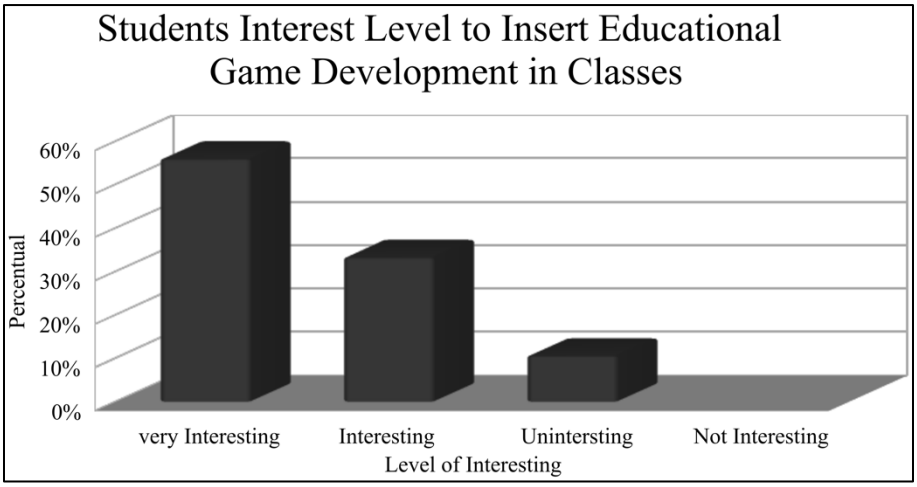

Figure 6: How motivated they are to insert game development in their educational practices.

PS: “Students Interest Level...”

3. PROPOSED METHOD

The herein educational method to introduce serious game development in classes is a consequence between tutorials experiments with students and teachers, as already presented. It integrates Agile Methods (XP and Scrum) and Design Patterns to plan interactive steps for the game development in classes and to contribute for the work team group interactions.

Here Serious games follows Prensky (PRENSKY, 2007) definition, which is a digital and interactive game in hardware or software available to broadcast educational content to players. Therefore, these serious games are twofold designed, to be an educational tool and, at the same time, an attractive entertainment to support and motivate students to research some required themes (GIRARD; ECALLE; MAGNAN, 2013; BELOTTI et al., 2013).

A process to develop a serious game usually consider the team collaborations, physical space and infrastructure, sharing information and creative process to design the users’ interactions and graphical game resources. However, from these broad range of factors the brainstorm and communication might be one of the key success factors in the serious game development (TRAN; BIDDLE, 2008).

It was also considered in this method some of the main concepts from the Agile Methods called Scrum and XP (DINGSØYR et al., 2012).

The Scrum method was chosen by its interactive and iterative method focusing on people and task management, being a Lean Information Technology (LIT) perspective extended and modified, basically, from the Toyota Product System (TPS) (MUSTAFA, 2014).

ISSN: 2236-269X
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By the task focus, the method iterations in Scrum is called Sprints, where the tasks execution are previously planned in a time-line defined during the Sprint Planning Meetings. Along the Sprint daily meetings occurs, being called Daily Scrum or Stand-up Meeting, to update the work team group about the project status. At the end of each Sprint a Review Meeting is scheduled presenting the results. Finally, when the total development process based on Scrum is completed a Sprint Retrospective is carried out to outline the strengths and weakness of the work team group and the adopted development criteria and technologies (THEUNS; VLAANDEREN; BRINKKEMPER, 2012; KIAT; KWONG, 2014).

These approaches are interesting concepts to be adopted in iterative classes where the teachers plan to insert games in their didactic practices, especially by its interaction with students and their continuous feedback that are necessary to follow the students' project and knowledge. Furthermore, the Sprint Review and Retrospective meetings are interesting to evaluate the student’s interactions.

Furthermore, the Scrum Master and Developers characters are suitably applied to teachers and students, respectively. The teacher is responsible to plan, manage and evaluate the work team group efforts, as usually the Scrum Master during the Sprints and students are responsible to study and apply their knowledge in software development under the Scrum Master's supervision.

The XP is the second Agile Method considered, being well justified by the student’s preferences to work in groups and it also overcame some laboratories infrastructure limitations, where it was necessary to allow two students per computer. These two students per machine fits to the Pair Programming concept, where one person is programming and the other is reviewing his work (MISHRA; MISHRA, 2011). Therefore, the integration XP and Scrum are of interest to people management in a dynamic and complex educational scenery.

The teachers and students are motivated to adopt this method by the inserting of reuse concepts and the promotion of championships to solve some challenges, which increase competitiveness for the development of the best games. These practices are described as gamification concepts (DETERDING et al., 2011).

The re-guise is interesting because the students usually interact with other medias that provide some characters in real or fantasy stories. It is also related with personal interests from the game, cultural and age groups (RICE et al., 2013).

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Finally, the educational competitiveness is a global theme recently discussed by different indexes and institutions, being reflected in some educational practices and policies (COOPER et al., 2010; WEST, 2012). These concepts are integrated here and are justified to design a personal educational method based on the game development, following studies that describe the knowledge improvement according to the students learning preferences (HWANG et al., 2012).

In order to start the students and teachers' serious games development tutorials a cyclic method following the previous techniques and technologies was proposed to present the game design concepts and developments using simple free and on-line approaches to support the game constructions. For this first initiative a total of 10 hours was planned to present three main topics, where 30% of this total time (3 hours) is using computers to develop their games (Figure 7).

Figure 7: First method version to analyze the serious games design insertion.

However, from an offered tutorial in a public school for 31 teachers from fundamental and high school level, the method was demonstrated as unsatisfactory from the perspectives of development knowledge and practices, including suggestions for the daily supervision in the teacher practices along the workshop offer, as show in Figure 8, where a graph with answers related to the following questions:

- Question 1: Have you already used a computer in your didactic practices?
- Question 2: Is the theoretical time enough?
- Question 3: Would you like to have time to develop your own serious game during the workshop?
- Question 4: Would you like to have any support to introduce the game design in your didactic practices?

ISSN: 2236-269X
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- Question 5: If a new workshop to attempt the last two questions were offered, would you do it?
- Question 6: How many people redo the workshop?

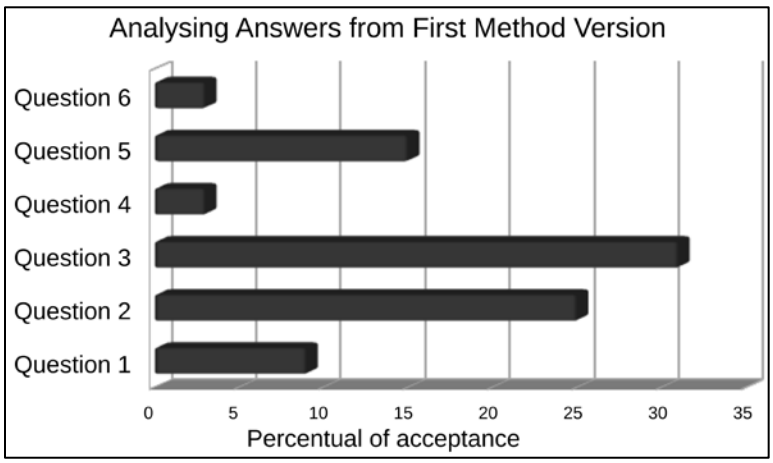

Figure 8: Answers from the first game design workshop.

From the graph in Figure 8 is possible to note the necessity to update the method in time and the insertion of different practices in order to introduce the serious game development in didactic practices. The question 2 argues the spent time to present the theoretical aspects and questions 2, 3 and 4 to analyze the possibilities to insert different ways to introduce the game development in their practices. In Question 5 the teachers answered about their interests to redo the workshop in order to promote experiments with computational tools to develop their own games. However, just 10% of the teachers redo the workshop to have more interactive participation.

Therefore, an update in the proposed method was necessary to attempt to meet the teachers demands, contributing to real introduction of the game development in their didactic daily practices. It promotes a novel workshop method, changing from 10 to 40 hours, incorporating more defined steps to continuously analyze the students results. The Figure 9 presented this method that is organized in activities grouped by colors red, blue and green, being:

- red: game design concepts presentation (story board, engines and patterns);
- blue: showing how to use the computational tool to develop educational games, introducing the association between the game design and scholar contents curricula, such as Mathematics and Science;

ISSN: 2236-269X
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- green: introduction of game design in specific areas and discussions to develop and test them to evaluate their interest and feed-back of their performance.

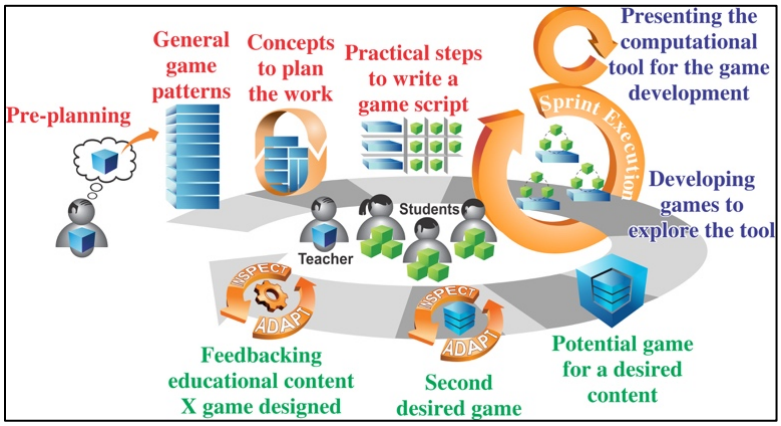

Figure 9: Final method version to introduce game design in primary and secondary educational levels.

In these color groups are willing 10 steps, where each one is performed in 4 hours, being:

- Pre-planning: it is the first with 4 hours to present the steps and common elements necessary to develop a game, also providing an overview about the necessary abilities to do it.
- General game patterns: discussions about serious games, the theme to be adopted and game characteristics;
- Concepts to plan the work, relating the learning under dilemmas, re-guise efforts, game elements (storyboard, sprites and sounds) and game documentation design;
- Practical steps here to write a game script based on (re-guise and dilemma) for a specific theme, game design document from this script and on-line search for sound and images for the sprites;
- Presenting the computational tool interface and its programming structure to perform some experiments with computer;
- Presenting main tools structures for a serious game design, such as Scratch the objects to introduce automatic movements and sounds management;
- Teacher's discovering by their own educational game development using free software;
- Development of a first guided game based on the concept of pacman, where a phantom walk through a board for game solving some enigmas (Figure 10);

ISSN: 2236-269X
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- Second guided game development is with Electric Invaders, applying dilemma principia in electric charge balancing and re-guise game concept by Asteroids game with story elements from Star Wars and Armageddon (Figure 11). This full development required two steps of four hours in the proposed method;
- Finally, the last step is an intersection between the game tests and how they improve their knowledge in relation to the game development and the theme proposed here. It can be an associated evaluation procedure in their daily didactic practices.

The XP pair programming is here adapted because in the computational laboratories, usually the number of machines is not enough to be individual explored. Therefore, a pair of teachers is recommended during the practices, when one is on the computer and other one follows him to review his tasks.

Figure 10: Pacman based game designed to calculate dot operations and Electric charge balancing by a re-guised game.

The results applied in this novel method are presented in the next section to parallel the games developed in classes and the final indexes of teacher's satisfaction.

4. RESULTS AND DISCUSSIONS

The results presented here consider the teachers and students point of view and experiences in each step of the last proposed method, focusing on the game development as an alternative procedure to motivate and insert the computer in educational daily practices in public high schools.

For this research, some groups of samples from an economic poor region from São Paulo State, Brazil, distributed in four different schools, within 60 Km of comprehensiveness. Furthermore, in every workshop the students were motivated to develop their own educational game in pairs, following the XP method, presenting some of their developed games here.

ISSN: 2236-269X
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The workshop starts with discussions to understand the students and teachers' abilities with computational technology experiences, their interest in using computers in educational practices and their requirements to do so, as previously presented in the graph of Figure 9.

The workshops adopt the Scratch software to design the games, well justified by their simple interface, object interaction and the Portuguese language interface was enabled. Besides, this software is evaluated by 31 students and 20 teachers (Figure 11) to support the programming logics learning by the animations and games development, as informed by the groups of teachers and students.

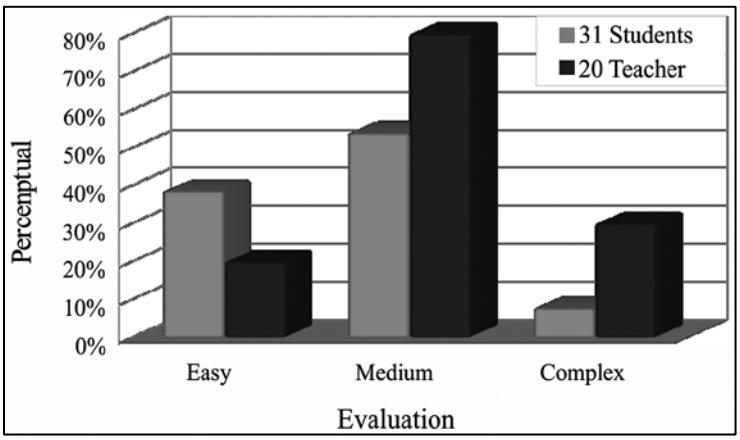

Figure 11: Scratch acceptance by the students and teachers' groups.

In order to evaluate the performance of the method proposed here, two different trials were performed with two different groups of students from the elementary school levels. At first, a group of 13 students under the Geography classes were considered (Figure 12) and they were motivated to develop a game to identify in a map.

The second experiment was performed with a group of 18 students from the elementary school level to perform Addition in Mathematic class. In Figure 13 an example of a game developed by a student, where a little chicken walks through a garden solving adding questions.

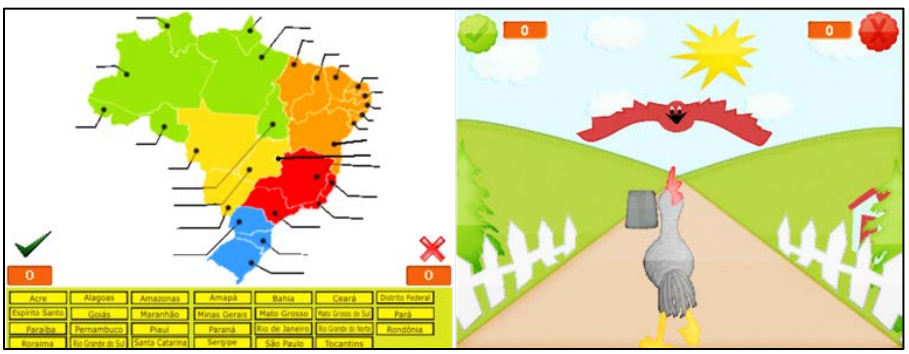

Figure 12: The Brazilian map game to identify the Federal States and the chicken math game for addition studies.

ISSN: 2236-269X
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In both experiments, the teacher applied a pre-test to understand the students' level and a similar post-tests were applied after the game workshop, with results presented in Figure 13. This procedure allows us to understand game method insertion impact in the educational content from different students' groups.

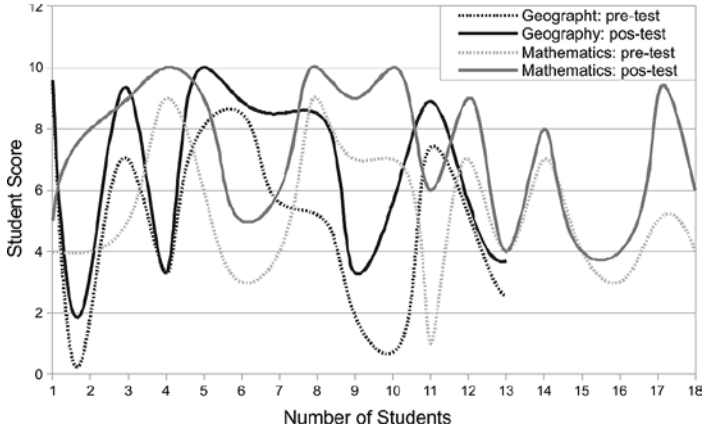

Figure 13: Students performance before and after evaluations.

In order to illustrate these results from another perspective, the graph from Figure 14 shows how the student's grades were improved in percentage. Cutting off the data far from the dispersion grades, the standard deviation of the grade are 26.7 and 28.7 for the Geography and Mathematic tests, respectively.

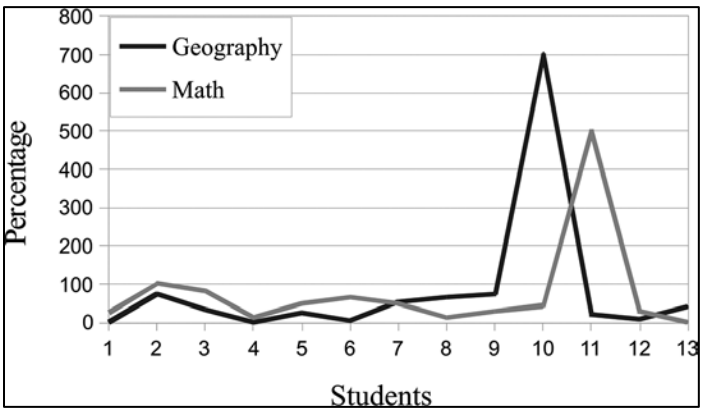

Figure 14: Percentage improvement of the students grades in pre and post-tests for the Geography and Mathematic applications.

Finally, in Figure 15, it is possible to see the satisfaction of the researched students and teachers, considering how they are satisfied to use the serious game development in their educational practices.

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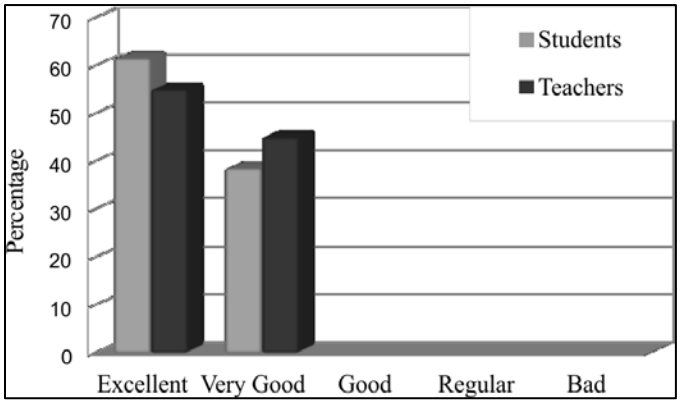

Figure 15: Students and Teachers evaluation of the method proposed here.

As the experiments here present a reduced number of samples and standard deviation is unknown, the t-test is a suitable statistical technique to validate the adopted data (DEVORE, 2015). Furthermore, considering the necessity to evaluate the pre and post-tests, a paired t-test is considered, where H0 is the null hypothesis, which means that the students in pre and post-tests have the same scores. As shown in Figures 16a. and 16b. the final t-test results pointed out to reject the H0 hypothesis, allowing statistically only samples with variations in these tests.

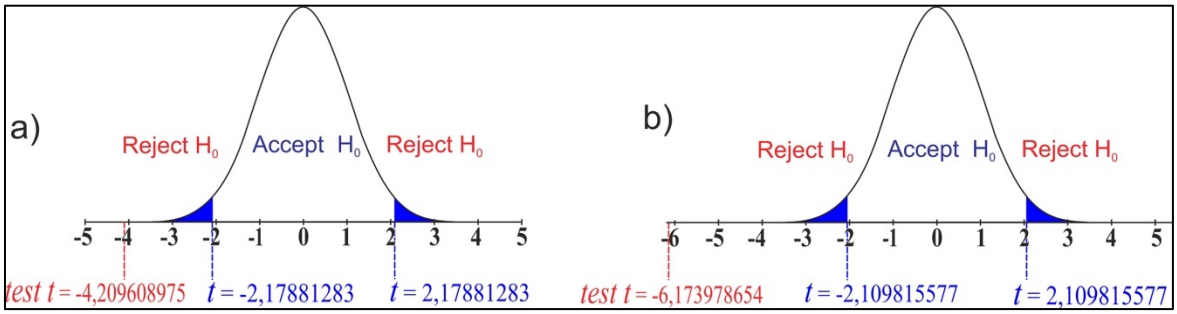

Figure 16. the t-tests results a) Geography and b) Mathematic experiments.

5. CONCLUSIONS

This work presents a successful method based on Agile Methods, Software Engineering and Design Patterns to clearly define steps to introduce the game design, by any teacher from any area of knowledge in primary and secondary school levels. It is validated by two different workshops offered by a teacher trained under these procedures, which demonstrates in practice that a cycle, since the teacher training until the student's content offer was successfully evaluated. However, this teacher just mentions the absence of well-defined steps to evaluate the students' performance, considering method, tools and contents, every methodical step.

This work team group is currently exploring the possibility to adopt this method in some under-graduation courses.

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