The Use of Serious Educational Games as a Successful Tool

Tiago Martins¹, Vitor Carvalho¹,², Filomena Soares¹ and Miguel Araújo²

¹University of Minho/Centre Algoritmi, Guimarães, Portugal
²IPCA/EST, Barcelos, Portugal

Abstract—The high potential of student’s digital literacy may revert, if proper used, to the benefit of Education. The students are encouraged to use social networks, collaborative online tools or simply the file shared storage tools, as educational resources. It is into the concept of “fun” learning where the so-called “serious games” are included. The future of Education may be to apply the subjacent concept of serious games using all potential technology resources available to students, teachers and schools to achieve an increase of education efficiency, capable to give a proper answer to the high standards of competitiveness. In this sense, we present the Total Challenge, a game oriented to learning, which stimulates cognitive abilities of children.

Index Terms—Competitiveness, education efficiency, fun learning, serious games.

I. INTRODUCTION

For a long time, several authors considered the game as a futile activity, focused on entertainment. But, others recognized games as extremely important in human cognitive development [1]. Among the latter, we can mention the teacher, historian and philosopher Johan Huizinga Dutch who, in his book Homo Ludens (1938), understands the game as such an essential activity to life as the reasoning and the manufacture of objects, but different from everyday life [2]. The Huizinga’s view seems to have been a premonition of what is currently happening with video games, in which a virtual existence is created as an extension of real life [3].

Games have emerged to accomplish a main objective, other than mere entertainment (it includes knowledge transmission to the player) and therefore are called serious games. The high potential of this approach has been used, among others, to military purposes, training of top athletes, rehabilitation and education at several levels. These games involve challenges and use of reward systems in order to motivate users to continue until the purpose is reached [4].

The idea of using games that, without forgetting the entertainment, give priority to other goals is not new. In fact, back in the mid-sixteenth century, the expression serio ludere began to be used in the literature, when the writer resorted to humor, to deal with more serious matters. This is the case of the humanist Michel Eyquem de Montaigne, whose literary style wore a light and humorous tone to denounce social problems [5].

In 1789, a nobleman named Helwing invented a game very similar to modern war games, which is the first reference to simulation games. This game was later improved by a military strategy scholar. Served only for fun, it cannot therefore be considered a serious game; it was useful to an army officer. The new game created, called Kriegsspiel, was for the official training of the Prussian army, with regard to their strategic and military capabilities; it was the first serious game in the military context. Throughout the twentieth century, the war games were up improving and gaining new features, reproducing the actual conditions of great historical battles, with all the details [3, 6].

The IntelliGym, available for hockey or basketball players, is a serious game designed to improve core competencies that until recently could not be trained, such as decision-making under pressure, running, peripheral vision, concentration or anticipation [7].

In health, more specifically in rehabilitation and physical therapy, the number of serious games has grown in recent years as a result of the very positive results, especially with regard to the motivation of patients to continue their treatment [8-11]. Among them we can highlight the Neurogame therapy, which is used in the rehabilitation of patients who stayed with the movements seriously compromised as a result of a stroke [12]; Handcopter, which consists in controlling a helicopter through flexion and relaxation of the finger of the patient [13]; Rehabimals Pro, where the physiotherapist analyzes the rotation angles captured notes reconstructions of movements or watching video sessions, to control and manage the treatment of patients [14].

Among the different areas in which serious games can make a contribution to solving problems, we can highlight the area of education, because in a world where the latest technological wonder becomes obsolete in a short time, where the student has experienced other forms of observing reality, the traditional classes tend to be unattractive and not very motivating [15]. Students are accustomed to using social networks, as Facebook, which allows creating specific groups for members, guaranteeing a closed communication platform for the course users, accessible at any time or place, with specific privileges for each user; or collaborative online tools, for example Google Drive or Microsoft One Drive, that allow the simultaneous content edition, by several users, especially useful for personal productivity in text documents, data sheets, between others; or simply the file shared storage tools as Dropbox.

Therefore, the teacher, in his/her dual task of motivating and teaching, can take advantage of this huge potential of digital literacy of students to introduce, in the classroom, technological innovations that create a playful component that enrich and encourage young people to...
teaching and learning activities. One way to bring this entertainment component to the learning environment can be achieved with the use of serious games in the classroom context. Students can test their ideas, converting them into a lived experience, making their learning more solid and effective [15].

Therefore, the potential of these technological resources in the field of education allows responding appropriately to the high standards of competitiveness.

Thus, the purpose of this article is to present some serious games that have been successful used as educational tools and also get to know a solution developed by our research team to be placed at the service of children learning attending the first four years of schooling.

This paper is structured as follows: Section II presents some examples of serious games as educational tools, Section III shows the developed serious game “Total Challenge” and finally, Section IV enunciates some final remarks about the project.

II. SERIOUS GAMES AS EDUCATIONAL TOOLS

Safety, cost, time, among others, prevent the students to experience certain situations in the real world, which hinders their understanding [16]. One solution to this problem can be found in the use of serious games as a learning tool. Security topic can be an example. If an army would use real weapons to train their strategies, there would be a high probability of an accident. However, as serious games are realistic and immersive, the training of different military tactics through these games is as productive as what reality provides, with the advantage that accidents cannot occur [5].

Given the advantages arising from the use of serious games in learning contexts, some examples are presented.

One of the highly successful games was The Oregon Trail (Fig. 1), based on real events. It was developed in 1971 with the original purpose of making known to school children the realities of life of the pioneers of the nineteenth century settlers, Oregon Trail, a historical route between the Missouri River and the valleys of Oregon, in the western United States of America [17].

The game Math Blaster! was developed in 1983, having a story of a rescue in a futuristic universe, which takes the player to learn mathematical skills [18].

The game Number Munchers (Fig. 2), designed in 1986 to learn math skills, consists of a grid square, with a numerical expression or word. This grid is roamed by deadly monsters that the player must avoid while controlling a green character (Muncher). The goal is to consume all the squares that meet a certain criteria (multiples, factors, primes, equality, inequality), stipulated by the game mode [19].

The Supercharged! game (Fig. 3) was developed for players to use the electromagnetism physics to load spaceship (a charged particle) and navigate through the three-dimensional space to achieve a goal. To achieve this, the player needs to know the relationship between load and distance. One way to facilitate navigation towards the ultimate goal is to put loads within the three-dimensional environment [20].

MyQuímica is a game that provides several challenges to drag the periodic table of chemical compounds to a test tube. The user can get information about the selected elements as well as the compound in challenge. This game also promotes motivation, as it shows the ranking at the end of each game and it allows go to the next challenge, even if the player is not successful in several attempts [21].

A chemistry lab is available in ActivChemistry game (Fig. 4). It is a kit that provides equipment and materials to students, such as Bunsen burners, chemicals, and a wide variety of gauges and indicators, with which they can conduct experiments, collect data and represent them graphically, and learn new concepts, in interactive and dynamic lessons. ActivChemistry presents several advantages compared to actual equipment. A first advantage relates to security that the game provides as it allows performing experiences without problems, avoiding dangerous situations. Another advantage is the cost savings avoiding the acquisition of expensive equipment and materials. Finally, there is the learning efficiency: students using the game do not feel the pressure of time, usually in the chemistry lab, and often complete tasks at a faster pace [22].
The serious game Where in the world is Carmen Sandiego? (Fig. 5) is a classic in which the player plays the role of a detective who must catch Carmen Sandiego, the most cunning of thieves. Carmen is leaving clues that the player must decipher in order to identify a location close to where she is. In general, the clues are true facts concerning actual geographical locations. Deciphering these clues, the player learns the geographic locations. It is, therefore, a game that focuses on world geography, flags, and coins [23].

It is not easy to learn to program. To decrease the difficulty, a serious game called Castle of Puzzles was created (Fig. 6). This game is based on the story of a student who only starts to study at night, for a programming test in the next day. He ends up falling asleep and dreams that he is in a castle, but without losing the awareness that he needs to get out going to the exam. The player is faced with several challenges, which can be instances of exploitation, where he has to defend and to attack, or obstacles that he can only overcome if he uses logical reasoning to solve a problem. Each conquered challenge corresponds to a studied subject and the player realizes he is learning. In the castle there are several rooms where are objects that the player can use, which is equivalent to activate certain useful actions for the puzzle solution [24].

III. THE DESIGN OF THE SERIOUS GAME

Several studies have shown that the use of new technologies in education awakens the students' attention to issues that otherwise, seemed boring. Therefore, the authors developed a serious game, called Total Challenge, a dynamic work environment that allows students to become more involved in various activities and to understand and consolidate knowledge.

The target group of this application consists of children attending the first four years of school.

A. General Outline of the Game

The most complex technical procedures are generally difficult to execute by the children that will play the game. So they must be supported by tutors, being recommended that this monitoring continues during the game.

Being our goal to track and improve the development of these children in terms of decision making, perception, association, memory and other cognitive abilities, it became necessary to build a system to monitor these developments and then send the data for further analysis.
In order to carry out the historical record, each user/tutor at home or at school, must ensure that the system is connected to a central database via Internet. In fact, to be played, the game has online and offline modes (Fig. 7). In online mode, the connection to the Internet is required but it has the advantage of giving the player a new level of competitiveness, which brings a greater motivation (he/she can fight for a top spot in the online ranking) while it allows the investigator to check the progress of the users. The help of a tutor may be necessary for the user to register in the official game site with his/her personal data (name, date of birth, responsible tutor). In order play each user must enter the identification (user ID) and the password after completing the registration.

At the end of each game, the result of each player is sent to a central server which stores all the data (Fig. 8). The centralization of all data has two functions. One of them allows the investigator to have access to all data for research, and consequently to treat them for research purposes. The other allows the user or his/her tutor to access the results, and therefore to analyze the evolution over time, through the game's official website. The difficulty level is directly related to the response time, the complexity of the contents and the number of rounds for each game level. All these parameters can be changed at any time by the researchers in order to optimize them. Offline mode is the most suitable for training and also when the device where the game is run does not have Internet access. It also allows to set all parameters of the game, such as response time, the number of rounds each level, among others. However, in this mode and since he/she has the possibility to know the parameter values, the player does not compete with others for rankings, except with himself/herself.

B. User Interface

The interface is simple as it was designed especially for children (Fig. 9).

The entire game is controlled with only three buttons (blue, yellow and red), which can be attached to keys or a specific command allowing to carry out actions, properly identified on the screen, such as fast forward, rewind and select (Fig. 10).

In the Total Challenge were implemented voice aids to facilitate the understanding of all areas of the game, though they are also written in text form. These voices have friendly and fun shades, also transmitting, sometimes, motivational messages such as “Congratulations”, “For the next time try to be more careful,” among others.

C. Idea and Design

The game is divided into 4 main sections, with a short introduction in the early part (Fig. 11). The first section, Instructions, presents a little help for the correct use of the game. In the second section, Ranking, are presented the results of the top 10 played, by difficulty level. The section "Settings", allows the user to do login for the online mode and parameterize the offline mode, as well as voice support. The section "Play" refers to the game itself, which is divided into three challenges.

All the three proposed challenges are based on interactions with images of different categories (transport, animals, and clothing) and test memory, decision-making time, the ability of observation, association, perception player and other cognitive disorders (Fig. 12).
In the first challenge, are presented randomly, three images, two of them belonging to a different category of the remaining. The player’s goal is to find the intruder, that is, the image that is outside the context of the others. In this challenge there are mainly tested the ability of perception, decision-making, association and categorization.

Depending on the difficulty level, the categories range from the general to the specific knowledge, testing the capabilities of the players in what concerns the decision-making, since there are different response times for the different degrees of difficulty.

The greater the degree of difficulty is, the greater will be the complexity of the shown categories. For example, in the easy level it will only be presented general categories such as clothing, animals, transport; however, if the difficult level is selected more specific categories will be presented, such as air, land, sea transports, among others. We can directly relate the difficulty level to the level of education required. Therefore we consider that the player must attend at least the 1st grade to play on the easy level, 2nd or 3rd grade in medium level and 4th grade in the difficult level. To each difficulty level it is associated a maximum response time for each challenge. This time can be parameterized in game settings, if we are playing in offline mode; however, in online mode, these settings are automatically.

Each correct answer has a fixed score of five points that is multiplied by the remaining time by the timer, which means that the quicker is the answer, the higher is the score.

After each challenge, the player can only advance to the next if he/she has a minimum score equivalent to 2/3 of the challenge total score in the worst conditions (to spend all the response time in each round). When the game ends, as an incentive, it is displayed one congratulatory message, such as “Congratulations for your result” or “Great, but a next time try to do better.” If the player cannot complete the game, he/she is encouraged to play again in order to try to get a better score. If the player is running the game in online mode, all the results obtained by level and by round, such as response times, numbers of correct or incorrect responses and final result will be sent to the remote server.

Figure 10. Controller pad.

Figure 11. Main menu.

Figure 12. Schemes of the different challenges.
IV. FINAL REMARKS

The changes that teaching has been experimenting over the years have been clearly visible, being also notable the efforts to make learning more enjoyable and more motivating. The solution seems to lie in the use of serious games that, in a dynamic way, combine educational content with fun activities.

In formal education, children are subdivided to rules imposed by adults, feeling obliged to give up what they want. And it seems to be here the paradox of the serious game: although it is characterized by a set of rules, children tend to regard it as an activity that stimulates competition, giving them the feel of a space detached of norms and impositions, that make them to be in tune with the adults, trying, only, to achieve their goals. Thus are created the conditions for a more effective learning, which allows maximizing the construction of knowledge.

As mentioned before, serious games are not only part of the present, as few decades have passed since they made their first appearance, initially in the military area, extending then to the health and entering later to the service of others areas including learning. Although, currently it is difficult to conceive a serious game without the use of the potential of the new technologies, the truth is that its origin is not digital. Since then, long was the path they traveled, but they were consolidating in its position as a learning tool.

Having features like competition, goals, rules, challenges, choices, and fantasy, serious games can trigger the necessary motivation to facilitate learning.

All the games that were discussed in this paper showed high degrees of success. We expect the ones that will come are more and more sophisticated and consequently promoters of more satisfactory results, so that the efficiency of education is a reality and competitiveness patterns lead to excellence.

We expect the Total Challenge to be a successful tool in relation to the development of cognitive skills of children. However, there are still no statistical results, which we propose to show in future work.

ACKNOWLEDGMENT

This work has been supported by FCT - Fundação para a Ciência e Tecnologia in the scope of the project: PEst-UID/CEEC/00319/2013. The authors are also grateful to the Portuguese Foundation (FCT) for funding through the SFRH/BD/74852/2010 PhD scholarship.

REFERENCES