Computer Games tell, show, involve... and teach*

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Abstract. Computer games have suffered a huge transformation during last 6 years. They are now to be considered as works of art in some cases, if we compare them with hollywood productions. These software pieces, which sometimes arrive to sell millions of copies, have a great influence on students. Present students are generally used to play computer games and, of course, to learn things from their virtual experiences playing computer games. This paper presents a handful of experiences and two new proposals which can be used to profit from this situation in order to make our students learn more, learn better and enjoy learning.

1 Introduction

It is well known that when some activity is funny our mind opens and lets knowledge establish itself inside our neurons. This is the key which leads us to continuously try to attack our students with funnier activities and subject programmes. But somehow we do fail and our efforts seem to vanish without any learning improvement or increased interest in our students.

Eventually we, really occupied workers, decide to return to our traditional methods which we master and students perfectly understand, thus eliminating the work overload which produced our failed attempts. Once arrived to this point, we are completely convinced that our attempts were crazy because students will never like activities, subject programmes, exercises, or something else which tastes like degree obligations.

Someone told us that small-groups collaborative learning [1] was the future and had surprising results, but it did not work properly with our class. We read in a paper that grouping students was not enough, and that Proyect Based Learning (PBL) [2] was the solution to our headaches... Once again, we did not manage. So, where is the problem? what did we do bad?

The main problem when we attempt to put into practice a new learning methodology or just new learning techniques in our class is getting our students engaged. We could be meticulous preparing our methodology or applying other's principles, but if we do not have a magic pill for engaging students we are driving off-road.

We need something they really like to do, and we also need a way to transform it in what we want them to do. But there is an activity that most young people love to do: playing computer games! Many young people often spend 7 hours or

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more playing computer games every week [3]. Could you imagine your students in front of their computers when almost midnight has arrived, and telling their parents "Oh! Please! Just 15 minutes more! I have to really finish this level!." Of course, it is imperative to make them take profit from this situation so as they can improve their qualifications.

In this paper we will give several key ideas which are useful for engaging students with computer games and driving them inside our concrete methodology. In section 2 we will explain the key elements of educational computer games and the main forms of implementing games in a classroom. In section 3 we will oversee several useful educative applications of computer games which have got great results. In section 4 we will describe some new ideas which would be interesting to experiment with. Finally, we will give our personal views and conclusions.

2 Using computer games to teach

Since computer games were born, there have been lot of attemps to create games intended to teach players some kind of knowledge or to train them in some selected ability. But not every game concept has been useful for teaching desired knowledge or ability. In words from Kirriemuir [4], "when gaming-oriented entertainment and learning or educational material are combined the result has been often disappointing; the educational value is debatable or irrelevant, and the gaming and engagement qualities compare poorly to those of pure games".

So, what are the main factors we have to embed in a game to motivate players and to lead them to learn? This is a really difficult question to understand. Many papers have addressed this issue [5][6][7][8]. As a starting point, the 3 key engaging factors which Malone [5] early identified were fantasy, challenge and curiosity. Recent studies have confirmed these basic characteristics from engaging computer games and also have set curiosity as the main one. On the other hand, Amory [6] made a study involving 20 students which revealed that logic, memory, visualisation and problem solving are the most important game elements. More deeply, Prensky [7] makes a subdivision and states that there are 6 key structural elements which strongly engage the player when mixed together. These 6 characteristics are: rules, goals, feedback, interaction, representation of story and challenge.

Well, it appears to be clear. We need computer games which stimulate our students' curiosity and present challenges to them in a fantasy world based on the things we want to teach them. It is as easy as doing this, while it is also as complicated as doing it. So, we need a form of implementing our ideas of Digital Game-Based Learning (DGBL) in our classroom. For this purpose, Van Eck [8] gives us 3 different implementations: have students build games from scratch, have educators and/or developers build educational games from scratch, integrate Comercial Off-The-Shelf (COTS) games into the classroom (Figure 1).

By building a computer game from scratch, our students are learning the contents of the game, as well as the necessary techniques for implementing the

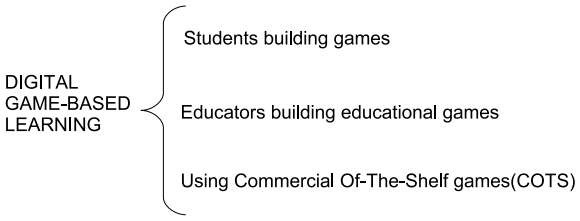

Fig. 1. Different forms of implementing Digital Game-Based Learning

computer game. This means that they are likely to develop problem-solving skills and programming. The second case gives us to a scenario where educators are resposible for designing a computer game with the knowledge embeded inside, so as to make students learn while they are playing the game. This approach is thought to be the best, but it is also the one which requires most resources. Thinking about it, seems very difficult that teachers could involve themselves in the production of a commercial-like computer game; it represents too much work overload for them. In spite of these difficulties, in some universities there are teachers developing educative games and bringing to life a new category of production of games: these are called Serious Games [9]. The third approach is the most reasonable for teachers in general, because whether they does not need to be able to guide students in programming abilities nor they have to invest big amounts of time creating their educational game. In contrast, it is very difficult to find a computer game with all the desirable educational characteristics. But it is always possible to use several games at the same time.

3 A taste of educative applications of computer games

One of the most important and known application fields of computer aided education technology mixed with Artificial Intelligence is the field of Intelligent Tutoring Systems (ITSs). ITSs are pieces of software devoted to track students' work and give feedback to them so they can improve their skills at some desired subject [11]. Basically, ITSs monitor the work of the student and try to inference a cognitive model of them. Based on this cognitive model, the ITS suggests activities to the student guiding them towards correcting mistakes, better understanding of concepts and improving performance (Figure 2).

Motivated by the present advances in game AI, graphics, user interfaces and so on, recent works have lead to meet computer game technologies with ITS [10]. In this area we find JV^{2}M [12], a project from Universidad Complutense de Madrid whose aim is developing a computer game to teach Java to undergraduate students. This game is based on an ITS architecture, including a virtual agent (JAVY) which tutors the player while them plays. Once the game is delevoped, teachers can tell their students to play it as exercise and students will learn Java in a challenging and engaging virtual environment.

Another interesting applicacion of computer games in a really different area, is the one shown by Griffiths [13]. In this case, computer games have been used in clinical practice (treating attention deficits, cognitive-attentional distraction, or even schizophrenia). Researches have found that computer games are very

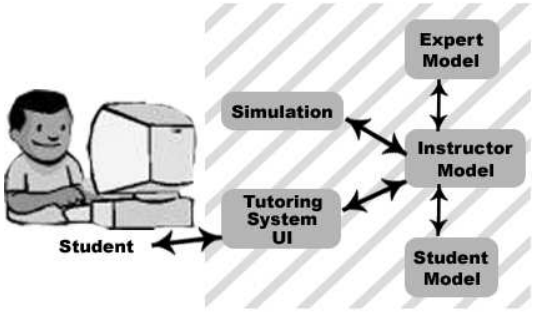

Fig. 2. Components of an Intelligent Tutoring System

useful in training for visual processing, and attention focusing. These studies have also been applied to children playing with popular video game devices with networking capabilities (including PCs and several consoles). According to Kirriemuir [4], those children got improvements in collaboration abilities.

Computer games have also been applied to develop reading skills. An interesting experience was conducted by Schwartz [14] with a group of 24 primary school children with average intelligence and no oral language comprehension deficits. The group was trained using 4 computer games to cover the 4 progresive-difficulty objectives of the programme The results where positive: almost all students experimented and improvement in reading comprehension tests after the training. But even more interesting was the result obtained by poor readers, which experimented the greater improvements of the classroom.

It is also really interesting the application of computer games to education described by Thomas et al. [15]. In their research, they tried to encourage safer sex negociation in high-risk adolescents by means of a computer game, specially designed by the New York Department of Health. The game was designed as a time travel adventure game called "Life Challenge". In the game, players can record and play back their responses as they negotiate with selected partners. The experiments showed that players took negotiations seriously, which lead them to statistically significant knowledge gains on self-efficacy in HIV/AIDS prevention. They concluded that computers games can play a unique role in health education, giving practice opportunities which are very difficult to achieve otherwise. This is due to the special characteristics of computer games with respect to pamphlets or videos; computer games are non-linear and they can interact with user, giving them information regarding their likes, or branching for partner preference, which is the feature players liked best.

One serius proof in favor of the use of COTS games is the one reported by Betz [16]. Betz took several experiments involving freshmen engineering students in Materials and Methods of Construction I, using the comercial computer game *Sim City 2000*. Sim City 2000 is a simulator game which embeds the player in the skin of a city mayor, giving them the control of the city budget and making them responsible for the evolution of the city through years. Sim City 2000 includes elements of architecture, urban planning, sociology, economics, politi-

cal science, environmental science, maths, demographics, history, management, computers..., and it is not a game you can win; instead, you set goals and try to achieve them.

In the first experiment, Betz splitted the classroom into two groups: the first group used Sim City 2000 in combination with a reading material which was intended to identify a wide range of social, political, economical and environmental consequences; the second group was only given the reading material. Both were given 1 week to read the material and pass an exam. The first group was also given 2 weeks for playing Sim City 2000. The exam showed that there was a tendency for the first group to learn more. A survey taken by the first group confirmed that they prefered using Sim City 2000 than reading. In words of Betz "The broader implications of using computer games in the classroom are for students to become more effective learners and thinkers enabling them to make connections across the curriculum." The findings of Betz are supported by Helliar et al. [17] and Roubidoux et al. [18].

4 Proposed research paths

The previous section presented some experiences taken with computer games and the interesting outcomes they obtained. Although there have been taken such interesting experiences (and lots more not referenced here), there is still lot of work to do in order to find the best ways to implement the use of computer games in our classrooms. Therefore, in this section we show some interesting paths to follow, so as to continue reporting experiments on new ways of involving the fantastic world of computer games in teaching.

4.1 Education and Research with Computer Games

As we stated in section 2, there are 3 different ways of implementing computer games in a classroom (See Figure 1). Most of us would really want to take the second one: creating an educational game from scratch. But, of course, our tight calendars make this possibility almost impossible. Our first priority is to do research and publish our results, because this is what give us rewards and is also what we like to do. So, why not rethink this two statements better? It is really imposible to make educational games while not leaving our research? Of course, it is not. There is a mixed solution which could be really interesting to test.

We are constantly constructing software applications to test our new algorithms and investigations. In most cases we could rethink these software applications to be developed as educational computer games. Let us show an example. Think about an application whose aim is to simulate an enviroment for a set of agents, each one of them using an experimental neural network. An environment like this could be designed as a computer game to teach multiagent systems and neural networks to our students. We could develop it to let our students (and, of course, to let us also) play around with neural network parameters, see the evolution of links and weights and even develop their personal algorithms to embed

in the game. Make agents compete and give our students the goal of creating the better possible AI for their agents, and the challenge is ready.

This proposal has the power of involving our students in the research cicle (Figure 3). Think about it. Our students play an educational computer game which can engage and motivate them for learning. They are also playing around with part of our research, so they could bring us useful ideas or comments about things we could have never noticed. Moreover, if we log their experiments, we could use all this information as performance tests of our algorithms, and may be tests we would have never thought about. And, of course, if we add the possibility of playing our computer game/research environment through the Internet, we could get lots of performance tests from people in general, not only our students.

By now, we have developed a computer game called Screaming Racers [19]. Screaming Racers was originally conceived as a platform for experimenting with Artificial Intelligence (AI) algorithms. In this game, players have to develop and train intelligent agents to give them the best possible car-driving abilities. At present, and we are working to match all of the exposed ideas to use Screaming Racers as a educational research environment, where students could learn AI subjects while testing under-research AI algorithms.

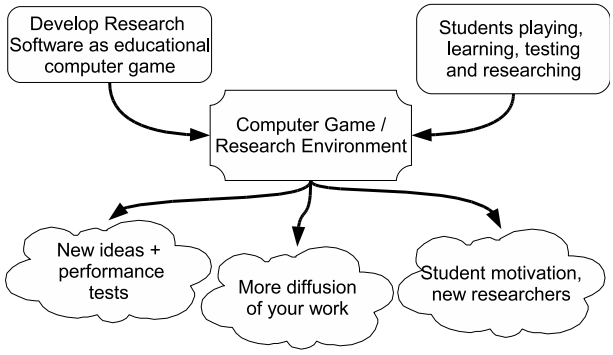

Fig. 3. Using computer games for education and research simultaneously

4.2 Full Digital Game-Based Learning

Other interesting proposal is what we call Full Digital Game-Based Learning (F-DGBL). There have been lot of experiences with computer games in a classroom, but all of them use computer games as a complement for students o just as an exersice. In opossite to this, F-DGBL would transform the classroom and center its work completelly on one or several computer game(s). So, this implies that a student would be evaluated in relation with their performance in the game. An example of a simple methodology could be this: imagine an adventure game in which the student had to carry out several 10 missions. The final grade of a student involved in this game will be the number of completed mission. Of

course, students would not be left alone playing the game. The teacher will be overseing them at every momment during the play.

This proposal has a large number of difficulties which is necessary to overcome in order to be effective. First of all, we need a special kind of computer game to give support to our needs. As the game is directly related to the qualification of students, it has to deal with students' identities, persistence of their achievements, security (it has to prevent students from cheating) and simultaneous playing with teacher supervision. There is a special kind of computer games which includes all these characteristics: Massive Multiplayer Online Role Playing Games (MMORPGs). So, we will be designing educational MMORPGs with our desired specific content.

Another problem could be students replacing other students. This could be a very big problem, because one student could complete required missions and then replace their classmates and complete the missions again for them. For solving this problem we propose some possible methods (These methods do not take into account software methods such us autentification or logging). One possibility could be to force students to complete some special missions during class-time. These missions could be prepared by the teacher and only those students which had done previous missions by themselves will be able to manage. Another possiblity could be to stimulate competence by setting a huge number of missions or a very difficult ones. If our students have to compete for getting the best mark, they will not have time for doing other students' work.

For sure, lots of different problems will claim for a solution, but this difficulties will remain unknown until someone had put this idea in practice and had reported those things we cannot see from outside.

5 Conclusions and Future Work

Along this paper we have developed arguments in favor of using computer games to teach. We also have shown the characteristics computer games have and how could we use them for our teaching issues. To better explain this, we have exposed a set of different experiences involving computer games for learning, which were successfully taken. Finally we have proposed 2 new ways of using computer games for teaching purposes.

We are now working on a computer game project called Screaming Racers which is intended for researching and teaching purposes. It will be used for testing AI algorithms as well as for teaching AI subjects. We expect this game to power up both research achievements and student motivation in a single environment which will join together students and teachers.

To finish this paper we will like to recall a chinese proverb: "Tell me and I forget. Show me and I remember. Involve me and I understand."

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