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A Serious Game to Improve Students' Skills in Global Software Development

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Abstract: In recent years, companies have been forced to change their business model, due to the phenomenon of globalization. Software development companies are no exception, and have attempted to join the global market so as to be able to hire labor in other countries, seeking to reduce costs, increase productivity and gain competitive advantages. This is known as *Global Software Development* (GSD). To perform this practice, companies require developers who possess knowledge and skills for solving problems that arise due to geographical, temporal and cultural distance. Traditional methods for teaching students or employees how to work in GSD environments are usually expensive, and require much effort. This is where serious games can play a key role, as they are educational games that allow for the acquisition of knowledge and skills at a low cost. This article presents a serious game with which some of the competencies needed in GSD can be acquired. The game simulates scenarios that usually occur in the overall development of a software project, so that the user can become aware of the problems concerning GSD and gain some experience in solving these problems.

1 INTRODUCTION

Many areas such as defense, education, health, policy, emergency management, engineering, etc. require people with proper training, who possess the knowledge, skills and abilities needed to successfully perform their job. Traditional teaching methods are often costly and require a lot of preparation time, which is why "Serious Games" are increasingly being introduced. Serious games are designed in such a way that their main purpose is not the entertainment of the user, but rather his or her training in a certain area (Michael and Chen, 2005). This does not mean that the game cannot be enjoyable, but the entertainment derived from the game is designed to educate, so that the learning experience of the player becomes fun (Guenaga et al., 2013). Some of the distinctive features of these kinds of games is that they are oriented towards skills training, the understanding of complex processes and the simulation of situations that occur in real life (Coster, 2013; Marcano, 2008).

In the area of software development, globalization has led many companies to undertake the development of their products in a distributed

way, with that process being conducted by different teams, even from different countries. This new development paradigm is known as "Global Software Development" (Herbsleb and Moitra, 2001); it brings with it a lot of additional problems in comparison to traditional software development. These include the delocalization of equipment, which involves problems of communication, coordination and control, as well as issues arising from cultural differences between the different teams (Vizcaino et al., 2014). Those problems often hinder understanding between project participants, especially when they must use a common language. When those taking part are not using their native language, misunderstandings that affect communication and coordination of work may occur; these could pose a risk for the project (Monasor et al., 2009). Another important aspect is trust among those involved in GSD. Mutual trust is necessary for people to be able to cooperate and work with each other and a lack in this key commodity can cause the breakdown of coordination efforts between remote teams. That makes it necessary for people working in the GSD to possess competencies over and above those required in traditional software development.

In general, it is difficult to find a suitable method for teaching these skills, given that lectures are insufficient. Other methods, such as that described in (Deiters et al., 2011), in which students located in different countries carry out a software development project, are costly and complex to coordinate.

To ease the problems that often arise in GSD, a serious game that allows the user to acquire the skills required for the GSD area is proposed. By playing a game, a global software development project will be simulated, so that students can become aware of the problems involved in GSD, and gain some experience when it comes to solving these issues.

2 SERIOUS GAMES AS A LEARNING TOOL

The educational paradigm is currently undergoing a major shift, moving from teacher-centered knowledge transfer to a new concept that focuses on the student; one that is based on the acquisition of certain competencies by the student that are key to his or her professional development. In recent years, these competencies are being incorporated into both compulsory education and higher education (Guenaga, et al., 2013). This is when the concept of serious games gains relevance, as it represents a new way to acquire these skills.

Serious games can be applied to all levels of education, inside and outside the classroom, from children to seniors, as well as to a wide variety of areas. The potential of serious games as a learning tool has been recognized for its ability to balance the entertainment, interactivity and replayability of the typical games with the aim of reaching a given educational objective. Moreover, the serious games approach focuses on learning as a difficult, yet rewarding challenge, aiming thus to increase the commitment of the players.

According to Dale's cone of learning (Dale, 1969) (Figure 1), learning outcomes increase from top to bottom. Learning by simulating a real experience (bottom part of Dale's cone) can improve understanding of what is being learned more than learning through reading or hearing can (top part of Dale's cone). Dale claims that users could remember 90 percent of what they learn by simulation. Thus, in order to create a highly efficient learning tool, with controlled risk and budget in actual practice, simulation with serious games is the most interesting method.

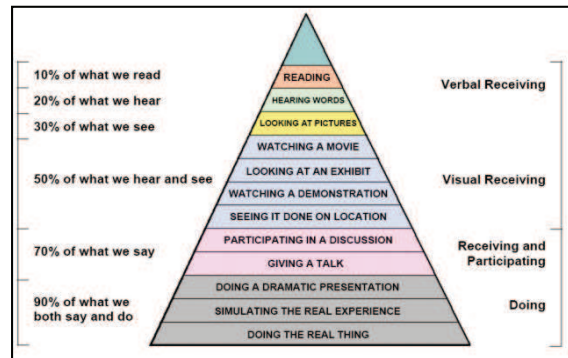


Figure 1: Dale's cone of learning (Dale, 1969).

Some serious games developed for very specific areas (military, health and education) are described below:

A. Military

The first games created were based on combat and fighting. For example, board games like Chaturanga and Hei Wei, both about 4000 years old, were games designed to develop strategies for battles. It was not until 1996, with the appearance of the game Marine Doom, that the potential of games was appreciated. This game is a modified version of the game Doom II (Riddell, 1997). Rather than it being kept as a first person shooting game, more realistic weapons were introduced; tasks that encouraged the learning of the proper sequence of attack were included, such as conservation of ammunition, effective communication, giving orders and teamwork.

In recent years, the United States Army has been exploring the use of serious games as a way to treat post-traumatic stress disorder in its soldiers (Farocki and Virilio, 2011).

B. Health

When it comes to health, serious games is a growing field. Such games are based on simulation and are used for training. For example, in 2008 in Birmingham, young doctors were allowed to gain experience in, and be trained for, a variety of medical scenarios using computerized mannequins as if they were patients. In (Graafland et al, 2012), the authors conducted a systematic review of serious games for teaching surgical skills and medical knowledge. Their review included 30 serious games, of which 17 had an educational purpose; 13 were designed to develop skills necessary for medical personnel. From this work they concluded that serious games can be used to develop both technical and non-technical skills in the surgical field.

Moreover, in (Smith, 2009), the author compared traditional teaching, for those carrying out laparoscopic surgery, with training using virtual reality and tools based on games. He noted that the latter was less expensive, took less time and resulted in fewer errors when the surgery was actually performed. As well as these examples, there are other games like The Virtual Dental Implant Training Simulation (Medical College of Georgia, 2009), which was designed to help dental students in diagnosis, decision making and training protocols.

This technology is also being studied to help in the rehabilitation of stroke patients, as well as to assess the cognitive abilities of adults with Alzheimer's.

C. Education

The limited use of serious games in formal education may be related to the issues around the use of leisure games. The games are therefore often not effective for all students. This is due in part to pedagogy; that is, players learn through repetition and exploration, which contrasts with the learning of discrete quantities of information, as can be found in schools (Squire, 2005).

Another aspect to consider is that the formal education system has to adhere to the knowledge and procedures required for external examinations. This means that games must also address these areas. For example, some educational serious games that can be found on the market are: *3D Networks*, a serious game whose aim is to train civil engineering students about the risks of public works near underground networks; and *NanoMission*, a serious game designed to teach players the concepts of nanoscience through real world practical applications.

Other interesting serious games are: *Quest for oil*, a serious game for oil exploration; *Cruise ship*, a game designed to train a cruise crew to respond appropriately to varying disasters; *RescueSim*, a virtual game that prepares security professionals for real-life accidents; and *SimjavaSP* (Shaw and Dermoundy, 2005), a game in which the student plays the role of project manager and focuses on the optimization of time, cost and quality of a software project.

Our research is centered on the software development process, specifically in GSD. One of the studies which focused on this area is set out in (Noll et al, 2014). In this work the researchers describe a serious game that simulates a GSD environment. The game's objective is to provide students with the necessary expertise to address the problems that often arise in environments of global development.

3 A SERIOUS GAME FOR GSD

This section focuses on describing the serious game tool that we propose. In this game the user will play the role of a project manager. The game is based on the planning of a software project, where working with people from around the world is simulated; the user has to deal with problems that arise because of the geographical, cultural and temporal distance that is present in GSD. Besides being a tool to acquire a body of knowledge, it combines the essential aspects of a game, resulting in a more entertaining and pleasant learning experience for the student.

A. The Game's Requirements

The system needed to meet a number of requirements to simulate scenarios that often occur when working on GSD projects. A scenario consists of a name, duration, budget, component modules and the countries involved.

Some of the main capabilities of the game are now described:

- The game should simulate a series of unexpected events or problems that could occur when participating in a GSD project. For example, a worker is on holiday or sick, or there is a public holiday in one of the countries in which part of the development team is located, or there is a problem with the server or repository that contains the project, etc. These events are produced randomly.
- The game should have different scenarios, which have a variety of levels of difficulty. The user will start with the simplest, increasing the level of difficulty as he progresses. In this way it is intended that students should acquire skills gradually. In addition, the application must allow a teacher to customize scenarios if his intention is for the student to practice a particular scenario.
- The game will simulate a chat, email and telephone, so that students have to work with both synchronous and asynchronous communication. The application will thus allow for the random simulation of incoming emails, telephone calls and chats.
- The user should be able to choose from a list of solutions whenever an unexpected event occurs; these solutions receive a higher or lower score depending on how appropriate they are for solving the problem in hand.

- The game will have a points system, which will fluctuate depending on the number of days remaining for the delivery of the software and on the available budget. A bad decision by the user when facing an unexpected event will thus result in a greater budget loss and reduction in days remaining than if the decision had been properly selected.
- The user will be able to ask for help when he is unable to overcome a particular scenario.
- The game will allow the user to modify the data in his profile, access instructions and use the game, as well as to see the history of his or her score achieved at a given time.
- The user will be able to interact with virtual employees in different scenarios. Employees are characterized by name, country, role, salary, email, experience and a photo that represents them.

B. Tool

The game consists of two main subsystems, one for students and the other for the teacher responsible for proposing scenarios and supervising the student. To access each subsystem both the student and the teacher must be registered; the system therefore has an interface for access and another for registration.

Once the student decides to play a game, the application will show him the main game interface (Figure 2). As can be seen, the interface is divided into three columns. The left column contains project information (name, budget, time remaining, the times of the countries involved, trust among members working in the project, etc.). It is also in this column that students can access the configuration of the modules that make up the project. Once the modules are configured, the game can be started. The middle column contains buttons to access phone, chat and email; in addition, information related to the action that is being executed at any one time is shown in this same column. Finally, the column on the right shows an image of the calendar, which can be accessed by clicking on the image; various actions that may be performed during the game can also be accessed by clicking on them.

During the execution of the game, problems which typically arise when working in GSD environments will appear randomly before the student; he or she must solve these as the game progresses. At the end of each game, the system will show the user the result obtained during the activity (see Figure 3).

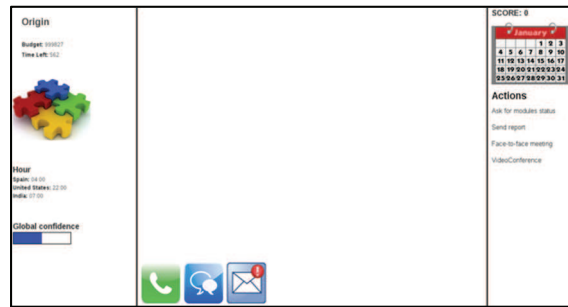


Figure 2: Game interface.

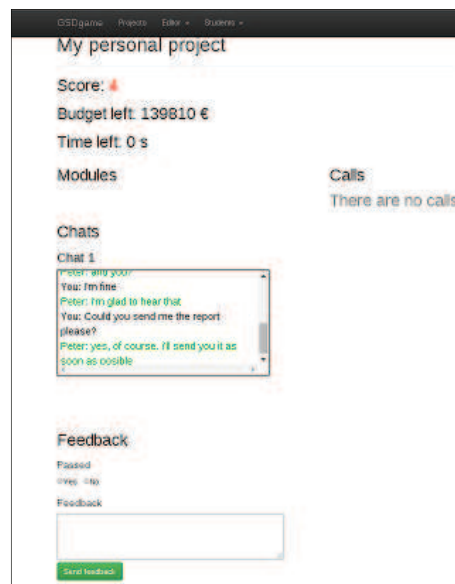


Figure 3: Information containing the outcome of the game.

Moreover, there is a subsystem that only the teacher can access. In this subsystem the teacher can create problems, voice calls, chats, projects, see the results of the student's game, etc. Some of the interfaces of the subsystem are shown below.

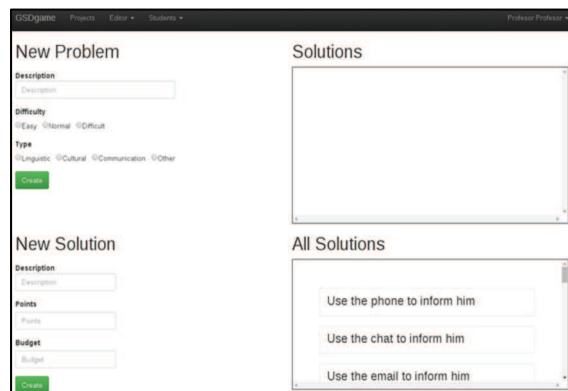


Figure 4: Interface used by the teacher to create a problema.

Figure 4 shows the interface used by the teacher to create a problem. The solutions to the problem are shown in the Solutions box. To add a solution, the player should select the one he wants from the box called All Solutions (bottom panel), which contains all the available solutions. Furthermore, the following fields must be captured: Description (problem description), Difficulty (difficulty level of the problem) and Type (type of problem, i.e., linguistic, cultural, communication or other).

Besides this, the user's teacher has the option of creating calls (Figure 5) and creating chats. Both options allow the teacher to formulate specific scenarios for each student at their discretion.

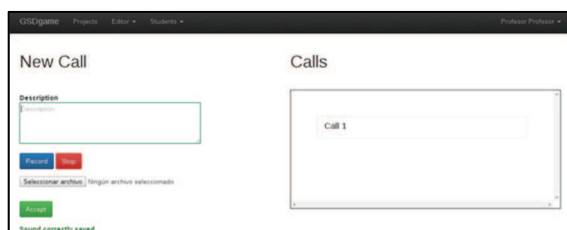


Figure 5: Interface used by the teacher to create a phone call.

Finally, the interface used by the teacher to create projects is shown (Figure 6). To create a new project, the teacher must complete the general project information: name, budget, duration, component modules, potential problems, phone calls, chats and countries of the participants in the development teams.

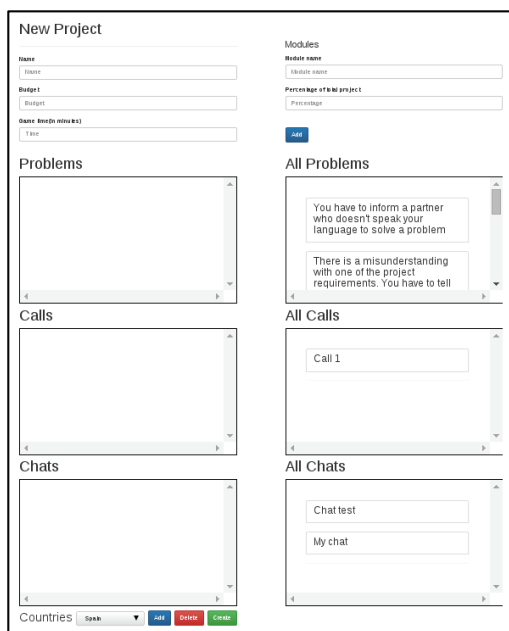


Figure 6: Interface used by the teacher to create a Project.

4 CONCLUSIONS AND FUTURE WORK

This article presents a serious game that supports the acquisition of the knowledge and skills needed in GSD. Since it is a game, it has the advantage of being much more affordable and entertaining than other traditional training methods.

The game is based on the simulation of a scenario in which a project is developed. The player must complete all phases that make up each module. During the development of the game a series of problems will arise, and the user should be able to reduce the likelihood of them getting worse, by choosing certain actions available to him.

The tool is in currently the process of validation and testing by experts in serious games through a quality model based on serious games (García-Mundo et al, 2015), and there are some proposals for future work. One of these is to adapt the tool to allow multiple users with different roles to play between them, offering the possibility of also training participants in leadership skills.

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