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GSDgame: A serious game for the acquisition of the competencies needed in GSD

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***Abstract*—The phenomenon of globalization has, in recent years, forced companies to change their business model. 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 in an attempt to reduce costs, increase productivity and gain competitive advantages. This is known *as Global Software Development (GSD)*. Those companies that wish to carry out this practice require developers who possess the knowledge and skills required to solve problems that arise as a result of 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. Serious games could, therefore, play a key role in this process, as they are educational games that allow the acquisition of knowledge and skills at a low cost. This paper presents a serious game called "GSDgame" 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, thus enabling the user to become aware of the problems concerning GSD and gain some experience in solving these problems. Finally, we present the validation and testing developed by experts in serious games by means of an SG-based quality model.**

Keywords—serious games; global software development.

I. 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" (SG) are increasingly being introduced. Serious games are designed in such a way that their main purpose is not to entertain the user, but rather to train him or her in a certain area [1]. This does not mean that the game cannot be enjoyable, but the entertainment derived from the game is designed to educate, so that the player's learning experience becomes fun [2]. Some of the distinctive features of these kinds of games are that they are oriented toward training skills, the understanding of complex processes and the simulation of situations that occur in real life [3, 4].

In the area of software development, globalization has led many companies to undertake the development of their products in a distributed manner, with the process being conducted by different teams that are even from different countries. This new development paradigm is known as "Global Software Development" [5] and 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, along with issues arising from cultural differences between the different teams [6]. These 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 might affect communication and the coordination of work may occur, which could pose a risk for the project [7]. 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 of this key commodity may cause the breakdown of coordination efforts between remote teams. This makes it necessary for people working in GSD to possess competencies over and above those required in traditional software development.

In general, it is difficult to find a suitable method with which to teach these skills, given that lectures are insufficient. Other methods, such as that described in [8, 9] in which students located in different countries carry out a software development project, are costly and complex to coordinate.

We therefore propose a serious game that will allow the user to acquire the skills required in the GSD in order to ease the problems that often arise in this area. When playing the game, a global software development project is simulated, thus enabling students to become aware of the problems involved in GSD, and gain some experience as regards solving these issues.

II. SERIOUS GAMES AS A LEARNING TOOL

The educational paradigm is currently undergoing a major shift, moving from the teacher-centered knowledge transfer to a new concept that focuses on the student: one that is based on the student's acquisition of certain competencies that are key to his or her professional development. In recent years, these competencies have been incorporated into both compulsory education and higher education [2]. The concept of serious games has therefore gained relevance, as it represents a new means to acquire these skills.

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Serious games can be applied to all levels of education, inside and outside the classroom, from children to seniors and to a wide variety of areas. The potential of serious games as a learning tool has been recognized owing to their ability to balance the entertainment, interactivity and replayability of typical games with the aim of attaining a particular educational objective. Moreover, the serious games approach focuses on learning as a difficult yet rewarding challenge, with the objective of increasing the players' commitment.

According to Dale's cone of learning [10] (Figure 1), learning outcomes increase from top to bottom. Learning by simulating a real experience (bottom part of Dale's cone) can improve the understanding of what is being learned more than occurs when learning by reading or hearing (top part of Dale's cone). Dale claims that users can remember 90 percent of what they learn by means of simulation. If we wish to create a highly efficient learning tool, with controlled risk and budget in actual practice, simulation with serious games is therefore the most interesting method.

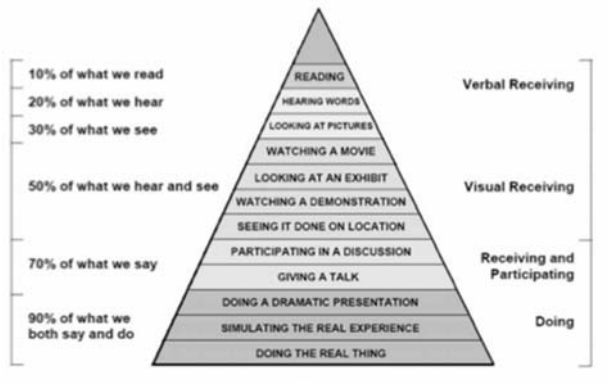

Fig. 1. Dale's cone of learning [10]

Several 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 [11]. Rather than being maintained as a first person shooting game, more realistic weapons were introduced, and tasks that encouraged the learning of the proper sequence of attack were included, such as the 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 means to treat post-traumatic stress disorder in its soldiers [12].

B. Health

With regard to health, serious games are a growing field. These 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 by using computerized mannequins as if they were patients. In [13], the authors conducted a systematic review of serious games whose purpose was to teach surgical skills and medical knowledge. The review carried out led to the discovery of 30 serious games, of which 17 had an educational purpose and 13 were designed to develop the skills required by medical personnel. This work allowed its authors to conclude that serious games can be used to develop both technical and non-technical skills in the surgical field.

Moreover, in [14], the author compared the traditional teaching of 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. In addition to these examples, there are other games such as The Virtual Dental Implant Training Simulation [15], which was designed to assist dental students in diagnosis, decision making and training protocols.

This technology is also being studied to help in the rehabilitation of stroke patients, along with assessing the cognitive abilities of adults with Alzheimer's disease.

C. Education

The limited use of serious games in formal education may be related to the issues surrounding the use of leisure games. The games are therefore often not effective for all students. This is, in part, owing to pedagogy, i.e., players learn through repetition and exploration, which contrasts with the learning of discrete quantities of information, as occurs in schools [16].

Another aspect to consider is that the formal education system has to adhere to the knowledge and procedures required to pass 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-ship crew to respond appropriately to varying disasters; *RescueSim*, a virtual game that prepares security professionals for real-life accidents; and SimjavaSP [17], a game in which the student plays the role of project manager and focuses on the optimization of the time, cost and quality of a software project.

Our research is specifically focused on the software development process in GSD. One of the studies which focuses on this area is set out in [18]. In this work, the researchers describe a serious game that simulates a GSD environment. The game's objective is to provide students with the expertise required to address the problems that often arise in global development environments. We took from this game the idea of using a budget and a time. However, the goal of both games are different as Noll et al. focused on tactical interventions and we focused on cultural, linguistic and temporal issues.

III. 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 as according to [19] project management of a virtual team must be carried out in a different way to that of a co-located setting. The game is based on the planning of a software project, in which 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 with which to acquire a body of knowledge, it combines the essential aspects of a game, thus resulting in a more entertaining and pleasant learning experience for the student.

A. The games'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, the duration, the budget, component modules and the countries involved.

Some of the main capabilities of the game are described as follows:

- The game simulates 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 has different scenarios, which have a variety of levels of difficulty. The user will start with the simplest, and the level of difficulty will increase as s/he progresses. The intention of this is for students to acquire skills gradually. The application also allows a teacher to customize scenarios if his/her intention is for the student to practice a particular scenario.
- The game can simulate a chat, email and telephone, so that students have to work with both synchronous and asynchronous communication. The application will thus allow the random simulation of incoming emails, telephone calls and chats.
- The user is 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 as regards solving the problem in hand.
- The game has a points system, which will fluctuate depending on the number of days remaining until the software should be delivered and on the budget available. If the user makes a bad decision when confronting an unexpected event, this will result in a greater budget loss and a reduction in the days remaining than if the decision had been made correctly.
- The user is able to ask for help when s/he is unable to overcome a challenge in a particular scenario.
- The game allows the user to modify the data in his/her profile, access instructions and use the game, in addition to seeing the history of his or her score achieved at a given time.
- The user is 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. In order to access each subsystem, both the student and the teacher must be registered; the system therefore has one interface for access purposes and another for registration.

Once the student has decided to play a game, the application shows him/her the main game interface (Figure 2). As can be seen, the interface is divided into three columns. The left-hand column contains project information (name, budget, time remaining, the times in the countries involved, trust among members working on the project, etc.). This column also allows students to 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. Information related to the action that is being executed at any one time is also shown in this same column. Finally, the right-hand column 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.

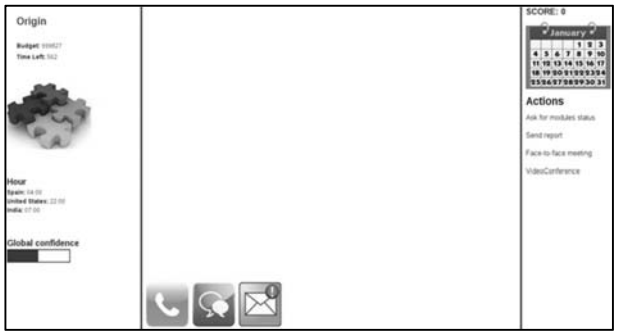

Fig. 2. Serious game interface

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).

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

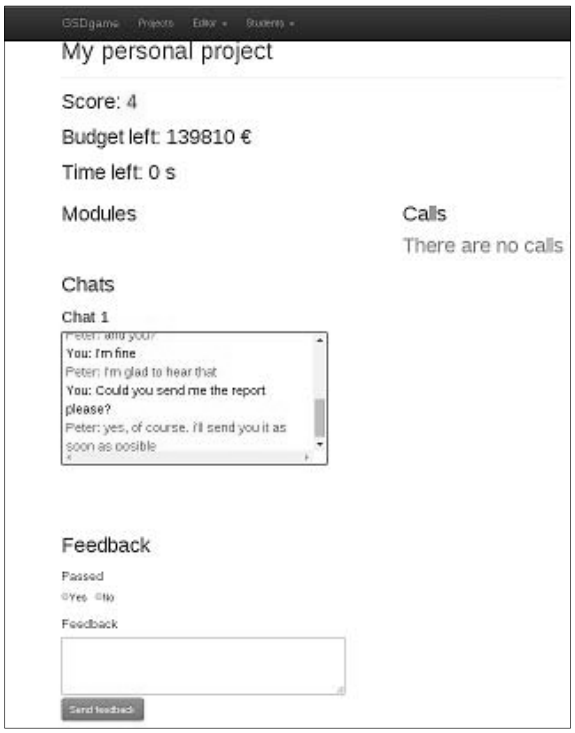

Fig. 3. Information containig the outcome of the serious game.

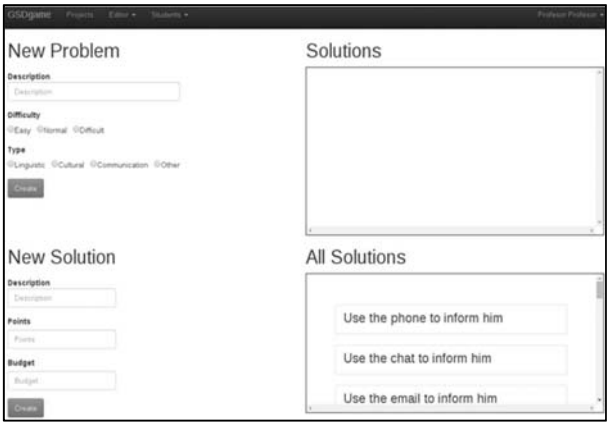

Fig. 4. Interface used by the teacher to create a problem.

Figure 4 shows the interface used by the teacher to create a problem. The solutions to the problem are shown in the Solutions box. In order 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).

The user's teacher additionally has the option of creating calls and creating chats. Both options allow the teacher to formulate specific scenarios for each student at their discretion.

Finally, the interface used by the teacher to create projects is shown (Figure 5). In order to create a new project, the teacher must complete the general project information: name, budget, duration, component modules (that means the activities of a project), potential problems, phone calls, chats and countries of the participants in the development teams.

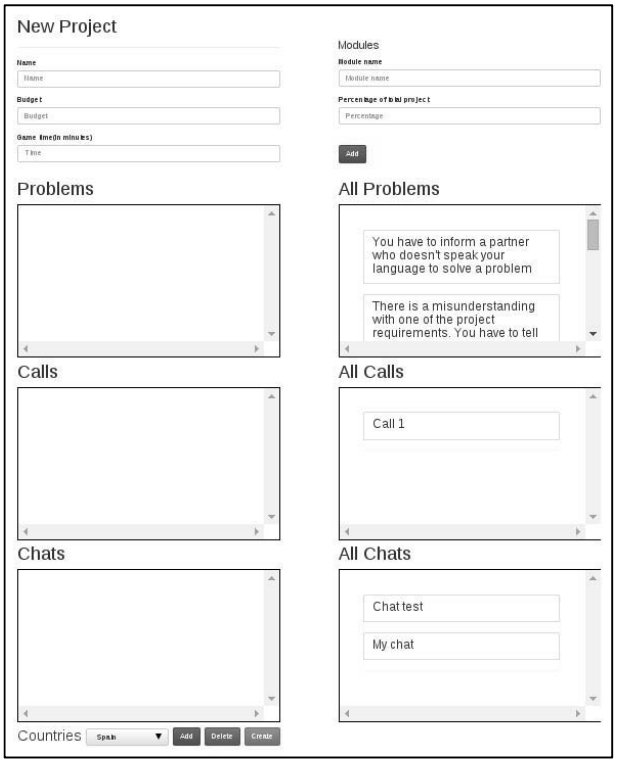

Fig. 5. Interface used by the teacher to create a project

IV. Evaluation of the GSDgame

In order to evaluate the tool an evaluation was performed by an expert in serious games. The results of this evaluation are described in this section.

Each of the attributes of the functional sub-characteristics of the proposed game has been analyzed.

Table 1 describes the measure name, measure description, measure function, the value obtained and the comments that are needed to clarify some aspects of the values obtained as regards the evaluation of the completeness of the functional sub-characteristics.

TABLE I. EVALUATION OF THE FUNCTIONAL COMPLETENESS OF SUB-CHARACTERISTICS OF THE GSDGAME.

Measure name	***Measure description***	***Measure function***	***Measure value/Comment***
Objective coverage	How complete is the implementation of SG functions according to established objectives?	X = 1 – A / B A = number of functions which do not have the ability to perform according to an established object on requirements. B = number of functions of SG X [0,1]; the closer to 1 the better	A = 0; B = 1 X = 1 – 0/1 = 1 – 0 = **1** None of the functions is performed on disagree with the established objectives.
Notes: The functions of SG are those directly related to game objectives. Game objectives and requirements are established in the SGDD.			
Mechanics coverage	How complete is the implementation of the game mechanics in the SG functions such that each function provides a challenge, and each challenge is expected to offer a reward according to the objective established in the function?	X = 1 – A / B A = number of functions missing. B = number of functions of SG. X [0,1]; the closer to 1 the better	A = 1; B = 1; X = 1 – 1/1 = 1/1 = **1** Function 4 “Play the scenario” provides points as a reward.
Notes: The game mechanics of each SG function are specified in the SGDD. A missing function is detected when an SG function does not have the ability to perform with mechanics, i.e., according to the established objective, it provides a challenge and offers a reward when the challenge is met.			
Coverage of progress	To what extent do SG functions indicate how the player will progress during the game?	X = A / B A = number of functions which indicate how the player will progress. B = number of functions of SG. X [0,1]; the closer to 1 the better.	A = 1; B = 1; X = 1/1 = 1 Function 4 “play the Scenario” Indicates how the progress will be obtained
Notes: The way in which the player will progress in the SG functions is established in the SGDD.			
overage of rewards	To what extent do SG functions specify how the rewards will be awarded in the game?	X = A / B A = number of functions which specify how the rewards will be awarded. B = number of functions of SG X [0,1]; the closer to 1 the better	A = 1; B = 1; X = 1/1 = 1 Although the game provides to the player accumulated points as rewards, in the SGDD is not specified how those points will be awarded.
Notes: The way in which rewards will be awarded to the player in SG functions is specified in the SGDD.			
Coverage of shared challenges	To what extent do the SG functions allow the player to share successfully confronted challenges achieved with other players?	X = A / B A = number of functions which allow successfully confronted challenges to be shared. B = number of functions of SG X [0,1]; the closer to 1 the better	A = 0; B = 1 X = 0/1 = **0**
Notes: Applies to online games. The SGDD (profile of game) establishes whether the game is played online. Allows player to share successfully confronted individual challenges with other players using the same game.			
Coverage of shared rewards	To what extent do SG functions allow the player to share the rewards s/he has obtained with other players?	X = A / B A = number of functions which allow rewards obtained to be shared. B = number of functions of SG. X [0,1]; the closer to 1 the better	A = 0; B = 1 X = 0/1 = **0**
Notes: Applies to online games. The SGDD (profile of game) establishes whether the game is played online. Allows player to share individual rewards obtained with other players using the same game.			

The results of the evaluation of the measures related to the Functional completeness sub-characteristic reveal that 4 out of 4 proposed measures attained a maximum value of 1.

There were two more measures that were not applied, these are:

- Coverage of shared challenges: This measure applies to online games. GSDgame is not an online game.
- Coverage of shared rewards: This measure applies to online games. GSDgame is not an online game.

Finally, Figure 6 describes all the measure values for the Functional suitability characteristics together. Upon observing these values we can conclude that the GSD game is of high quality with regard to most of the measures of the Functional suitability characteristic, with the exception of the following measures, which are of low quality: functional customization, functional realism, functional storyline and storytelling and appropriateness level of difficulty.

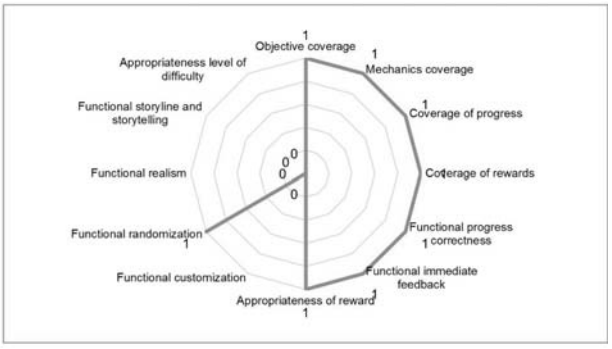

Fig. 6. Functional suitability characteristic evaluation results of GSDgameSG

V. Conclusions and Future Work

This paper presents a serious game prototype that helps students to be aware about some cultural, linguistic and temporal problems that take place 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/her. The tool was validated and tested by an expert in serious games by means of a quality model based on serious games [20], the results of the evaluation were successful. However, some issues should be improved as showing the information about how to obtain the rewards. Moreover, there exist frameworks for evaluating the teaching of GSD competences [9] and recommendations for the design of GSE courses [21] that should be applied to our game in order to evaluate it from a GSD point of view. Furthermore, a case study should be performed in order to evaluate the game with students.

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