

ProDec: a Serious Game for Software Project Management Training

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Abstract – Although there are some works related to the application of serious games for software project management training, there is a lack of tools that combine training and assessment in a single tool and that provide an environment for the learner where they can experiment decision making in real-life like scenarios. Project Decision (ProDec) is a simulation-based serious game created with the intention to train and assess students in software project management. The main objective is to take advantage of the engaging nature of games to place the learners in a virtual organization where they can manage software projects and solve real-life problems in a risk-free environment. For the trainer, ProDec is a support tool for training in matters such as leadership, task and team management, project monitoring and control, and risk management. It also helps the trainer assess the skills that the learners develop by playing the game. After any game play, ProDec offers a complete report including the logs representing every decision the players made and the result of applying the assessment criteria provided by the trainer at the beginning of the game play.

Keywords - software project management; serious games; simulation

I. INTRODUCTION

Nowadays, the importance of teaching project management in computing curricula is out of discussion. In fact, the joint curricula developed by IEEE and ACM for Computer Science (CS), Computer Engineering (CE), Information Technology (IT), Information Science (IS) and Software Engineering (SE), currently under revision and planned to be released during the summer of 2013, acknowledge that computer professionals need training in project management. And not any kind of training, but a training that is beyond technical skills so that the future professionals develop professional practice during their studies.

Despite the importance that these curricula give to this topic and the increasing demand of the software companies seeking for professionals highly qualified in project management, very often we find that software project management syllabus are highly theoretical and quite uninteresting for the future professionals [1].

Compared with other studies, such as medicine, aeronautics, or engineering, computing future professionals do not receive the same practical training regarding real-life scenarios and rely on solving highly conceptual problems. As a consequence, novel professionals develop their experience working in real projects, where the effects of a

wrong plan or decision-making can lead to a failed project or the loss of benefit for the companies they work for.

A serious game is a game designed for a primary purpose other than pure entertainment. Although serious games can be entertaining, their main purpose is to train or educate users. Based on this feature, this paper introduces ProDec, a serious game for software project management that helps:

- a) Learners to develop and acquire practical experience in software project management, by allowing the players to plan a project, simulate its execution, track its performance and make decisions to keep the project on track.
- b) Trainers to design real-world scenarios for developing learners' problem solving skills, and assess their learning.
- c) Overcome the problems of lack of motivation of learners towards project management related subjects.

The structure of the paper is as follows: Section II shows the works related to our proposal; Section III describes the developed serious game, and Section IV shows how this game helps perform the learner's assessment. Finally, our conclusions and further work are given in Section V.

II. RELATED WORK

There exist numerous works related to the application of serious games for software engineering education. Most of these works have been retrieved and analyzed by Caulfield, Xia, Veal, and Maj in their systematic review of the literature [2]. However, if we focus on the field of software project management, the works found are scarce and quite specific. Within this area, the following tools are outstanding: SIMSOFT [3], SimSE [4] and DELIVER! [5].

SIMSOFT [3] is a serious game materialized as a printed game board, that shows the players the flow of the game, and a Java-based board, where the players can see the current and historical state of the project and adjust the project's settings. SIMSOFT mainly focuses on human resource management, with an emphasis on how the ability of the staff affects the outcomes of the project.

DELIVER! [5] is also based on a printed game board designed to help students develop the skills needed to measure and control project performance by applying the Earned Value Management technique. As stated by its authors, DELIVER! is mainly a game to motivate students in their learning process.

On the other hand, SimSE [4] is a serious game completely developed as a software tool that is based on software project simulation. SimSE allows students to practice a "virtual" software engineering process (or sub-process) in a fully graphical, interactive, and fun setting in which direct, graphical feedback enables them to learn the complex cause and effect relationships underlying the processes of software engineering. The game supports several development methodologies and focuses on the development of abilities for software process management.

Similar to SimSE, we can find SESAM [6], another serious game that uses a software application and simulation techniques to motivate learners in learning software project management. SESAM has a natural language interface and, during the game, records information about the game's progress with the goal of showing several statistics at the end of the game.

If we focus on the educational objectives that can be achieved by using these games and compare them with a well-known taxonomy of learning objectives such as Bloom's taxonomy [7], [8], we can find out that only SIMSOFT reaches the higher levels of the taxonomy, while the other tools place their educational objectives at the basic levels of the hierarchy, mainly the Knowledge level.

Regarding learners' experience, the games already mentioned have been assessed through surveys so that the players provide some information regarding their experience where playing the game. However, the assessment of the learners' new abilities developed by playing the games is always made by traditional methods and does not have any connection or feedback from the exercise of playing the game itself.

Unlike the above tools, ProDec does provide support for the learners' assessment, by accepting and applying the assessment criteria that the instructor provides to the game tool.

III. DESCRIPTION OF PRODEC

ProDec is a serious game to teach software project management. The game is intended to be used at the end of an undergraduate course on software project management in computer science, information technology, information systems or software engineering programs. ProDec is intended to be a collaborative game, that is, it is a game to be played by teams of players. It is also possible to be played by individuals, but in that case the richness and benefits of the interaction with other players of your team are lost. It is important to emphasize that ProDec is a collaborative game, not a competitive one. This means that the group of players works collaboratively to win the game not to compete among them.

ProDec has also been developed to provide an automatic assessment of the performance of the players after a game play. This assessment is based on the assessment criteria set by the instructor.

A. Objective

The aim of the game is to successfully manage a software project. The game is over when the project significantly overruns either the approved budget or the allocated time. During the game, the players have to plan a project, manage its execution and deal with the risks and unplanned events that may occur. They will succeed in the game if they are able to complete the project within the time and costs limits.

B. Basic Play

ProDec can be used in two different modes, namely, Full Play and Quick Play. When played in Full Play mode, the game allows the players to manage a software project they have previously planned. In this mode, the play is structured in three steps:

1. Onset. In this step, the player follows a process that guides them to make the project plan. The game helps the players to provide the information regarding the general data of the project, tasks definition, time and cost estimation, project team definition, personnel allocation to every task and risk estimation. It is important to highlight that for any member of the project team, the player has also to provide information about their professional experience and personality factors according to the sixteen personality factors described by Cattell [9], so that, during the play, it will be possible to simulate and assess how good or bad was the players' decision during the team creation and task allocation. Figure 1 shows a screenshot of this process step focused on the personnel features.

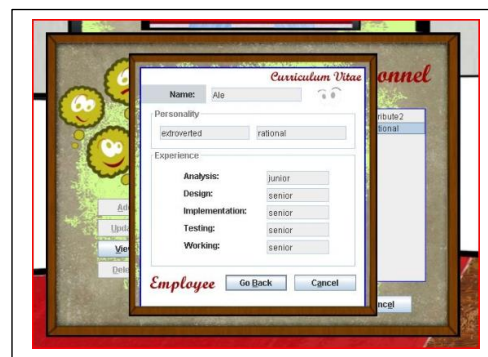


Figure 1. Screenshot of making the project plan

2. Execution. The second step consists on executing the project created in the first step. To do this, ProDec uses the information provided by the players to automatically generate the source code of a simulation model of the planned project. Once generated, the simulation model is run and the players start managing the project. The progress of the project depends on how well the project plan has been made, that is, the accuracy of the estimates of

time and cost, the quality and suitability of the project team, and the adequacy of the tasks allocated to the members of the project team. During the simulation of the project execution, the game shows the players a Control Screen where the progress of the project is shown as it can be seen in Figure 2. The following elements are shown in real time:

- a. The time and budget spent and remaining.
- b. The results of the earned value analysis of the progress of the project.
- c. The level of the motivation of the project team.

Based on the progress of the project and their analysis of the situation, the players can make the following decisions:

- a. Hire or fire a team member. In this case, every change in the project team will have a direct effect on the productivity because of the communication and training overheads derived from the team size, the contribution of the experience of the new or lost member, the overall team synergy, their motivation, etc.
- b. Reorganize the project tasks. In this case, the players can reorganize the network of tasks which are yet to start. ProDec will check that the new network of activities is still consistent with the restrictions established to the tasks precedence in the project plan.
- c. Send a thanks/congrats e-mail. According to the progress of the project, the player can decide to send a thanks note or congratulations e-mail to the project team members to, for instance, congratulate them for the consecution of a project phase on time and within budget. This will have a positive effect on the motivation of the team and, therefore, on their productivity. However, the game controls the unreasonable use of this option.
- d. Give an extra payment. According to the available budget and the progress of the project, the player can also decide to give an extra payment to the project team. In this case, this action seeks to increase the external motivation of the team members leading, in some cases, to an increase in their productivity. Accordingly, this action will also reduce the available budget.
- e. Try your luck. This option simulates the appearance of not planned risks. When selected, a random event takes place in the project. This event can have either a positive consequence, such as your sponsor

increasing the budget, or a negative one, such as losing one of your team members because he decides to leave your company.



Figure 2. Project execute and control view

3. End. Once the simulation of the project execution is over, the last phase consists on the assessment of the players. By using the information that ProDec has been recording during the game play and the assessment criteria established by the instructor, ProDec generates an assessment report of the learners describing their level of achievement and uploads the results in the qualification book of Moodle, which is the Course Management System used in our subject currently. This report is mainly intended to be used by the instructor. In addition, ProDec prepares also this information to be provided in a very different format so that the learners get informed about their performance in a more engaging way. Basically, once a game play is over, ProDec automatically tweets a message to the Twitter account of the course telling about how the graces and disgraces of the team of future project managers. It also updates the Hall of Fame in the Facebook account of the course and gives a badge to those users who managed their project significantly well.

On the other hand, when the game is played in the Quick Play mode, the players go through a simplified onset phase, since the information describing the project plan has been provided by the instructor and they only need to select the project they want to manage among the ones already uploaded. The aim of this game mode is focused on the phase of execution of the project and the assessment of the management decisions. In this case, there is no need to assess the correctness of the project plan since it is assumed

to be correct. Hence, the instructor, in this case, has also more options to establish the assessment criteria.

C. Lifecycle

Once the basics of the game have been described, it can be seen that the game helps the learner to see in action the group of processes of project management defined by the Project Management Institute (PMI) [10]. Figure 3 illustrates the relation between a game play’s lifecycle and a project lifecycle. It can be seen that ProDec’s Onset phase is related to the initiation and planning process groups, the Executing phase of the game with the cycle of executing, controlling and planning, and the End phase is related with the Closing process group proposed by PMI.

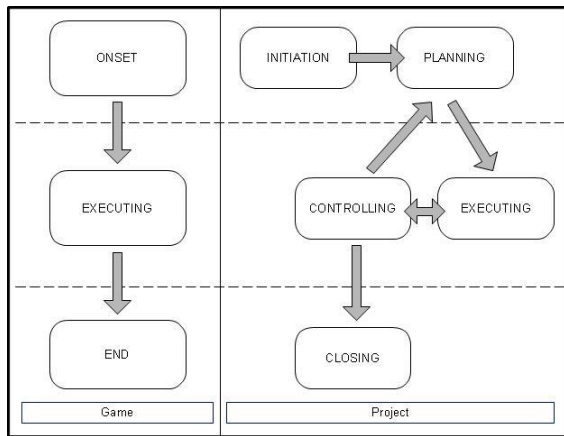


Figure 3. Lifecycle

D. Architecture

In order to address the functionality described above, ProDec has been developed using Java™, Anylogic™ and MySQL™ technologies. Figure 4 shows ProDec’s architecture. As it can be seen, ProDec follows a three layer architecture. Two Java applications and the simulation model deal with the presentation and business layer, while two databases managed by MySQL™ deal with the data layer.

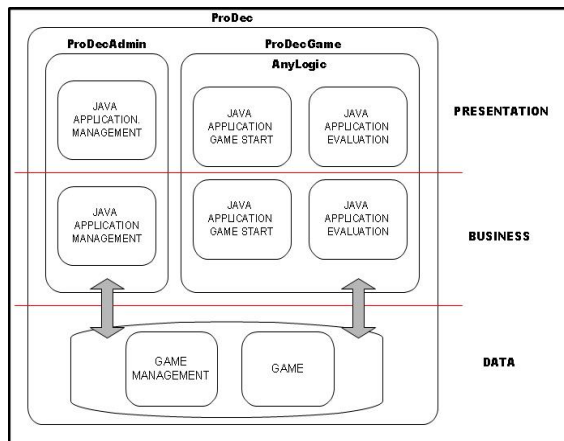


Figure 4. Architecture of ProDec

A description of the software applications follows:

- a) ProDecAdmin is the software application that allows trainers to upload all the information required by the game. The trainers use this application to set the different game scenarios that can be played together with the rubrics for the players’ assessment.
- b) ProDecGame is the software application used by the players. This application is really composed of three applications:
 - An initial application that starts the game and dynamically generates the source file of the simulation model required to simulate the project.
 - A software application to simulate the execution of the project and allow for project monitoring.
 - A final application that finishes the game and performs the learners’ evaluation by applying the rubric set by the trainer for the scenario that has been played.

IV. LEARNERS’ ASSESSMENT

The process of assessing the learners’ skills developed by playing the game is a process involving several elements belonging to different areas of ProDec. During the course of the game, the system saves records of the decisions made by the players during the simulation of the project, mainly as a response to a problem. In addition, ProDec also saves recurrently and autonomously records regarding the project status during the simulation and the initial estimates and risk analysis provided by the players at the beginning of the game. As a result, there are three sources of information for the application of the assessment criteria: a) the project plan with the initial estimates, b) the project monitoring data, and c) the kind and nature of the decisions the players made. Having these three sources of information about the learner performance, it allows the instructor to assess different types of skills.

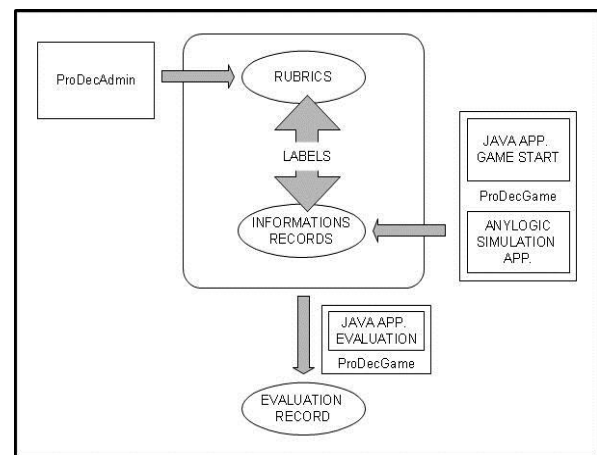


Figure 5. Elements of the assessment process

The assessment criteria are provided by the instructor in the form of a rubric by using ProDecAdmin. A rubric is structured in sections, each of which consists of an assessment criterion. An assessment criterion effectively links the information recorded in the rubric with the information recorded during the game by using a labeling system that matches the labels describing the skills that an assessment criterion with the records of the game that contain the information needed to assess such criterion.

As a consequence, ProDec is able to perform the learners' assessment by analyzing the information stored during the game and applying the assessment criteria set by the instructor, concluding with the generation of a detailed report, which describes the skills acquired by the players. This report allows learners and instructors to study the course of the played game, making it easier to analyze the decisions taken during the game and their results. Figure 5 shows the elements involved in the assessment process.

V. CONCLUSIONS AND FURTHER WORK

In this paper, we presented a serious game for software project management. The main objective is to take advantage of the engaging nature of games to place the learners in a virtual organization where they can manage software projects and solve real-life problems in a risk-free environment. The game accepts the information describing a software project plan and generates automatically a source code file with the equations of a simulation model to simulate the planned project. By running the simulation model, the game provides the players with the experience of seeing the effect of their planning and the decisions they are taking during the project execution. When the simulation of the project ends, the game performs an assessment of the learners according with the assessment criteria that the instructor has previously set.

The main contributions that make this game unique are the following:

1. The range of management options available for the instructor and learners to play with is larger than those of other similar tools. In fact, while other similar initiatives focus on practicing only certain aspects or techniques of project management, ProDec provides a training environment for learning the following:
 - a. Project planning: Task identification, task time and cost estimates, among others.
 - b. Project control and monitoring: Earned Value System and control scoreboards.
 - c. Risk management: Quantitative risk analysis, incidence monitoring, unpredicted events and decision-making.
 - d. Team management: Task allocation based on the experience of the team and the nature of the task, team motivation, team synergy, Brook's law [11], among others.
2. Dynamic and automatic generation of an ad-hoc simulation model. The information of the project plan is transformed into a set of equations of a discrete-event simulation model together with the source instructions that generate the user interface of the second phase of the game. Although using simulation at the core of a project management game is not an original feature, the available similar tools based on simulation models have a prebuilt simulation one. Hence, this kind of games provides only one scenario for simulation. ProDec, on the contrary, surpasses this limitation by creating an ad-hoc simulation model for every project plan the player can think of. Moreover, during the simulation, some of the decisions the player can make, can even change the equations of the simulation model in runtime.
3. There have been also other initiatives to apply serious games in software project management and in learning in general. However, most of these initiatives apply the benefits of game during the learning process only, forgetting the assessment part of every teaching and learning process. Very often, these experiences make use of the game to help learners learn, but they do not help instructors with the assessment, using the instructors more traditional assessment techniques for that phase. However, ProDec is intended to help also instructors with their assessment task by providing them with an environment where they can upload the assessment criteria for a project scenario that will be applied at the end of the game play to the data collected by ProDec during the play. The results of the assessment are also offered in several formats: as a report, as an update of the qualification book of Moodle and by different actions in the social networks used in the subject such as Twitter and Facebook.
4. The use of gamification elements. As a game, ProDec has been designed paying special attention to the user interface elements and the interactivity that can be expected in a game. In addition, some features coming from the gamification approach have also been added. These features, such as a Hall of Fame or a system of badges help to keep the learners engaged and motivated.

We can say that the game supports the three domains of Bloom's taxonomy: knowing, feeling and doing. Obviously, before playing the game the learners need to have studied the principles of the body of knowledge of software project management. This knowledge is put into practice by playing the game and having to evaluate the progress of the project and make decisions to achieve the initial objectives. Hence playing the game also helps to learn by doing. Finally, playing the game is also a social experience, since: a) the game is to be played in teams, and b) it also helps to share

the results through social networks. These features, together with the engagement nature of games, transform the learning process into a social one where the feelings and emotions are naturally linked to the learning experience. We consider that the game also covers the six levels of Bloom's taxonomy. For example, at the lowest order process, ProDec helps the learners to remember what they have studied in their lectures about the software project management body of knowledge. To play the game, players also need to demonstrate they understand the facts they have studied, and they have to solve problems in new situations, such as estimating the budget of a new project, allocating tasks and making software teams with different traits of personality, or reacting to a risk they had never suffered before. The level of analysis is worked every time the player has to make a decision to improve the project results, since they need to carefully analyze the elements of the project, their relationships and the organizational principles that rule the progress of the project they are managing. After the analysis, players have to synthesize all the information into the decision they are going to make. Finally, the level of evaluation is achieved given the social nature of the game, where the players need to discuss, present their judgments and evidences that support the decision they would make, and then, negotiate with the rest of the members of their team about the decision to finally make.

Our aim is to build a tool for software project management learning as complete as possible. For this reason, our future works are aimed at two main objectives:

1. To perform evaluations of the current version of ProDec so that we can get the necessary feedback to design our following steps. We are currently working on this step with some evaluation sessions planned in different universities. So far, some evaluations have been made with one group of professors. During this academic course, we will conduct evaluation sessions with the students. In order to do this, we have based our evaluation process on the evaluation method developed at the Federal University of Santa Catarina [12].
2. To add new features to the game regarding software project management such as configuration management, change management, different methodologies of software development, among others.

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