Game-Based Learning Applied to Project Management Professional Certification

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Resumo

Com o potencial de melhorar atividades de formação e desenvolvimento devido ás suas características, como por exemplo a capacidade de motivar e cativar ou mesmo aprender através da prática, o Ensino Baseado em Jogos é hoje um tema relevante e alvo de investigação.

O trabalho desenvolvido nesta tese têm como objectivo perceber o impacto do Ensino Baseado em Jogos em contextos específicos, no nosso caso a certificação Project Management Professional (PMP), na qual acreditamos que possa ter um impacto positivo junto dos estudantes, ajudando-os a obter ou melhorar os seus conhecimentos na área.

Além desta hipótese, procuramos também comprovar que este tipo de conceito pode ser aceite pelos estudantes como uma ferramenta auxiliar para o estudo.

Com o objectivo de avaliar estas hipóteses, desenvolvemos um jogo sério que poderá ser utilizado por estudantes como uma possível ferramenta de estudo que permite testar os conhecimentos relacionados com alguns dos conceitos presentes no ”A Guide to Project Management Body of Knowledg” (PMBoK), conhecimentos estes necessários para obter a certificação PMP.

A utilização deste jogo e posteriormente a realização dos testes permitiu-nos assim medir o ganho de conhecimento obtido através da utilização do jogo, bem como perceber o impacto deste junto dos estudantes.

Com base nos resultados foi comprovado que o Ensino Baseado em Jogos aplicado á certificação PMP consegue ajudar os utilizadores a obter ou melhorar os seus conhecimentos, provando ter um impacto positivo. Com base no questionário realizado junto dos utilizadores concluímos também que o jogo sério foi aceite pelos estudantes e considerado útil como ferramenta auxiliar para o estudo.

Abstract

With the potential of improving training and learning activities by virtue of engagement, motivation, role-playing or even learn-by-doing, Game-Based Learning (GBL) has become an important research field.

In this work we focused on understanding the impact of GBL in a specific context, Project Management Professional (PMP) Certification, in which we believe that it can have a positive impact within students, helping them acquire or improve their knowledge as well as being accepted as another tool for their study.

To investigate our hypothesis we designed and built a serious game, which may be used by students to help them study and test their knowledge regarding some of the concepts present in the ”Guide to Project Management Body of Knowledg” (PMBoK), necessary for the PMP Certification.

The use of this serious game allowed us to do some experiments in order to measure the knowledge assimilation and the impact of the game within students.

Our evaluation strongly suggests that Game-Based Learning applied to the PMP Certification can have a positive impact by increasing knowledge assimilation. We also concluded that users accepted our game and considered it as a useful auxiliary tool to their study.

Palavras Chave

Certificação
Desenvolvimento
Ensino Baseado em Jogos
Formação
Gestão de Projectos
Jogo Sério

Keywords

Certification
Game-Based Learning
Project Management
Serious Game
Training

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Abbreviations

ACTA	*Applied Cognitive Task Analysis.* A method, based on three interviews, that helps to extract information about the cognitive demands and skills required for a task.
GBL	*Game-Based Learning.* Learning based on games that, besides the fun factor, have also defined learning outcomes.
NPC	*Non-Player Character.* Is any character in a game that is controlled by the computer and not by players.
PDU	*Professional Development Units.* A measuring units used to quantify approved learning and professional service activities.
PM	*Project Management.* Discipline of planning, organizing, securing, managing, leading and controlling resources to achieve a specific goal.
PMBoK	*Project Management Body of Knowledge.* Is a set of standard terminology and guidelines for project management.
PMI	*Project Management Institute.* PMI is a not-for-profit professional organization for the project management profession with the purpose of advancing project management.
PMP	*Project Management Professional.* Is a credential offered by the PMI to individuals that attended and passed the PMP exam.
VIMMI	*Visualization and Intelligent MultiModal Interfaces Group.* Research group focused in novel user interaction paradigms and applications for Design and Manufacturing applications.
WBS	*Work Breakdown Structure.* Is a model of the work to be performed in a project, decomposed and organized into smaller components and represented in a hierarchical structure.

1

Introduction

Contents

1.1 Introduction

The technological boom and rapid dissemination of new digital technology in the last two decades has changed our society fundamentally.

Society lives now in an era where digital technology is integrated everywhere, from work and education to personal life, creating a new generation of individuals that interact with the world at a faster-pace than previous generations.

This new generation, popularized by Prensky as Digital Natives, is characterized as a generation that grew up in a world where the use of digital technology was widely spread and easily accessible, which resulted in individuals with unique characteristics, such as multitasking and parallel thinking, and with different ways of thinking and processing information [1].

Based on the idea of this new generation, Prensky [1] and Tapscott [2] believe that some of the problems faced by actual education systems, such as lack of interest and attention from students, could be mitigated if they fit the education models to this new generation' needs. They argue that previous educational models, that worked for past generations, are no longer valid due to differences between generations, such as skills, interests, how students learn and even due to teachers, who are said to belong to another generation entitled Digital Immigrants: individuals that grew up without digital technology but somehow learned and adopted it later while retaining, to some degree, their foot in the past [1].

Digital Natives are used to instant gratification and frequent rewards. They are used to interact with the world, to be always connected with it, to control what they are doing all the time at real-time, obtaining information fast, sometimes from multiple sources, while doing multiple tasks. They are also characterized for preferring experimental learning, where they can try multiple options, learning and adjusting from their mistakes.

Digital Immigrants, on the other hand, are characterized for preferring passive learning, where students have almost no control or interaction, where step-by-step learning is promoted and everything should be carefully analysed before testing: no space for interactive learning.

Regarding this opposite characteristics, Prensky [1] argue: "it is highly unlikely the Digital Natives will go backwards (...) if not impossible". With this in mind, it is suggested that both education's methodology and its contents should be reconsidered in order to fit Digital Natives.

While logical, some authors [3, 4] argue that this positive view of this new generation is too optimistic and generalized therefore further studies must be done in order to understand what is happening. Recent findings suggest that some of the characteristics of Digital Natives, such as technology skills and experience are far from universal among young people, and that they are related with the socio-economic status, cultural and ethnic background and even gender and age groups of individuals [5–9].

Based on these findings, research indicates that only specific groups of young people, who are highly adept with technology and have the means and, or, opportunity to access it, have all the technological skills propounded by the Digital Natives idea; therefore, the idea of a generalized generation

may not be entirely correct unless it is focused on those groups.

With this in mind, it is important to consider that significant changes in education models, in general, may not be the best choice since it may neglect smaller groups and overlook the impact of this changes in social-economic and cultural factors [3]. However, if the changes are focused on specific groups of students that fit into the Digital Native's type, for instance Information Technology students, some of the generalization problems may be avoided while the benefits remain.

One of the possible alternatives that may be used to engage Digital Natives is the use of games, more precisely, "Serious Games".

Although "Serious Games" is today a popular term, its definition is yet an open discussion that raises different opinions and results in some disagreements due to its large scope. Based on Abt [10] definition, serious games are games that have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for entertainment. Also, to Corti [11], serious games are "all about leveraging the power of computer games to captivate and engage end-users for a specific purpose, such as too develop new knowledge and skills".

In fact, a simplified definition says that serious games are games for purposes other than entertainment [12] and therefore has lots of diverse applications such as:

- **Advergames:** web-based computer games that incorporates advertising messages and images, which allow organizations to, for instance, reach more customers and gather their information, promote services or products, improve their brand image or even do market studies at low or any cost [13, 14].

- **Simulation Games:** Games that try to imitate real-world situations, events, systems, complex structures and variables such as physics laws [15, 16]. One of the main advantages of simulation games is the possibility of simulating actions that in the real world would be impossible to happen due to their risk, price or even danger [17]. This type of games is so useful that in some areas it's mandatory that professionals use these systems for tests or training, such as Flight Simulators.

- **Games for Health:** Some authors [18, 19] defend that serious games for Health are those who seek to train or modify the behaviour of people in order to improve health care. Health care is always associated with high costs and high-risk situations meaning that it is a sensitive area where changes can have a huge negative impact. The usage of these tools is vast, it allows professionals to try and practice anything that goes from management to skill training without any real risks or costs.

One out of many applications of serious games is education [1, 20].

As mentioned before, one of the possible alternatives to engage students in education is the use of games: Game-Based Learning (GBL). For Tan et al. [21], Game-Based Learning is the usage of games as a medium for conveying the learning contents. Freitas [22], Prensky [23] and Eck [24] define Game-Based Learning as playing games capable of creating engaging and immersive learning experiences for delivering specified learning goals, outcomes and experiences. Freitas [22] also argue

that one of main barriers of this type of games is the lack of empirical data to support the fact that they work, but still some authors defend some advantages of these games.

Silva et al. [25] and Seager et al. [26] say that these games allow the creation of immersive and engaging environments that capture users attention, increasing their motivation and facilitating knowledge transfer. Also, as decisions in game are cost and risk free, these games allows students to learn-by-doing and do what-if decisions in order to experiment and explore new options, improving their knowledge and skills, such as performance and decision-making skills [27].

The work presented in this thesis describes the development, testing and result analysis of a serious game focused on the Project Management Professional (PMP) Certification, a credential offered by the Project Management Institute. In order to obtain this credential, professionals must have experience in project management as well as obtain a specific number of Professional Development Units (PDU) each three years.

In this thesis, the objects of focus are PDUs related with academic courses or educational courses, therefore, the developed serious game is based on some of the contents described in the Project Management Body of Knowledge (PMBoK) [28] and is meant to be used as an auxiliary tool by PMP Certification students in order to help them to understand some of the main concepts taught in the certification program.

With this approach it is expected to understand if Game-Based Learning applied to the PMP Certification can be beneficial, this is, if the use of a serious game in this context can improve the knowledge assimilation and if students can easily accept/adopt it.

1.2 Context

The dissertation work and research was done in the Visualization and Intelligent MultiModal Interfaces Group (VIMMI) at INESC-ID, during the 2012/2013 scholar year.

The work developed on this thesis is meant to be used mainly by students of the Project Management Professional Certification (PMP) , and its main focus is to understand the impact of Game-Based Learning when applied to PMP Certification.

In this context a serious game was developed, which may be used by PMP Certification students in order to help them acquire and test their knowledge regarding some of the concepts contemplated by the Project Management Body of Knowledge (PMBoK).

The use of this serious game allowed us to do some tests in order to measure the knowledge assimilation and the impact of the game within students.

1.3 Problem Statement

With the potential of improving training and learning activities by virtue of engagement, motivation, role-playing, repeatability, learn-by-doing and risk free [11], Game-Based Learning (GBL) has become an important research field.

Some authors defend that the benefits of gaming could be adapted in order to fit or adapt education models. These changes would allow education to ”reach” their students, retaining their attention through immersive experiences while improving learning [1, 2, 10, 11, 23].

It is also said that games can support the development of a number of different skills as well as allow players to experience situations that are impossible or impracticable in the real world. The use of games in learning environments allows users to test different alternatives, promoting learn-by-doing methodologies and giving players the opportunity of exploring in a cost, time and risk free environment [11, 29]. As is also reported by Szczurek [30], VanSickle [31], Randel et al. [32] and Van Eck [24], research in the last years proves consistently that games can promote learning.

On the other hand some authors claim that this generalist and optimist view of GBL lacks of empirical data, and therefore must be carefully analysed before applicable to education [22]. Although the effectiveness of GBL is not in question, Bennett, Maton and Kervin [3] claim that it ”questions the assumption that their (GBL) apparent popularity in everyday life makes them directly and unproblematically applicable to education”. Van Eck [24] also argue that ”continuing to preach the effectiveness of games may create the impressian that all games are good for all learning outcomes, which is categorically not the case”.

In order to understand the real impact of GBL in education and to maximise its benefits more research must be done. Based on a literature review we summarized some of the main challenges faced by GBL:

- To understand how to integrate games and learning processes
- To understand when GBL should or shouldn’t be used,
- To understand with whom GBL could be used,
- To understand the benefits of GBL in education.

Although this summarizes some of the main challenges faced by GBL, due the focus of this thesis, we will only explore the last two challenges, as i will explain in the next section, Contributions.

1.4 Contributions

In order to explore some of the challenges presented above, we focused this thesis on the Project Management Professional Certification. This choice allowed us to test Game-Based Learning in a specific environment where the users involved are more familiarized with technology and games and therefore are more willing to accept this concept. By doing so, we are targeting the last two challenges: with whom GBL could be used and its benefits in education.

With this in mind, this thesis presents and describes a serious game that focus on supporting students to learn or test their knowledge regarding Project Management Professional certification. This thesis has yielded the following contributions:

- A serious game focused in PMP Certification,

- Findings regarding the benefits of GBL when applied to PMP Certification,
- Findings regarding the impact of GBL with ”Digital Native” students.

1.5 Document Structure

The rest of this dissertation is organized in four chapters and three appendixes.

Chapter 2, Related Work, presents some of the work related to our research, which includes an approach to elicit knowledge from experts, an analysis of two serious games focused in teaching project management and an analysis of two serious games focused in practicing project management.

Chapter 3, Serious Game, describes in detail the serious game developed in this thesis. It starts by introducing its purpose and objectives. Next we describe how it is played, its features, user interface and how it was designed and implemented.

Chapter 5, Evaluation, describes our approach and methodology to test thesis' hypothesis. It starts by presenting each step of our evaluation and its results finishing with a discussion regarding what we accomplished.

Chapter 6, Conclusion and Future Work, as the name suggests, concludes the dissertation with an overall discussion of the work and proposes some of future work.

Finally, in appendixes we have the tests and questionnaire discussed and presented in the Evaluation chapter.

2

Related Work

Contents

2.1 Related Work

The first CHAOS Report [33] in 1994 reported that only 16% of projects were successful. Since then, this rate has been increasing but still there are a significant percentage of failed or challenged projects [34]. Evidences show that most of the problems that led to project failure are strongly related with Project Management activities [34].

In order to face some of those problems, several tools, such as Serious Games and Simulators, have been proposed and developed. Through the use of these tools professionals and students are able to acquire, practice and improve their skills in multiple areas of project management, decreasing the possibilities of project failure while promoting good practices.

Since the serious game developed for this thesis aims for project management certification it was important to first do a review of the related work: mostly serious games or simulations related with project management. This literature review not only allowed us to understand the impact of those games but also their main challenges and features, which were the basis and inspiration for our game.

In this chapter we are going to start by analyze and describe an approach to obtain knowledge from experts, which can be used to build serious games. After that we will analyze some serious games with different purposes, teaching and practicing, and try to understand their focus and objectives.

2.2 Eliciting Knowledge to Create Serious Games

Seager et al. [26] believe that to build a successful serious game, developers should start by achieving a clear understanding of the learning domain using a systematized approach. In their work it is presented and applied a structured approach to develop a serious game for project management, that leaded to a group of possible game features and a serious game.

The main focus of their proposal is to gather information from domain experts and present it in a way that can be easily interpreted by game designers and developers.

They divide their approach in three stages, Knowledge Elicitation, Knowledge Representation and Game design, and focused in the first two. For the focused stages it was used Applied Cognitive Task Analysis (ACTA), which consists in a group of three interviews [35].

- The first type of interview of ACTA, Task Diagram Interview, focuses on eliciting information about a task structured within a task domain. This allows interviewers to identify the most dificult or challenging tasks components.
- The second and third type, Knowledge Audit and Simulation Interview focus in those tasks components identified before and tries to elicit more detailed information.

Using ACTA protocols within interviews with experts, it was asked to each expert to select five tasks, and sub-divide them into three to six subtasks, and again, sub-divide into smaller tasks. The result of this interaction was a set of Task Diagrams.

To those tasks mentioned by four or more experts, it was done a Knowledge Audit and Simulation interviews. Based on this last interviews, it was possible to gather information regarding why the task was dificult, it's potential errors and cues and strategies to mitigate errors.

The outcome of this study was a serious game where users start by receiving a project brief with a given Work Breakdown Structure, WBS. Players are then challenged to monitor the progress of the project, ensuring that tasks are completed and that budget, time, quality and scope are respected in the end. To do so, players need to manage various stakeholders and manage unexpected issues.

Beside this serious game, which was not the focus of the study, the authors also suggest a group of game features regarding the task Scope Definition.

Focused in the process Project Requirements, users would interact with Stakeholders (NPCs). Each Stakeholder would give a group of requirements regarding what they want, and, in some cases, give some extra information or hints about other Stakeholders.

The main objective of the user should be manage and negotiate with all the Stakeholders, understanding what they really need and what cant be done.

Each Stakeholder and requirement have properties that help user throughout their judgement and management. The output of this would be the requirement list.

Discussion on Eliciting Knowledge to Create Serious Games

Through the analysis of this work and its results it is proven that the use of a methodology, a consistent and repeatable process, to elicit knowledge from experts can make the task simpler and its results more trustable and useful.

The use of a systematized approach allows the process to be applied with similar conditions to larger groups of experts and therefore assures that the results will become more coherent and trustable, which may be useful to filter results or even to support decisions such as which information may be more correct or useful for the game.

One of the main advantages of using the described methodology is that all the elicited information is only based on experts' experience and knowledge, therefore its use in a serious game will allow users to have a more realistic experience since all the problems are based in real situations. Another benefit of this process is that the result of interviews, besides the knowledge acquisition, can also include useful tips and ideas which may end-up to be interesting features in-game, improving once again the experience.

In the work described in this thesis most of the information was already acquired and available in the Project Management Body of Knowledge book, therefore there was no need to elicit most of the knowledge from experts. Still, our game facilitates the update of its contents, which allows experts to easily add their experience and their knowledge to our game, improving its content and consequently, the game.

2.3 User-Centered Game Design

Developing a serious game that is at the same time enjoyable to play and an efficient learning tool is a challenge: If the game is fun but the learning is neglected, it loses its main goal as a serious game. On the other hand, if the application is too focused in learning, it may become dull for users.

As a mean to reduce these risks, Holloway et al. [36] suggested a user-centered game design methodology, the Star Method, for developing serious games that accounts for the interdisciplinary nature of designing serious games.

This methodology, based on the Rankin's methodology, is composed by four phases: Research, Validation, Design and Implementation. Holloway et al. argue that Research, as a starting point to develop a serious game is a must. Developing a serious game is an interdisciplinary project where both experts from the game domain and from game design must be consulted in order to fulfill its purpose.

According to the Star Method proposed, in Research phase game designers should do observational studies, literature search and market, data analysis. By doing so, designers will be able to have a better understanding of the domain and its needs. Also, by doing literature search and market analysis, designers will be able to do a comparative analysis with other similar games, understand what already exists, what features worked, what can be used in the game and what can be improved. With this phase, it is expected that the concept behind the serious game starts to become better defined, allowing designers to move to the next phase, Validation.

Validation, as the name suggests, is where the designer validates and verifies the game, its concepts, mechanics, user interface and other game-specific and domain-specific functions. This phase is a key in moving between the other three phases since it allows designers to have a clear understanding on what users think and feel about the game, helping them to achieve a successful game.

During Validation users are recommended to consult experts, apply evaluation tests such as heuristics, and continuously resort to user experiments in order to obtain constant feedback.

Another important phase in this game design methodology is Design, where the game concept and its implementation details emerge. During this phase users can resort to, for instance, brainstorming to produce the game concept, its mechanics, features and user interface. All the outputs of this phase can be subject of the Validation phase in order to understand if they meet their goals.

The last phase of this methodology is Implementation. Implementation occurs based on the other phase's outputs, but it doesn't necessary mean that it must be executed last. During Implementation the designer can produce mock-ups, low fidelity and high fidelity prototypes, game features and the game itself. All this outputs are used in Validation phase as a mean to validate the game.

As Holloway et al. state, this four phases aren't mutually exclusive, instead, it's likely that a designer is simultaneously validating the game, researching, designing and implementing.

Discussion on User-Centered Game Design

The work described in this thesis includes the conceptualization and development of a serious game which main objective is to help students test and acquire knowledge regarding some of the concepts described in the Project Management Body of Knowledge. As a game where learning has such an important role, reducing the risk of developing a game that doesn't fulfill user's needs or isn't as intuitive, easy and fun to play as it should is a priority, therefore, we resorted to the methodology described above to develop our game.

This iterative methodology assures that through constant feedback from users and experts together with constant research and validation, the developed serious game has higher chances of having the main characteristics, game and learning, balanced.

Using this methodology, we were able to develop a game that was build based in constant user feedback, obtained through releasing and testing multiple prototypes with users. Besides the prototype testing, we also researched other game's features, described in this chapter, in order to understand how to introduce features in our game that would have a positive impact. Also, we were able to validate our game domain with experts.

The outcome of this methodology was the game described in Chapter 3.1.

2.4 Serious Games for Teaching Project Management

In this section we are going to analyse two non-digital serious games that allow players to learn about project management activity.

The first game focus on teaching some project management lessons as well as promoting good practices and create awareness of the consequences. The second game focus on teaching Scrum, an agile method for project management.

Problems and Programmers

Problems and Programmers [37] is a serious game that aims to teach both general and specific lessons inside the project management as well as promote good practices, be fun and quick to play. Baker et al. believe that if they manage to fulfil those objectives, they succeeded in creating an innovative and efective teaching tool [37].

The game consists on a competitive card-game where players will have a project leader role. Their objective is to complete a project, the same for all players, as quick as possible with the minimum problems. The game has seven type of cards: Documentation, Design, Code, Programmers, Problems, Concept and Project cards. (Figure 2.1)

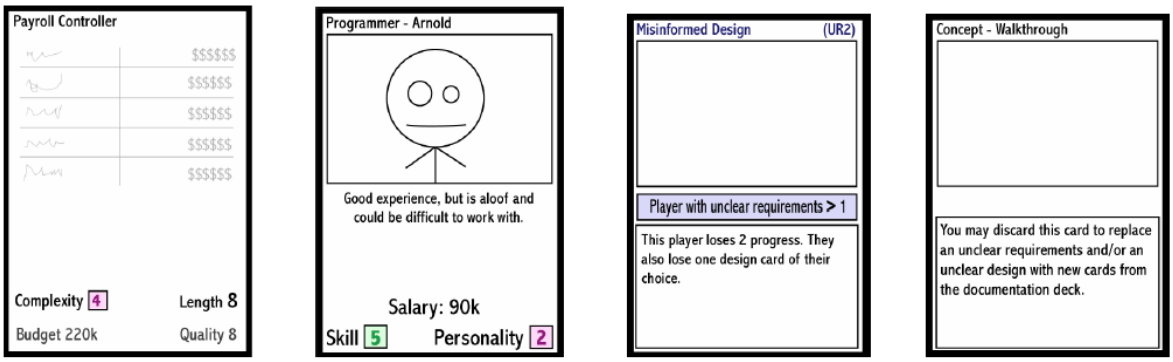

Figure 2.1: Program and Programmers: Cards.

- Documentation and Design cards are white cards that may have errors. If so, they need to be returned to the deck.
- Code cards are cards divided into two parts. Each part represents a type of developed code, fast or good code, that can have problems. There are three kinds of problems: Easy, Normal and Dificult. Easy problems take one turn to solve; normal problems take more time to solve because it is proportional with the number of rounds players have done so far, and dificult problems can't be solved, which means players need to develop code again, spending money and rounds on it.
- Programmer cards have the information regarding programmers, this includes their wage, skill and personality.
- Problem cards are cards with messages that aim to delay other players project.
- Concept cards are cards used as response to Problems cards, or other problems that may occur during the game.
- The last card, Project card, has information regarding the project, which includes the project complexity, time, quality and budget.

All cards are available during the whole game and can be acquired in the deck of cards.

The game is divided into six phases: Setup, Requirement, Design, Implementation, Integration and Maintenance.

Setup, as the name suggests, is where players will start the game. A project card is selected and each player acquires five cards. The game then starts in the Requirement phase.

Requirement phase is optional, this means that players can move on to the next phase whenever they want, but they are encourage to remain here for some rounds and acquire some cards, specially Documentation cards. Every time a Documentation card is acquired and has an error, player is forced to return the card to the deck and acquire another one, using one round to do it. Whenever players feel like they have a good number of Documentation cards they move to the next phase, Design.

Design phase is played exactly as the Requirement. Players acquire two cards per round, expecting to get Design cards that may have errors, and if so, they need to return it too. Again, this phase is also optional and users can move to Implementation whenever they want. Implementation phase

is where players start to develop their project by playing Programmer Cards to develop Code cards. There are two possible options to develop code: Fast and Good. Good code option is slower but has lower chances of having problems, on the other side, fast code speeds up the process but has higher risks. After their development users can inspect code cards, Figure 2.2, to find and solve problems.

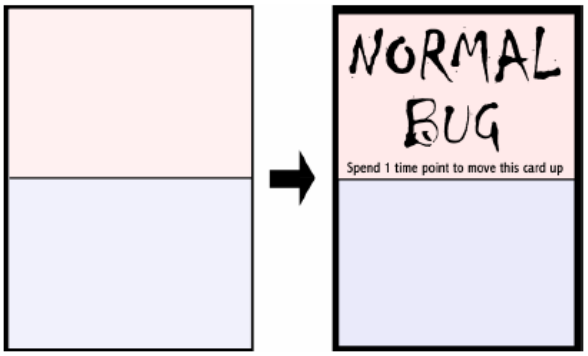

Figure 2.2: Program and Programmers: Code Card.

In this phase users can also play Problems and Concept cards to delay other players.

After obtaining the number of Code cards required by the Project card, users move to the Integration Phase. In Integration phase players will need to wait a number of rounds equal to the number of developers. After that time players achieve the last phase, Maintenance.

At this phase each player shuffle its Code cards and show a predefined number. If any of the cards has a problem, users are forced to solve them.

Problems and Programmers was tested with 28 students and the results were quite favourable. The game proved to be enjoyable to play and quite easy. Also, it was proved that the game help students to reinforce some of the already learned concepts, as well as to help players understand the consequences of ignoring good practices by addressing some of the most common errors in project management.

PlayScrum

PlayScrum [37] is a card game based on its predecessor, Problems and Programmers [38], that allow university-level students to learn Scrum, an agile software development method.

In a quick overview, in Scrum projects are divided into small items that are prioritized by the project owner and developed upon previously created items. With this, Scrum assure that teams respond quicker to change and stakeholders feedback.

In scrum there are three-core roles:

- Product Owner: responsible for creating and prioritizing a wish list, called product backlog.
- Team: responsible for the development of the project.
- Scrum Master: responsible for ensuring that all the rules and practices of scrum are being respected. He's also responsible for protect the Development Team and keep it focused on their tasks.

Another concept present in Scrum is Sprint. Sprint is a unit of development in Scrum. It defines a restrict duration where teams have to complete their work.

During the sprint planning, teams choose items from the top of the product backlog, prioritizes that items based on the team and create the sprint backlog. Later, the team chooses items from the sprint backlog and decides how to implement them.

After that, the team has a sprint to complete their work. At the end of each sprint, the work is passed on to the customer that will later give feedback. All this process is repeated until the project is finished.

In PlayScrum each player will use Scrum's methodology and will play as a Scrum Master. The game only ends when a player finishes all the tasks with no errors or with fewer errors than other players. Also, players lose the game if the cost used with developers and with concept cards exceeds project's budget.

The game itself is composed by cards, Figure 2.3, and a board, that users will use to organize their game.

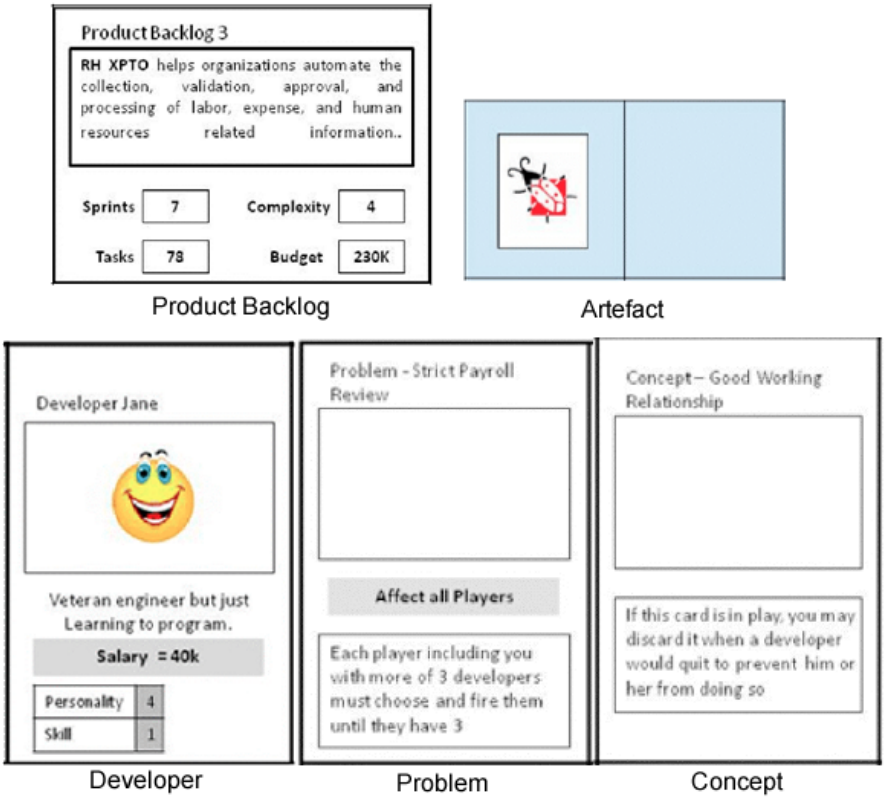

Figure 2.3: PlayScrum: Cards.

The cards present in this game are:

- Product Backlog: contains all the information regarding sprints, complexity, tasks and budget.
- Problems: represent common problems in project management. Opponents play these cards in order to mess up other players management. Each card has a small description of the problem

and can affect one or all the players at the same time. These cards are the main source of problems in the game.

- Concepts: represent good practices and are used to solve problems described in Problems cards. They contain a small description, a consequence of their usage and their cost. This cost tries to simulate real-life situations where problems will affect project's budget and time.
- Developers: each of this card represents a developer. They contain information regarding their name, a small description, their salary, personality, important to know if it is a good developer and it's used in Problems cards, and skill. These cards will allow users to develop the project.
- Artefacts: represent tasks already done by Developers. There are two types of Artefact cards: red and blue. The blue artefact cards are more expensive, their price is defined by complexity value in Product Backlog, but have less chances of containing problems. The red cards are half the value of blue cards but have a higher chance of having problems.

In the beginning of the game each player receives two random developer cards and is selected a Product Backlog, the same for all players. Based on the Product Backlog, each player knows how many sprints and tasks they have to do in order to finish the game, as well as project complexity, important to know the price of each artefact.

The game is played in turns. In each turn players will roll the dice and act on top of the number obtained. If players get between 1 or 3, they only can get Problems or Concept cards, equivalent to the number obtained. If players get a number between 4 and 6, they are allowed to pick three cards of Problems or Concepts plus the number obtained minus three of developer cards. Players can have a maximum of 6 cards in their possession.

In each turn, after picking cards, players can buy artefacts and assign them to a developer. Player can also inspect artefacts in order to find errors, and later to correct them. Every action has a cost of 1. In the end of each turn players can dismiss or hire one developers.

Product Backlog's sprints have duration of four rounds. In the end of each round, the game moderator will verify each player artefact, in order to differentiate players points in case of draw. At the end of the sprint verification every artefact returns to the deck of artefacts and a new sprint is started. If at some point of the sprint verification a player has the number of artefacts completed equal or higher than the number of tasks in the Product Backlog, that player wins unless it is a draw. In that case the player with the less errors in artefacts win.

PlayScrum tries to relate as many game-concepts as it can with the Scrum method in order give players a better experience while increasing knowledge assimilation. Product Backlog is represented in the game as the project card with all the information necessary to finish the project. Also the sprint is contemplated, as well as the delivery of items at the end of each sprint in order to receive feedback or changes like in real-life situations.

The game also share some restrictions with Scrum, like for instance the number of members in the team should be low in Scrum, in the game this is forced by the budget. Also the flexibility and adaptability are present due to Problems and Concept cards.

The overall evaluation of the game is positive, users considered the game fun and easy to play but also considered that the gameplay necessary in order to finish the game may be a bit longer than expect. Regarding the knowledge assimilation and experience, users said that the game is helpful and it could be used as a tool to practice the concepts learned in classes.

Discussion on Serious Games for Teaching Project Management

Although the previous analyzed games focus on different subjects regarding project management, both shared similar results and features, which allowed us to understand some important features and characteristics of serious games that can be used to engage players in them.

Both games were carefully designed to be intuitive, fast and easy to play. Due to this features players were able to quickly understand how both games worked and engage in them improving some important soft skills such as adaptability, flexibility and decision-making.

The most relevant feature of the two games is their multiplayer nature. Both games offer a competitive experience, where players play against each other, which results in a richer and more engaging experience for players while it teaches some basic but important concepts, such as the advantage of a good effort in requirement phase.

Based on these two games we are able to better understand how the competitiveness of a game can have such a significant and positive effect in its engaging factor. With this in mind, we decided to introduce a competitive feature into the game described in this thesis: a ranking system - with this we expect to have the same outcomes described above.

2.5 Serious Games for Practicing Project Management

In this section we are going to analyse two diferent digital serious games. Both games are single-player and provide an engaging environment capable of challenging players by simulating project management's problems. With this, players can practice project management in a controlled environment, cost and risk free, and be able to understand their major flaws while managing projects.

Serious Game for Practicing Resource Allocation

McFarlane et al. describes a new approach to the development of a serious game that aims to improve the practice of project management [39].

In this approach the authors propose a new game that instead of focusing in teaching specific rules and predefined actions, has it happens in traditional teaching methods for instance, focus in confronting users with problems that have a complex and stochastic nature as it happens in project management. With this they expect to give players a closer and richer experience has if they were having on-job training.

The game focus on the task of resource allocation during the lifetime of the project and it is divided into two diferent parts, the Basic Game and the Stochastic Game.

The project featured in the game is a Software Development Project with diferent tasks: Scope, Planning, Module 1 and 2, each one with subtasks design, development and review, Integration and Documentation.

Starting with the ”Basic Game”, this part of the game has three diferent phases: Planning, Simulation and Summary.

In Planning Phase user will start by allocate some of the resources based on the Gantt Chart and Dependency Chart. Every time players allocate something, if the allocation is correct and respects game constraints, they will be able to compare its result with other allocations, otherwise, they will have to re-do the allocation.

Whenever users specify a valid allocation they start the Simulation phase. Here the game pauses every two weeks, game time, and shows a project report with information regarding task status, which includes its progress and estimated end date, Figure 2.4. Every time the game pauses users can make changes to resource allocation.

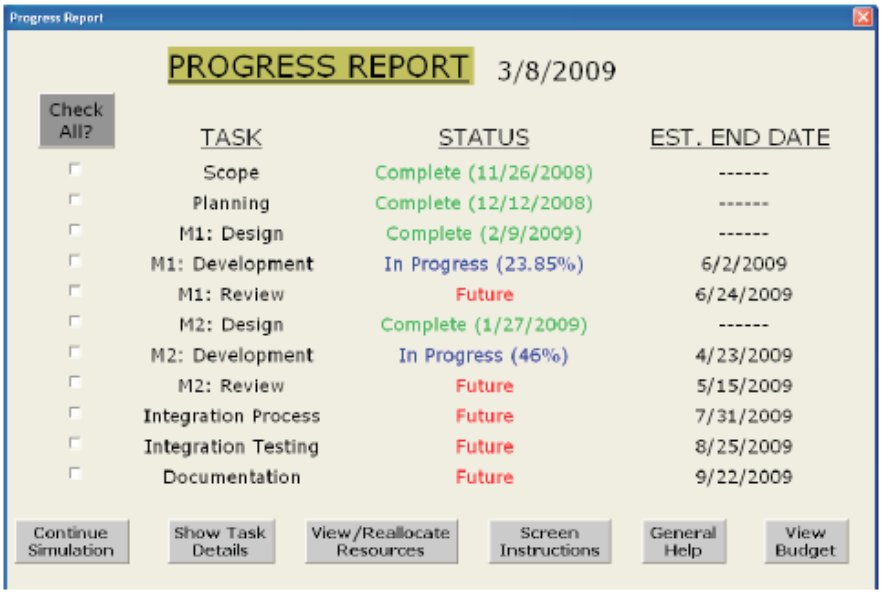

Figure 2.4: Periodical Project Report.

After the project is completed, users will be then presented with a report that has all the information regarding the project. Users will be able to see if they respected their budget and schedule.

After the end of the Basic Game, it was developed a Stochastic Game that is meant to be played by users that already mastered the Basic Game. In this seconds part of the game, Stochastic Game, it was introduced new variables that try to approach this game to real life situations. The game mechanic is still the same; users do the initial allocation and move on to the simulation phase where the game will pause every two weeks.

The Stochastic game introduced Defects,Worker Efficiency, Budget Variability and Stochastic Task Durations.

Defects were introduced during the Module 1 and 2 and Integration phases. Whenever defects appear, users can fix them and continue the game, fix them and search for more defects or ignore

them. As in real life situations, the earlier the defects are corrected, the less resources and implications they will have late game. Users need to balance this otherwise they can spend too much or too less resources.

Worker effciency adds another problem to players. In Basic Game, if two workers are allocated for a twenty hour task for ten hours, the task would be done in ten hours, and if the player allocated a third worker, this time would drop consequently. With worker efficiency limitation, inserting new workers may lead to higher times because learning curves are taking into consideration. The task status is now based in a function of the time a worker has spent on the task and takes into consideration the optimal profile of the task. This means that if a task is optimized for two workers, if the users inserts a third one this will delay the task.

Budget Variability basically means that the budget, instead of been a constant like in Basic Game, may alter from time to time as it happens may happen in real life situations.

The last change was the Stochastic Task Durations. With this feature, the actual time needed to complete a task and the estimated time presented to the users are diferent but converge during time. With this new feature, every time a user adds or removes resources from a task, the distribution of the estimated time for each task and its dependencies is re-calculated and the Gantt Chart is updated. This means that users need to carefully choose their allocations otherwise they may disrespect the schedule.

SimSE: A Project Management Simulation Game

SimSE [40] is game-based simulation environment that is interactive, educational and easily customizable. It is also the closest approach to our proposal.

In contrast with the above solutions, where we have non-digital games, SimSE offers a digital environment where students are able to learn the intended concepts while having an enjoyable experience. Besides the experience it gives to players, SimSE also offers a model builder that allows instructors to build their own customized simulation models. With this component instructors are able to decide what lessons they want their students to learn, creating a customized simulation game based on those lessons.

The biggest advantage of SimSE Model Builder, Figure 2.5, is allowing instructors to create their own simulation without needing to hard-code it, it hides all the textual representation of the modelling language by giving users a graphical interface composed by tabs, buttons, drop-down lists, menus and dialog boxes.

In SimSE Model Builder users navigate through tabs in order to specify the object types, start states, actions, rules and graphics for a specific model, creating the best environment for their purpose.

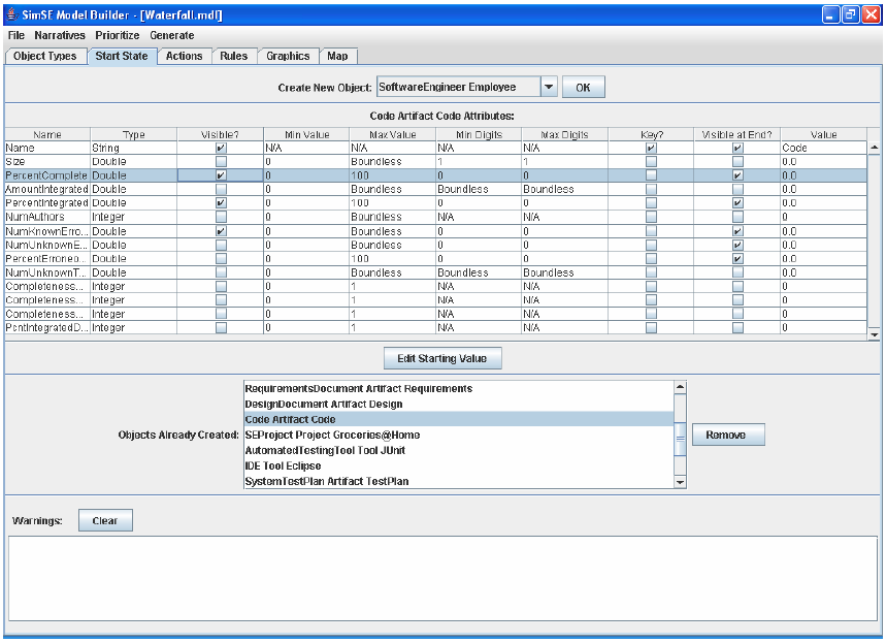

Figure 2.5: SimSE: Model Builder Screenshot.

In Object Types tab users can create or edit objects. First users need to select the object meta-type, which can be employee, artefact, tool, project or customer. After choosing the meta-type for their object, they will be prompted with a dialog request the information for that specific type of object.

The Start State tab allow users to select the previous created Object Types and define their start values and state.

In the Actions tab users can define the actions on their model. Users start by adding participants to actions, where they define all the information to each participant, and then proceed to adding triggers. A trigger is defined by their type and frequency. If the trigger type is user-initiated, this means that the trigger starts in one of the selected participants and therefore the user will need to enter the message that appear in the selected participants. Triggers can also be defined as the Game-ending trigger, and therefore, whenever the trigger occurs, this means that game is over.

The rules tab allows the creation of simulation rules. Rules can be added to actions, and there are three types of rules: create object rules, destroy object rules and effect rules. The first two types allow the creation of conditions to constrain the creation and destruction of any object. For instance, a destroy object rule can be created to constrain the action fire employee. The last type, effect rules, can be used to create effects to whenever an action occurs. For instance to decrease the energy of a employee whenever he develops code.

The graphics tab is used to assign images to each object in the start state. With this, each object will have a graphical representation in the game interface.

The last tab, Map, allow the user to create the map interface in the simulation, this includes placing the furniture, doors, walls, floor and objects defined in the Start State and Graphics Tab.

The Model Builder includes also menus to create Narratives for the whole game, Prioritize their triggers, destroyers and rules, and Generate the model.

Whenever the user generates the model, the Model Builder will create the simulation game code based on all the information inserted in the above tabs. There are already six SimSE models that have been completed using Model Builder: a waterfall model, an incremental model, a code inspection model, a rapid prototyping model, a Rational Unified Process model and an Extreme Programming model.

For players, SimSE Game is a single-player game in which the player takes on the role of project manager. As a project manager, players will need to manage a team of developers, this includes hiring and firing employees, assign tasks to team members, monitor the progress of the project and acquire tools to improve the project.

The game starts by present to players a description of their project. This includes the game goals, the time and budget player has, how to achieve the final score and, in some cases, some hints.

The player then starts playing the game by monitoring the progress of the project and managing its team and resources. Whenever the player achieves the end of the game, he will receive its score and information regarding its game in order to players have insight into why they achieved that score.

The whole game is played in a graphical environment defined in the Model Builder, Figure 2.6.

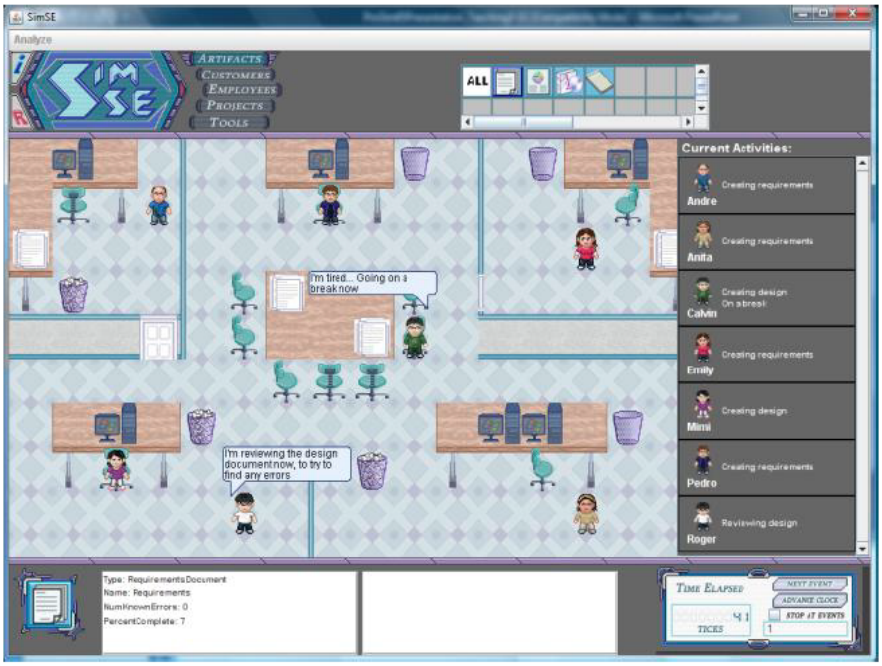

Figure 2.6: SimSE: SimSE Game Environment.

During the game players can interact with the employees and other NPCs that may exist. All this interaction between then will be based in speech bubbles, allowing users to get some guidance and hints about the state of the project and employees situation. The game will also randomly trigger some events to test players capacity to solve problematic situations.

The goal of SimSE is to allow students to put into practice all the theoretical project management knowledge given in lectures. In order to evaluate if this could be achieved the game was tested in diferent sites and the result was a positive feedback by students [41]. In average all students said

that SimSE was an enjoyable experience. Also the game proved to be more educationally effective when used as an auxiliary tool in other teaching methods, specially if players have some background knowledge on the subject.

Discussion on Serious Games for Practicing Project Management

Based on the analyzes of the last two serious games we concluded that their main advantage is that they are digital, which allowed the introduction of interesting features such as randomness in actions and consequences as well as modularity.

As described above, the first game had two different parts, a simple and static initial part that can be considered as a game introduction and the second part: a stochastic and more complex game. Through the features introduced in the second part, the authors were able to create a digital game that targeted multiple problems, which are difficult to predict and control in real life projects, giving players a more realistic experience while preparing them for this type of events.

The second game analyzed in this chapter, SimSE, introduced an important feature: modularity. The result of this feature was a fully adaptable game where players can customize everything and therefore can create levels and environments that focus in a specific knowledge or experience. Another main advantage of this feature is the possibility of improving the game quickly and easily based on constant feedback from players.

The game described in this thesis focused on teaching the basic of project management instead of practicing it; still, both of the features discussed here were taken into consideration and adapted to our game. The modularity is introduced in the knowledge source, which can be easily modified in order to improve it. The randomness was introduced in multiple parts of the game with the purpose of increasing the game difficulty and avoid patterns.

2.6 Summary

This chapter presented a comprehensive analysis of multiple serious games as well as an analysis of a methodology proposed to elicit knowledge from experts for serious games. Based on these analysis we discussed in each topic their main advantages and how we could relate and benefit from them in our work. The outcome was a better understanding of some important characteristics and considerations that should be considered in our work, such as:

- Expert's feedback as a mean to create a more realistic experience,
- Competitiveness as an engaging factor for players,
- Modularity as a mean to improve the game easily,
- Randomness as a mean to retain user attention.

In the next chapter we will introduce our approach to a serious game, which can be used by PMP Certification students as an auxiliary tool.

We will start by explaining the game purpose and how it is played. Next we will explore its main features and the user interface finishing with an explanation of our main challenges and decisions regarding the design and implementation.

3

Serious Game

Contents

3.1 Introduction

It is well known that a significant percentage of developing projects fail due to management problems [34]. To mitigate this problem, companies and professionals around the world invest more and more in project management expecting to reduce this risk of failure.

One of the main solutions to mitigate this problem is to assure that professionals have the minimum skills and knowledge needed to manage projects. These minimum requirements can be achieved by many means, such as on-job training, workshops or certification, the focus of the thesis.

Today, more than ever, with the market awareness for the need of this professionals, it is necessary that organizations are able to fulfill market needs in a quick and efficient way, certificating professionals that are able to respond to organization's needs. Project Management Institute (PMI) is an example of such organizations, where Project Management Professional (PMP) certification can be obtained.

Taking this into consideration, the work developed in this thesis focus on the impact of game-based learning when applied to the PMP Certification. With it, we expected to understand if a game developed specifically for this context, PMP Certification, could be accepted by its students as an auxiliary tool for their study, and if so, if it could increase the knowledge assimilation throughout its use.

In order to evaluate this we developed a serious game that allows players to test their knowledge regarding some of the concepts described in "A Guide to Project Management Body of Knowledge" (PMBoK Guide) [28], which is a recognized standard that describes a set of standard terminology and guidelines for project management.

According to PMBoK, project management is accomplished through the appropriate application and integration of the 42 logically grouped project management processes comprising the 5 Project Management Process Groups, or Process Groups.

Each project management process can be described as a set of Inputs, Tools & Techniques and Outputs that overlap and interact throughout a project.

Although these concepts are part of an adaptive standard that crosscut multiple knowledge fields, its expected that a project management professional master them.

With this in mind, we designed and developed a 2D game which main objective is to allow players to practice and validate how well they understood these guidelines.

The game can be categorized as a puzzle game, where players will need to relate different elements in order to unlock new ones and progress. This gameplay, explained in the next section, encourages players to try and fail as a mean to understand what and why they are wrong.

3.2 Gameplay

As mentioned above, the game's main purpose is to validate how well a player understood the relations and dependencies between different project management processes and their elements 3.1.

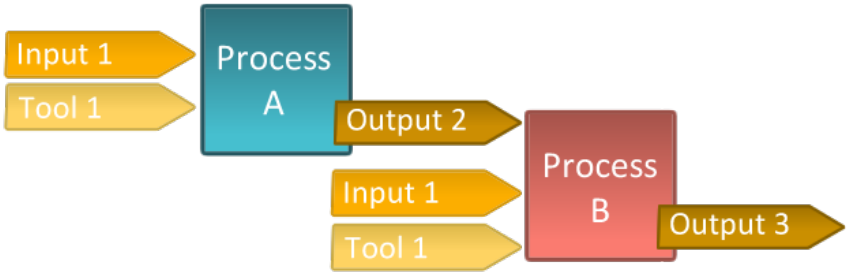

Figure 3.1: Process Elements and Relations

In order to play the game, players must first understand how these elements are related:

- Process Group: Group of processes logically related and linked by the outputs they produce. There are 5 Process Groups: Initiation, Planning, Execution, Monitoring & Controlling and Closing.
- Process: A set of Inputs, Tools & Techniques and Outputs that overlap and interact throughout a project. During the game, players will be able to associate elements to processes in order to obtain their output. In total there are 42 processes distributed by 5 groups.
- Inputs: Documents, Plains, Designs or other information that are relevant to processes.
- Tools & Techniques: Events or actions applied to inputs and processes, such as Expert Judgment or Brainstorming.
- Outputs: Result of a execution of a process. An output of a given process can be the input of other processes.

Throughout the game, players will be able to test their knowledge regarding these concepts by selecting processes from process groups and associating elements to them.

Every time a player decides that all the elements are associated correctly, he can try to validate that process. There are two possible outcomes from a process validation.

The first, Incorrect Validation, means that the associated elements are wrong or there are some elements missing. When this happens players receive some feedback in order to understand what is the problem and can modify their associations as many times as they want.

The second possible outcome, Correct Validation, occurs when a player associated all, or almost all, the correct elements and therefore, the process is now complete and its outputs are unlocked. When this happens players also receive some feedback regarding what they have achieved and unlocked.

In order to finish the game, players will need to validate correctly every Process of each Process Group, which means they were able to associate all the correct elements to each process as well as understand the dependencies between processes and between process groups.

3.3 Game Features

According to PMI, projects can be defined as a temporary endeavor, with a definite beginning and an end, undertaken to create a unique product or service. Project management, then, is the application of knowledge, skills and techniques to execute projects effectively and efficiently [28].

As a serious game where the main theme is Project Management, it was important to add some features that would help players to experience that a project is a continuous activity, where all the elements are related and where good practices must be respected in order to fulfill its objectives. As a game, it was also important to introduce some motivational and engaging elements in order to captivate user attention and encourage them to play it.

3.3.1 Lock State

One of the features we introduced in game was a lock state. In project management, processes overlap and interact with each through their inputs and outputs; still, there is a logical sequence in their execution that must be respected.

To replicate this characteristic into our game we decided that most of the elements start locked and will only be available based on the progress of the player. This lock state introduced in elements acts differently for each type of element.

Process Groups start locked, which means that all its processes are also locked and inaccessible. To become available, the previous process group must have a pre-defined trust rate, which means that the player understood enough of the previous group and its ready to move to the next one.

All the information regarding a Process Group state can be easily obtained in game by checking the icon under the group name or the color of the group name. (Figure 3.2)

Figure 3.2: Process Group States

Regarding Processes, there are two different rules that define their state. The first rule, already

mentioned above, is the state of the process group where it is inserted. If the group is locked, the process is automatically locked and inaccessible too.

The second rule states that the process is dependent from its Inputs. This rule was created to simplify the game for players since they can only access processes that have all the elements needed available, avoiding possible mistakes and allowing players to understand that some processes are dependent from others.

For players to know the state of a given process, players only need to look at the icon next to the process name. (Figure 3.3)

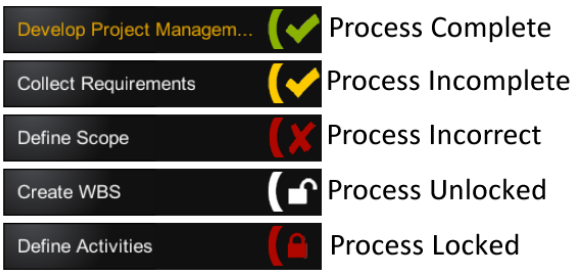

Figure 3.3: Process States

The next element affected by this feature is Information, which is processes' Inputs & Outputs. At the start of the game, only the minimum and necessary Information is available, however, most of the locked Inputs can be easily unlocked by validating Processes. As mentioned before, whenever a process is validated, it may unlock its Outputs, which may be needed for other processes as Inputs.

3.3.2 Trust Rate

To improve players experience and to encourage learning and curiosity while playing our game, we decided to add a new feature: Trust Rate.

Trust Rate can be defined as a measure that is present in Process Groups, Processes and Information, that allows players to understand how correct, or trustable, an element is. With this feature we expect to encourage and motivate players to go search and understand why some elements have a lower Trust Rate, what lead to that value and how can they fix it.

In Information, trust rate is based on the Process that unlocked it. If a user validates a process where the trust rate is, for instance, fifty percent, all its outputs will assume the same trust rate. This implies that users need to be careful with the outcome of validations because if they use the output of an incorrect process in another process, it will affect that process trust rate.

The consequences of this actions will result in a cascade effect where trust rates will always get lower until a point where players must go back and correct its mistakes in order to proceed in game.

Processes trust rate is slightly more complex since it takes into consideration 3 aspects.

- Average trust rate of correct elements,
- Number of incorrect elements,

- Number of missing elements.

Initially the trust rate is based on the average values of each of the correct associated elements. After that, it is applied a penalty for every incorrect or missing elements. Besides allowing players to understand how correct or incorrect a process is; trust rate is also used to decide the state of the process and whether or not the outputs of a given process are released.

As mentioned before, processes can be Locked or Unlocked. With this feature we introduced three new states:

- Process Complete: in this state the process has the maximum trust rate, 100%, which means that the process has all the correct elements associated and its now completed.
- Process Incomplete: this state means that the process has a high trust rate, high enough to release its outputs, but still has some incorrect or missing elements, or even because some of the inputs have a low trust rate.
- Process Incorrect: means that the process has a low trust rate and therefore the outputs won't be released.

As explained before, if a player wants to know the state of a given process he can check the icon next to the process name or select the process. In Figure 3.3 its possible to see the different representations of process states.

Since trust rate represents the state of each process we decided to use it as a metric for the overall game state, which can be seen in the progress bar on the top-right corner of the game (Figure 3.4).

Figure 3.4: Main Screen

3.3.3 Score

One of the most important findings to come out of our Related Work review is that competitiveness in games can have a significant and positive effect as an engaging and motivational factor.

Competition allow players to satisfy the need to win, provides the opportunity and reason for improving their performance while motivating them to put forth greater effort that can result in high levels of performance [42].

In order to benefit from some of these advantages we decided to introduce a new feature, Score, that would add some competition to our game.

Score is a metric that is updated after validation and is based on the progress of a player as he plays the game. For its calculus it is considered various factors:

- Game overall state: based in the trust rate of each element of the game. Can be seen as the percentage of completed game.
- Number of perfect validations: number of process validations that were completely correct at the first try. Each one of these validations increases the score.
- Number of incorrect validations: number of process validations that weren't completely correct. Each one of these validations applies a penalty to score.
- Number of hints used by players. Each time players use hints to understand their mistakes a new penalty is added to score. This encourages players to study and understand their mistakes instead of just using hints.

At the end of the game players will have access to an Overview screen (Figure 3.5) where they can submit score to our ranking. This ranking, which can be consulted by selecting the menu on the top of the screen, has the score and name of the top ten players as well as the actual score of the player.

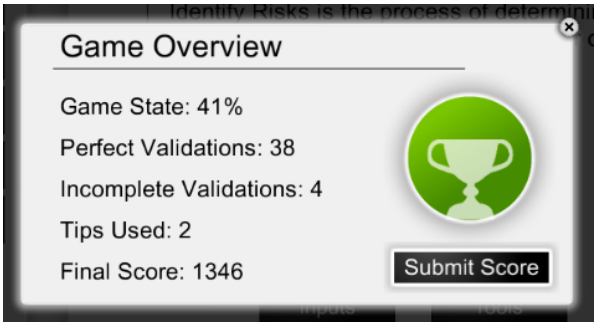

Figure 3.5: Overview Information

3.3.4 Other Features

Besides the previous explained features, which have a major impact in our game, we also added some small features that are useful to players as they progress in game:

- Hints: As an approach to help players understand where they have made mistakes we added a feature, Hints, that allows players to check how many elements are missing or are wrongly associated to a given process. By viewing hints players are able to understand where they have mistakes but it applies a penalty to their score.

With this decision we hope to encourage players to first try to understand where they have made mistakes by search and studying the standard instead of just use hints.

- Diagrams: Since each process can have multiple elements associated it was important to create a quick way of resuming this information. To solve this we added a feature that builds diagrams with the associated elements of each Process or Process Group. This feature is used in two different contexts.

  The first is whenever a player tries to validate a process; a diagram of the process is built so that the player can review its associations just before validating.

  The second one can be accessed on the top menu of the game and builds diagrams of Process Groups. Unlike the first case, this diagram includes all the Processes of each Process Group and it is only built with information that is correct, allowing players to safely use this diagram as a source of knowledge (Figure 3.6).

- Tutorial & Rules: Since our game requires some previous theoretical knowledge to play it, it was imperative that added some feature that would reduce the impact of the first contact with the game as well as to reduce its negative effects. To accomplish this we added a Tutorial at the beginning of the game that introduces new players to it.

  With this we expect to contextualize players to our game by reviewing some concepts of Project Management as well as explain the game purpose, its goals, interface and how it can be played.

  Since our game has multiple features, some explained above, it was also relevant to explain how they work and their impact in game. To do this we complemented the tutorial with a Rules screen that covers some of the most relevant topics, such as validating processes, locked elements, trust rate and score.

  Both features can be reviewed at any time by selecting the proper icon on the top of the main screen.

- Save & Load: Since our game is complex and covers a wide range of knowledge it is expected that players spend some time playing it. To give players the opportunity of pausing the game and return later we added an option to Save the state of the game, and Load it whenever the game is re-opened.

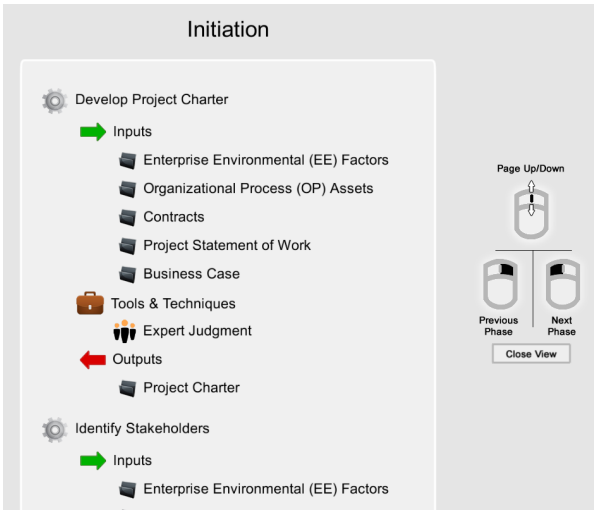

Figure 3.6: Diagram View

3.4 Design & Implementation

Our game is comprised of approximately 4500 lines of C# code. Its design is shown in Figure 3.7, and consists of two main components: the Game and the Logic.

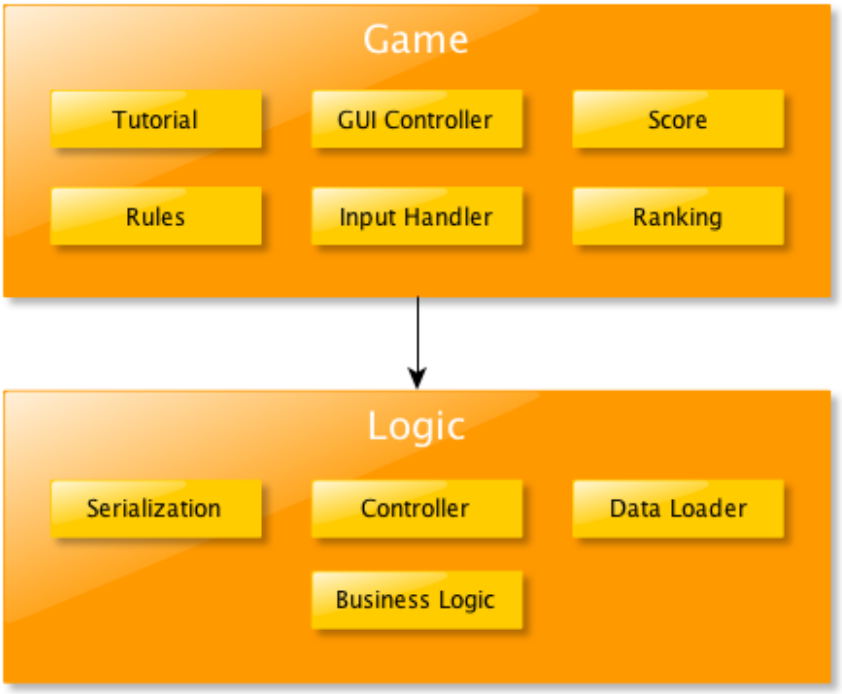

Figure 3.7: Game Design

The Game is responsible for all the components of the user interface, as well as some features non-related with the business logic, such as the Score or Ranking. Within we have 6 sub-components:

- GUI Controller: This component is responsible for the entire user interface. It manages all the different screens and the corresponding information. In order to manage screens he interacts and relies on the Input Handler component, described bellow, to receive the user inputs and apply changes based on that input. The displayed information in each screen is obtained through interaction with all the other components, in special with the Controller in the Logic component, which retrieves all the business information.
- Input Handler: As mentioned before, this component is responsible for handling all the players inputs. It detects inputs, interprets them and invokes the corresponding action or event on other components.
- Tutorial and Rules: As the name suggests, are responsible for the correspondent features. Each one controls the interaction of players in each feature, as well as the information that it presents. Both of them interact with the GUI Controller to display the information.
- Score: This component is responsible for the score feature. It keeps record of the actual score of the player, managing it based on the user progress in game.

- Ranking: This component is responsible for connecting to the server, upload the user score and download the actual ranking. It relies on the GUI Controller to display the ranking information and on the Score component to keep record of the score.

The Logic Component houses all the components responsible for the business logic and the game logic. It is composed by 5 sub-components:

- Controller: This component works as broker between Game and the Logic, which allowed some decoupling between the two components. Its major responsibility is to receive all the requests from Game component, interpret them and forward to one of the other 5 sub-components.
- Serialization: This is the component responsible for serialize the game state. Through this component it is possible to save & load the game state locally, allowing players to stop the game and continue at any time.

  It creates an XML file with the game state, which includes, not only but also, the state of each validated process, all the elements associations, and the score of the player.
- Data Loader: It is responsible to read all the information from the XML files, interpret it and load it to the Business Logic component, that will be responsible for maintaining the information and make it available for the game.
- Business Logic: This component is responsible for managing all the game logic and information, which is loaded by Data Loader and saved in a data structure to be used by the game (Figure 3.8). Its responsibilities include hold information, manage elements and its characteristics, such as trust rate and lock state, manage associations and validate them. This component is constantly interacting with the controller in order to provide information and to apply changes in game.

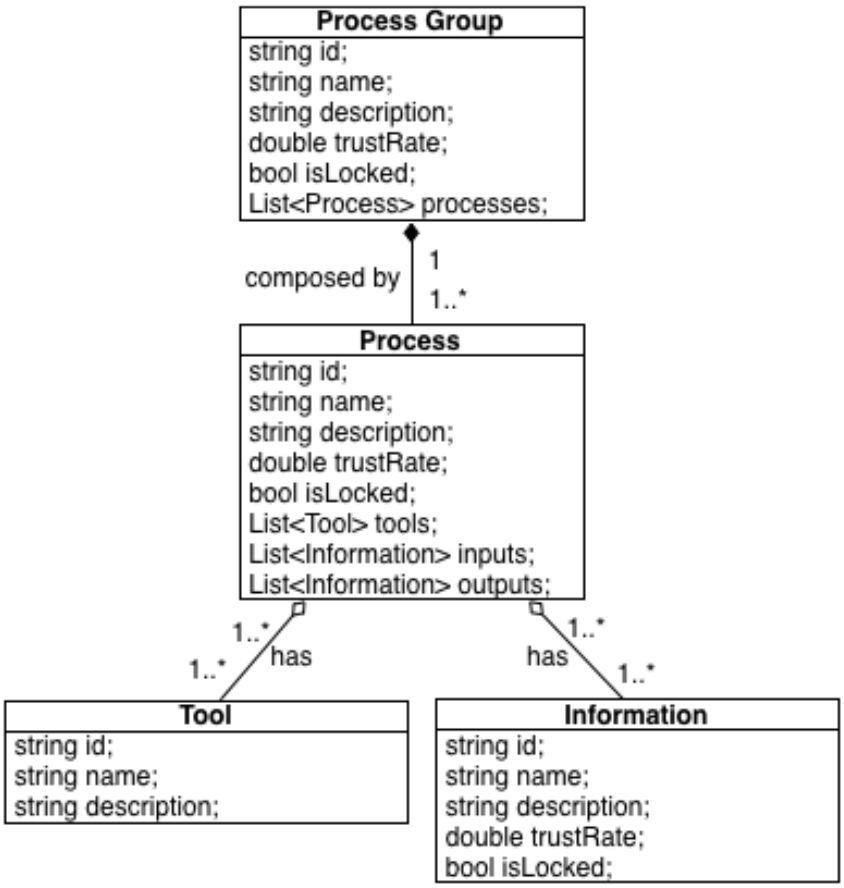

Figure 3.8: Class Diagram - Data Structure

One of the main features discussed in the Related Work chapter, regarding SimSE, was game customization and adaptability. As mentioned before, the main advantage of customization is the possibility of improving games quickly and easily based on constant feedback from players.

Since Project Management Standard is a constant growing and improving standard that evolves from the recognized good practices of project management practitioners it is constantly being updated. With this in mind, it was important to add some customization and adaptability to our game in order to keep its information updated without needing to do major changes in the game itself.

Our solution for this challenge was to keep all the game information apart from the game, allowing it to be the updated, added or removed at any time, without affect or need to update the game. To do this we used eXtensible Markup Language (XML) files as source of all the game domain knowledge. All the knowledge was structured in elements, which are related between each other by unique identifiers. In Figure 3.8 it is possible to see an example of a file. The game, when initializing, loads all the information from the XML file to a data structure displayed in Figure 3.8.

```
<?xml version="1.0" encoding="UTF-8"?>
<PMI>
    <informacoes>
        <informacao start="unlocked" id="0.0.1">
            <nome>Project Statement of Work</nome>
            <descricao>...</descricao>
        </informacao>

        <informacao start="unlocked" id="0.0.2">...</informacao>
    </informacoes>

    <ferramentas>
        <ferramenta id="t.1">
            <nome>Expert Judgment</nome>
            <descricao>...</descricao>
        </ferramenta>

        <ferramenta id="t.2">...</ferramenta>
    </ferramentas>

    <fases>
        <fase id="1" start="unlocked" next="2">
            <nome>Initiation</nome>
            <descricao>...</descricao>

            <processo id="1.1">
                <nome>Develop Project Charter</nome>
                <descricao>...</descricao>
                <ferramenta id="t.1"></ferramenta>
                <input id="0.0.1"></input>
                <output id="1.1.1"></output>
            </processo>

            <processo id="1.2">...</processo>

        </fase>

        <fase id="2" start="locked" previous="1" next="3">...</fase>
    </fases>
</PMI>
```

Figure 3.9: Game Information's XML File

Another important design decision in our game was the separation of the GUI and the Business Logic. By doing so we were able to keep low coupling between the two modules and avoid the ripple effect. This means that we are able to modify the business logic, improving some of its features or create new ones for instance, without needing to change the game.

3.5 User Interface

As discussed in [43], the design of a User Interface has a relevant role in applications usability, performance and engagement. A well-designed User Interface not only allows the improvement of productivity but can also influence the user satisfaction, capabilities and limitations towards the application.

”The best interface is one that is not notice, and the one that permits the user to focus on the information and task at hand instead of the mechanisms used to present the information and perform the task” [43].

In games, User Interface plays an important role since it can significantly influence player’s first impression of a game, and therefore, his motivation to play it. A well-designed game interface not only simplifies the gameplay but can also decrease the gameplay-learning phase.

To assure that our game had a strong, useful and appealing interface that is easy to use, user friendly and engaging, we decided to develop the game following a user centered design methodology.

While developing the game we frequently resorted to user experiments focused in gameplay and interface, where we allowed players to play and test it. During these tests we constantly questioned users and suggested new features or changes in order to obtain some feedback and new ideas regarding game’s present state and future features.

By following this methodology, we were able to build a user interface based in users needs and feedback and therefore, achieving what we believe to be a well design and user-friendly interface.

3.5.1 Game Screens

Tutorial Screen

The first screen that a player will encounter when initializes the game for the first time is the Tutorial screen (Figure 3.10).

The tutorial is presented as a slide show where players can navigate through using the mouse. As a tutorial with introductory content it was important to allow players to review it as many times as they needed. With this in mind we added a button in the main screen, described bellow, where players can access and re-play the tutorial.

As mentioned before, through this tutorial we expect to contextualize players to our game by reviewing some concepts of Project Management as well as explain the game purpose, its goals, interface and how it can be played.

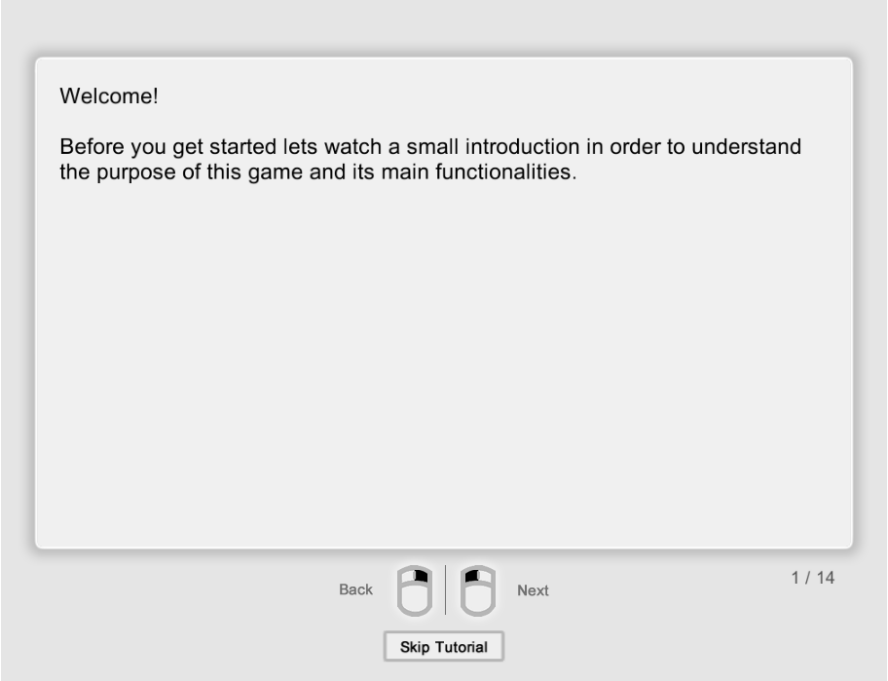

Figure 3.10: Tutorial

Rules Screen

Since our game is rather complex due to its rules, features and specificity, it was difficult to include all the relevant information in the tutorial otherwise it would become too wearisome for players. Our solution was to create a Rules screen that explores various topics of the game, explaining all the required information and the most important features (Figure 3.11). The navigation on this screen is very intuitive: players have a context menu on the left where they select one topic, which will fill the right section with its information.

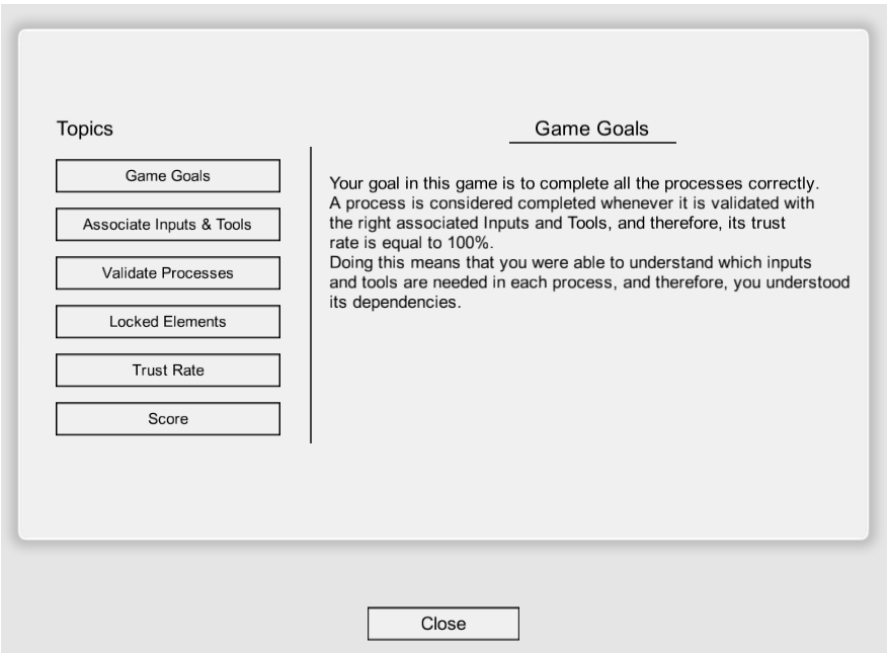

Figure 3.11: Rules Screen

Main Screen

After tutorial players are redirected to the Main Screen (Figure 3.3) where they have access to all information and features of the game.

The main screen is divided into three sections related by their content: Process Groups, Processes List and Process Information.

Besides these three sections, players also have on the top of the screen five buttons that allow them to navigate through different menus/options (from left to right):

- Options: This button opens a pop-up menu where players can save the game state, restart it or exit the game.
- Tutorial: This is the button that allows players to re-play the tutorial to review any information there.
- Rules: This button opens the Rules screen explained above.
- Diagram: This menu opens a screen with a diagram that has all the Process Groups, their processes and all its associated elements. The diagram is only built with information that was validated by the player while playing (Figure 3.6).
- Ranking: This menu opens a pop-up window with the current Top-10 ranking and the player score.

Still on the top of the screen players also have their current score and the game progress bar allowing them to easily control their progress and performance.

On the bottom of the screen we have one of the three sections mentioned above: list of Process Groups. In this section players can view each Process Group current state, name and how many processes of each group where validated. Selecting an unlocked Process Group will affect another section: the list of processes, on the left of the screen.

In this section, List of Processes, it is loaded the list of processes of the selected Process Group. In this list players are able to see each Process name, its state, its Trust Rate and, if the process has some problem, a hint regarding what to review.

Every time a player select a process on the List of Process, its information is loaded to the Process' Information section where players can view its description, view Hints, access the Associate screen of either Inputs and Tools and validate the process.

Both Inputs and Tools association screen are similar (Figure 3.12). They have two lists, the available and the associated items, where players are able to select them to associate or disassociate. To help players understand the role of each element they can view each item description by placing the mouse over it.

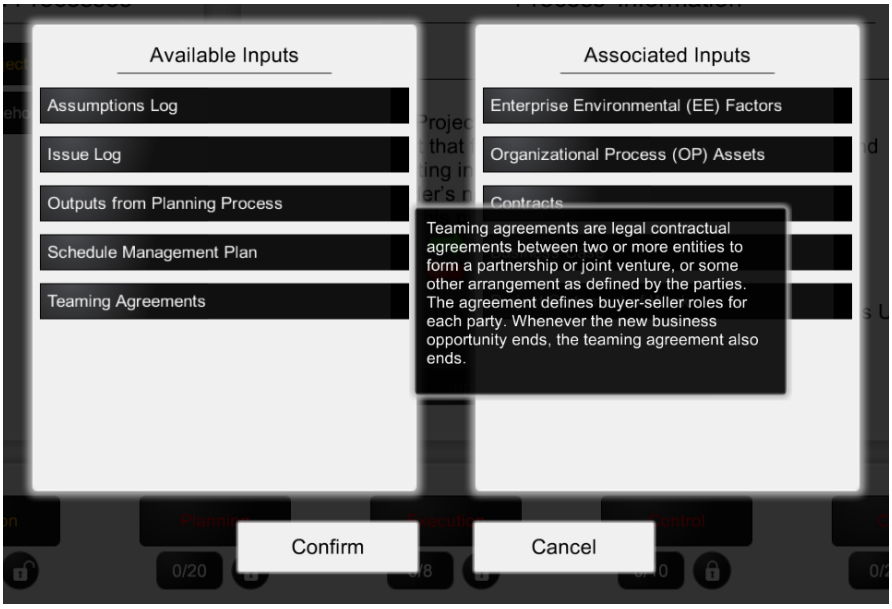

Figure 3.12: Associate Inputs Screen

When players select the Validate button it opens a new screen with the diagram of the process, similar to the diagram in Figure 3.6. There the player can review process associations and confirm its validation or cancel it.

After each validation, players will receive some feedback regarding its outcome. This feedback is presented as several pop-up windows, each one regarding different achievements such as process outputs released, new unlocked elements and actual state of processes and process groups.

Figure 3.13 is a representation of this messages.

Figure 3.13: Feedback messages

3.6 Summary

In this chapter I presented our serious game, which was developed to understand the impact of Game-Based Learning in Project Management Professional Certification.

Firstly we introduce our gameplay, where we explored what players should know before starting to play and how the game can be played and its objective.

Secondly we discussed some of the main features, some of them based in the conclusions obtained in the analysis of the related work. During this section we explained how each feature works and what we expect to be its impact in our game.

After presenting the features we changed our topic to User Interface. There we discussed our methodology used during user interface development, the reasons behind this decision and the final result, where we explore some game screens and their purposes.

Our final topic was Design & Implementation. In this topic we started by analyzing our game design and describe its components. After that we discussed some of the challenges faced during this phase and our solutions towards this challenges.

In the next chapter we will discuss our Evaluation as well as its results and conclusions.

4

Evaluation

Contents

4.1 Evaluation

To frame the discussion of this work's evaluation, let us first revisit the research questions on which our thesis is based, and which have driven the design of our evaluation plan.

The approach in this work has been focused on the design and implementation of a serious game, which is intended to be an auxiliary tool for PMP Certification students. As mentioned before, this serious game allows players to test and improve their knowledge regarding some of the concepts described in PMBoK Guide, a standard by PMI.

Through this approach we expected to explore some of the GBL challenges described in Chapter 1.3:

- Understand how to integrate games and learning processes,
- Understand when GBL should or shouldn't be used,
- Understand with whom GBL could be used,
- Understand why and how GBL could be effective in education.

Choosing PMP Certification as the subject of our thesis allowed us not only to explore some of these challenges presented above but also to take advantage of some characteristics of students with knowledge in this field.

By testing Game-Based Learning in such a specific context where users have already some predisposition and familiarization with technology and games, we were assured that they would be more willing and receptive to this research and tests. In doing so, we targeted the last two challenges: with whom GBL could be used and its benefits in education.

Although it is not the focus of this thesis, this decision, if proven correct, will support part of the results achieved by [5, 6], which state that specific groups of people, who are highly adept with technology are more propounded to accept this concepts.

With this in mind, our thesis focus on understanding if Game-Based Learning applied in an environment such as PMP Certification can increase the knowledge assimilation. It is also our purpose to test if a development of a game for such effect can be accepted by students as an auxiliary tool for study.

With our research questions outlined, the remaining of this chapter describes the evaluation methodology used to discover answers to our questions.

4.2 Knowledge Assimilation Tests

For our first experiment, our goal was to understand if through the use of our game, users where able to acquire and improve their knowledge regarding PMP Certification.

To assess this question we resorted to a pre-experimental design where we first selected a focus group based in characteristics that we considered important and relevant for our tests. We recruited a group of fifteen computer science students to participate in our experiment.

By selecting computer science students we were able to assure that they had enough background knowledge to understand the game and its contents, as well as some familiarization with technology and games. Another relevant characteristic of our selected users is their previous experience with Project Management, acquired in specific graduation course's classes, training or experience.

Our group was constituted by a majority of BSc students, Figure 4.1, with an average age of 24 years old, Figure 4.2.

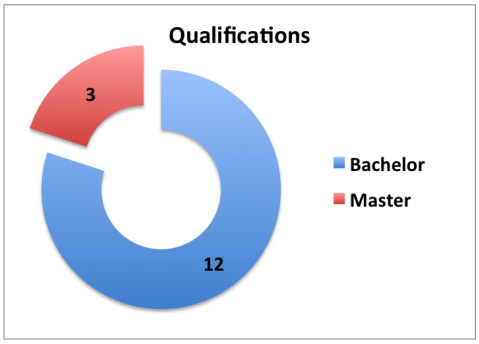

Figure 4.1: Users Qualifications

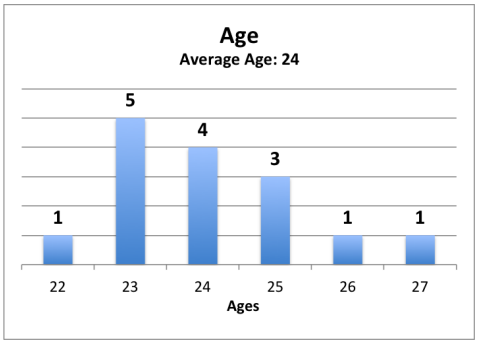

Figure 4.2: Users Age Distribution

The selected pre-experimental design for this experiment was the One-Group Pretest-Posttest Design, which consisted in a group of two tests, Pretests and Posttests, applied to one group before and after playing our game respectively.

Taking into account the small size of our sample, we considered that this experimental design was the most appropriate in opposition to others since it didn't had the need to separate the sample into smaller groups, such as control group and treatment group.

In order to better control our experiment and avoid as much as possible external influences, our experiment was conducted individually and in a sequencial manner: Briefing, Pretest, Treatment and Posttest.

In the briefing stage of the experiment, students were introduced to the game, its purpose, the experiment and its goals, followed up by the Pretest.

Our Pretests were designed to understand what our users knew before playing our game. The result of these tests was used later as a variable to measure the assimilated knowledge.

Our Posttests were similar to our Pretests, although their purpose was to test users knowledge after playing our game.

Through these tests, we were able to do a comparison between its results. This analysis allowed us to measure the knowledge assimilation of our focus group, which allowed us to conclude the impact of our game regarding knowledge assimilation.

In this experience, subjects first received an introduction to our research where we explained its purpose, what is the procedure of this experiment and how to play our game. Following this introduction they were submitted to our first test, where they answered to a random group of multiple-choice questions. After Pretest, they were allowed to explore and play our game freely followed by the second test, Posttest.

To assure that results were fair and valid, we selected, randomly, for each student a pair of Pretest

and Posttest with different questions. By doing so, we were assuring that results didn't improve because players searched for the correct answers when playing the game, but because the game had a real and positive impact in their knowledge. Both tests, used to do two different combinations of Pretest and Posttest can be found in Appendix B and Appendix C.

4.2.1 Results

As explained above, we selected for each user, randomly, a group of two tests: Group 1 and Group 2. The results of these tests, represented in Figure 4.3 and Figure 4.4, showed that in both Groups users improved their performance in almost every question.

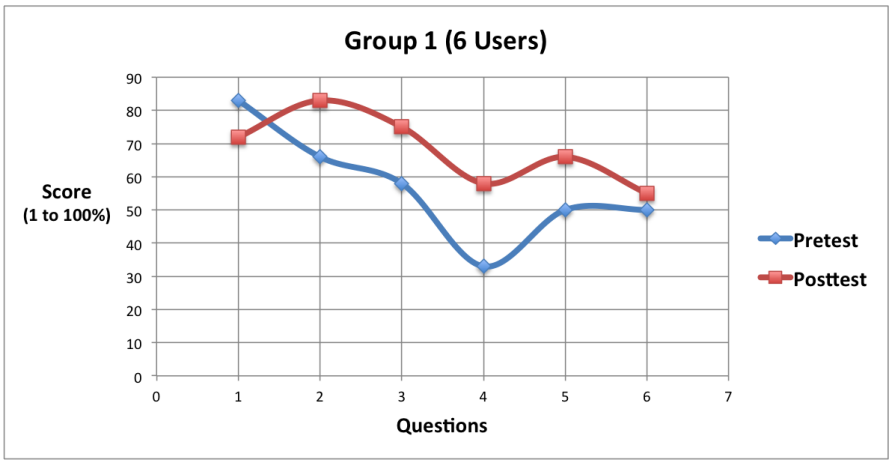

Figure 4.3: Group 1 Results

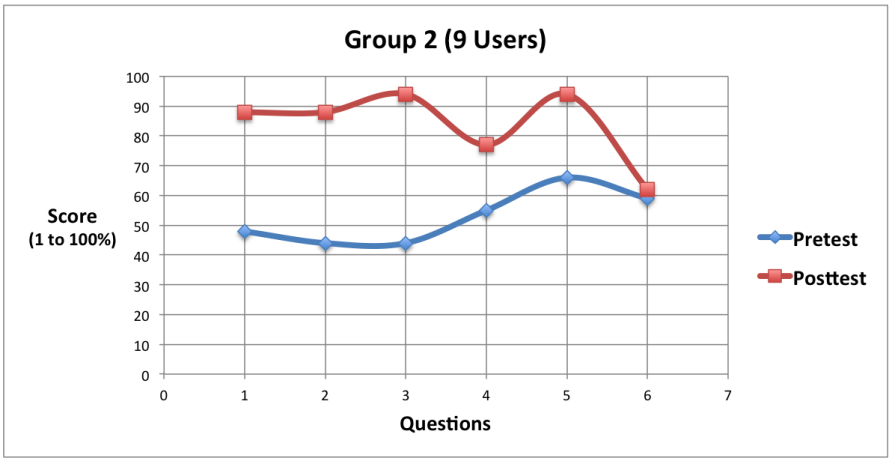

Figure 4.4: Group 2 Results

To validate our findings we resorted to statistical analysis to assure that our results were scientifically valid.

We started by interpreting our information with a descriptive analysis.

As we can see in Table 4.1, the Posttest results are significantly higher than the Pretest results, $Me_{Posttest} = 78.13 > Me_{Pretest} = 54.67$, with an overall difference of approximately 23%.

Descriptives

			Statistic	Std. Error
PreTest	Mean		54,666667	3,6288089
	95% Confidence Interval for Mean	Lower Bound	46,883646	
		Upper Bound	62,449688	
	5% Trimmed Mean		54,518519	
	Median		56,000000	
	Variance		197,524	
	Std. Deviation		14,0543164	
	Minimum		31,0000	
	Maximum		81,0000	
	Range		50,0000	
	Interquartile Range		22,0000	
	Skewness		-,036	,580
	Kurtosis		-,637	1,121
PostTest	Mean		78,133333	5,1398227
	95% Confidence Interval for Mean	Lower Bound	67,109510	
		Upper Bound	89,157157	
	5% Trimmed Mean		79,703704	
	Median		81,000000	
	Variance		396,267	
	Std. Deviation		19,9064479	
	Minimum		28,0000	
	Maximum		100,0000	
	Range		72,0000	
	Interquartile Range		25,0000	
	Skewness		-1,370	,580
	Kurtosis		1,796	1,121

Table 4.1: Descriptive Analysis Results

After the descriptive analysis we used the non-parametric Wilcoxon Signed-Rank Unilateral Test, Figure 4.2, to prove that the result of both tests differ and validate our findings.

We decided to use this test because our sample was small, 15 elements, and characterized as paired samples where the normal distribution couldn't be verified in both measures.

The statistical analysis was performed using the SPSS Statistics software with α=0.05 and our hypothesis being H_0: $F(X_{Pretest}) \geq F(X_{Posttest})$, Pretest scores higher or equal to Posttest scores, and H_1: $F(X_{Pretest}) < F(X_{Posttest})$, Posttest scores higher than Pretest scores.

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
PostTest - PreTest	Negative Ranks	2[a]	3,25	6,50
	Positive Ranks	13[b]	8,73	113,50
	Ties	0[c]		
	Total	15		

a. PostTest < PreTest

b. PostTest > PreTest

c. PostTest = PreTest

Test Statistics[a]

	PostTest - PreTest
Z	-3,041049[b]
Asymp. Sig. (2-tailed)	,002357553
Exact Sig. (2-tailed)	,000915527
Exact Sig. (1-tailed)	,000457764
Point Probability	,000061035

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Table 4.2: Wilcoxon Signed-Rank Unilateral Test Results

Our results show a p-value = 0.00045 $<\alpha$ = 0.05, therefore we have evidences to reject our null hypothesis and concluded that the scores, measured in a scale from 0 to 100%, from the Posttest (Me=78.13) are higher then the scores of Pretest (Me=54.67), which means that the students that participated in our experiment were able to retain more knowledge after playing our game.

Based on these results, we were able to conclude that Game-Based Learning applied to PMP Certification can influence positively the knowledge assimilation.

Although we had such positive results in these tests, we believe that in order to assure these results we need to do more tests, this time with PMP certification students. By doing so, we would be able to re-validate more reliable results.

4.3 Questionnaire

In order to assess our second research question, if a serious game can be accepted and used by students as an auxiliary tool for their studying, we submitted our users to a questionnaire.

This questionnaire was presented after completion of the previous experiment and focused in understanding four topics:

- If the serious game is, and how it is accepted by users,
- If the serious game is adequate to its theme: PMP,

- If the game mechanics is adequate to its targeted users,
- And what could be improved.

For the first two topics we have a group of multiple-choice questions where users give feedback regarding whether the game is interesting, adequate to its context, formative and motivating. At the end of this group, we also have an opened-answer question where we ask for their opinion regarding the impact of the game in PMP Certification.

To address the last two topics we had the same type of approach, multiple choice and opened-answer questions where we pursuit to understand if the game mechanics and interface were adequate and what could be improved. To do that we asked how users feel about its intuitiveness, how easy it was to use and interact with the game interface and how attractive it was.

To close the questionnaire we questioned users about a possible feature in our game: an opportunity to experience each of the most relevant processes of Project Management in a 3D simulation.

Although this feature wasn't developed in our game due to deadlines, it was considered initially to our project due to its possible advantages. By simulating and playing a specific process, users would have the possibility of not only studying the theoretical concepts, but also to experience what really happens in those processes. When questioning users about this feature we expected to understand how viable this feature might be and how would players accept it. The questionnaire can be found in Appendix A.

4.3.1 Results

As mentioned before, our users had already some familiarization and predisposition to games and technology, which, besides relevant to our study, may have also been determinant for our results.

With this in mind, users response to our research was positive, they considered the concept Game-Based Learning interesting and stated that the use of games for educational purposes would affect their study by increasing their motivation while introducing a funnier and simple way of learning complex topics.

Users overall satisfaction towards our game was positive. They considered the game interesting (94%), easy to adapt to (80%) and formative (100%). When asked about how motivating the game was, only 73% considered the game motivating.

These results demonstrate that although users enjoyed the experience with our game, they considered it too complex, long and static, which affected our results regarding motivation.

To reinforce our results, we questioned users about their opinion regarding the impact of the game in a more realistic or practical environment, such as the certification.

In general, users considered that the game would have a good impact because "it allows us to study in a non-traditional and less boring way", and "the usage of such games, in special games with a competitive component, works, most of the time, as a motivational factor to study and practice".

Also,"the game would have a positive impact in learning because it would help us to understand and learn such a complex topic quicker".

As mentioned before, in the second part of our questionnaire we tried understand how users feel about the game, its interface and its mechanics. The results were favourable to, with users considering the game and its interface very organized (100%), attractive (86%) and intuitive to play with (93%).

Regarding some of the features of our game, users considered the diagrams perceptible (100%), the game feedback messages enlightening (93%) and the hint system useful (97%).

These results demonstrate that our game was adequate for our users and the its context. Still, as expected, some users suggested some improvements.

The first suggestion was about our hint system, which ”should be more helpful after validating a process”. It was also suggested that the tutorial, while necessary, is too long and has too much information/text, and therefore should be revised. Users also considered that our game lacks of stimulus such as animations and sounds.

In conclusion, we can infer that users accepted our game and consider it as a useful auxiliary tool for their study, and by doing so, we validate our last research question.

4.4 Summary

In this chapter I presented the evaluation of our work.

We started by reviewing the research questions on which our thesis is based.

After that, we introduced our evaluation methodology where I described both phases and their purpose. First, I presented the knowledge assimilation tests, where I described the users who were submitted to our tests, how the tests were performed and finally its results.

To finish our evaluation, I presented the questionnaire and its results.

In the next chapter we will conclude our work as well as discuss the future work.

5

Conclusions and Future Work

Contents

5.1 Conclusions

This thesis focused on the impact and benefits of Game-Based Learning when applied in a specific context. Since this concept can be applied to almost any context, we started by selecting one where we believed we could yield some advantages of its characteristics: Project Management Professional Certification.

As explained in Chapter 4.1, focusing in PMP Certification allowed us to assure that users would be more receptive to this research due to their familiarization and predisposition towards technology and games. With this decision we addressed a topic presented in Chapter 1.3, where we concluded that one of the challenges faced by Game-Based Learning was to understand with whom it could be used.

With this in mind, the main goal of this thesis was to verify if the use of Game-Based Learning in PMP Certification could be beneficial, that is, if the use of a serious game in this context could improve the knowledge assimilation and if students could easily accept/adopt it as an auxiliary tool for their study.

To verify this hypothesis, we developed a serious game where users could test their knowledge regarding some of the concepts described in ”A Guide to Project Management Body of Knowledge” (PMBoK Guide) [28].

In this game, explained in more detail in Chapter 3.2, users are able to play with the existing relations and dependencies between different elements of Project Management, according to PMBoK Guide.

Throughout the game, players start by selecting processes from process groups and associate elements to them. After that players can validate the process in order to understand which associated elements are correct or incorrect and unlock new elements.

With this mechanics and the feedback given by the game as the player validates more and more processes, we expect players to acquire or test their knowledge regarding some the concepts in this exercise. In the end, players should have a better understanding regarding which elements each process needs, why they need them and what is the result and purpose of each process.

To evaluate our hypothesis and our serious game, we submitted users to a group of tests that allowed us to measure their evolution regarding knowledge acquisition and to understand what they think about our game, its interface and its gameplay.

As explained in Chapter 4.1, our tests were divided into two phases, the pretest, before playing our game, and the posttest, after playing our game. Through this approach we were able to compare results of both tests, which allowed us to understand if players acquired knowledge by playing our game.

Since our thesis is focused in such a specific context, PMP Certification, we needed to perform tests with users that should have, at least, some experience or introductory knowledge regarding project management. With such a specific requirement and due to thesis deadline, we weren’t able to do as many tests as we wanted to assert, without doubts, that Game-Based Learning, when applied

to PMP Certification, can increase the knowledge assimilation.

Based in the fifteen tests that we were able to perform with users, we concluded that through the use of our serious game, students performance in the Posttest improved by 23% when compared to Pretest, which means that there is a positive tendency regarding knowledge acquisition and therefore, we were able to verify our main hypothesis, that is, GBL applied to PMP Certification can increase the knowledge assimilation.

Besides the Pretest and Posttest, users were also submitted to a Questionnaire that focus in our second research question, if a serious game can be accepted and used by students as an auxiliary tool for their studying.

Based on the results of the Questionnaire, discussed in Chapter 4.3, we can conclude that users considered our game interesting, motivating, educational and suitable to their needs. Also, when queried about game's easy of use; they considered the game intuitive, "well organized and structured", enlightening and a "good and useful auxiliary tool" to test their knowledge.

With this in mind, we can conclude that our second research question was also verified: users believe that our game can be useful to their study as an auxiliary tool.

5.2 Future Work

As mentioned before, during the initiation of our thesis it was considered the development of a complex feature that would allow players to play a simulation of some of the processes addressed in our game. Since we didn't had the time to developed such feature in our game, and based in the positive feedback of users regarding this feature, it should be considered as part of the future work.

Besides this feature, we should also consider some improvements in our game, suggested by users, that we believe that would have a positive impact in game's motivational and engaging factor. Some of the improvements include, for instance, the hints system, which could be more helpful, and more animations and visual feedback to improve the interface.

As part of the future work, we should also consider to validate our game with experts to assure that we are using all the information correctly, as well as to improve or add new information that, while not contemplated in PMBoK, may be relevant and based in their experience.

Further suggestions on future work may also include more tests with a larger audience, preferently with students of the Project Management Professional certification, in order to re-validate the findings of this work as well as to obtain a more reliable conclusion

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A

Questionnaire

Avaliação: Game-Based Learning Applied to Project Management Professional Certification

Desde já obrigado pelo seu tempo.
Este questionário encontra-se no âmbito da tese de mestrado Game-Based Learning Applied to Project Management Professional Certification e tem como objectivo obter alguma informação dos utilizadores sobre o jogo desenvolvido.
O questionário é anónimo e o tempo necessário para o preencher é de aproximadamente 5 minutos.

*Obrigatório

Informação Pessoal

1. **Idade** *

   .....

2. **Género** *
   Marcar apenas uma oval.

   - ◯ Feminino
   - ◯ Masculino

3. **Habilitações Literárias (concluídas)** *
   Marcar apenas uma oval.

   - ◯ Bacharelato
   - ◯ Licenciatura
   - ◯ Mestrado
   - ◯ Doutoramento

4. **Experiência na área de gestão de projectos** *
   Marcar apenas uma oval.

   - ◯ Sim
   - ◯ Não

Avaliação do jogo

5. **Numa escala de 1 a 4, sendo 1 muito mau e 4 muito bom, como classificaria o jogo, em geral?** *
   Marcar apenas uma oval.

	1	2	3	4	
Muito Mau	◯	◯	◯	◯	Muito Bom

6. **Comentários**
   Caso resposta seja inferior a 3, qual o motivo?

   .....

   .....

   .....

   .....

   .....

7. **Numa escala de 1 a 4, sendo 1 pouco interessante e 4 muito interessante, como classificaria o jogo?** *
   Marcar apenas uma oval.

	1	2	3	4	
Pouco Interessante	◯	◯	◯	◯	Muito Interessante

8. **Comentários**
   Caso resposta seja inferior a 3, qual o motivo?

   .....

   .....

   .....

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   .....

9. **Numa escala de 1 a 4, sendo 1 muito difícil e 4 muito fácil, como classificaria a adaptação ao jogo?** *
   Marcar apenas uma oval.

	1	2	3	4	
Muito Difícil	◯	◯	◯	◯	Muito Fácil

10. **Comentários**
    Caso resposta seja inferior a 3, qual o motivo?

    .....

    .....

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    .....

    .....

11. **Numa escala de 1 a 4, sendo 1 muito difícil e 4 muito fácil, como classificaria a facilidade de utilização do jogo? ***
Marcar apenas uma oval.

	1	2	3	4	
Muito Difícil	◯	◯	◯	◯	Muito Fácil

12. **Comentários**
Caso resposta seja inferior a 3, qual o motivo?

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13. **Numa escala de 1 a 4, sendo 1 nada formativo e 4 muito formativo, como classificaria o jogo? ***
Marcar apenas uma oval.

	1	2	3	4	
Nada Formativo	◯	◯	◯	◯	Muito Formativo

14. **Comentários**
Caso resposta seja inferior a 3, qual o motivo?

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15. **Numa escala de 1 a 4, sendo 1 nada motivante e 4 muito motivante, como classificaria o jogo? ***
Marcar apenas uma oval.

	1	2	3	4	
Nada Motivante	◯	◯	◯	◯	Muito Motivante

16. **Comentários**

Avaliação da interface

17. **Numa escala de 1 a 4, sendo 1 nada atrativo e 4 muito atrativo, como classificaria a interface do jogo?** *

Marcar apenas uma oval.

	1	2	3	4	
Nada Atrativo	◯	◯	◯	◯	Muito Atrativo

18. **Comentários**

19. **Numa escala de 1 a 4, sendo 1 nada intuitivo e 4 muito intuitivo, como classificaria a interface do jogo?** *

Marcar apenas uma oval.

	1	2	3	4	
Nada Intuitivo	◯	◯	◯	◯	Muito Intuitivo

20. **Comentários**

21. **Numa escala de 1 a 4, sendo 1 nada organizado e 4 muito organizado, como classificaria a organização da informação do jogo?** *

Marcar apenas uma oval.

	1	2	3	4	
Nada Organizado	◯	◯	◯	◯	Muito Organizado

22. **Comentários**

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23. **Numa escala de 1 a 4, sendo 1 pouco perceptível e 4 muito perceptível, como classificaria o diagrama geral dos processos no jogo?** *

Marcar apenas uma oval.

	1	2	3	4	
Nada Perceptível	◯	◯	◯	◯	Muito Perceptível

24. **Comentários**

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25. **Numa escala de 1 a 4, sendo 1 nada esclarecedor e 4 muito esclarecedor, como classificaria as mensagens que surgem ao longo do jogo?** *

Marcar apenas uma oval.

	1	2	3	4	
Nada Esclarecedor	◯	◯	◯	◯	Muito Esclarecedor

26. **Comentários**

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27. **Numa escala de 1 a 4, sendo 1 nada útil e 4 muito útil, como classificaria o sistema de ajuda do jogo? (Tutorial, Regras, Hints)** *
Marcar apenas uma oval.

	1	2	3	4	
Nada Útil	◯	◯	◯	◯	Muito Útil

28. **Comentários**
Caso resposta seja inferior a 3, qual o motivo?

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Outras

29. **Aspectos negativos do jogo?**

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30. **Aspectos positivos do jogo?**

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31. **Achou o jogo motivante? Porquê?**

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32. **Aspectos a melhorar no jogo?**

33. **Na sua opinião, a oportunidade de jogar/simular alguns dos processos mais relevantes num ambiente 3D, controlado pelo utilizador, iria trazer vantagens? Se sim, quais?** *

34. **Quando aplicado num ambiente mais profissional como no processo de certificação PMP, na sua opinião qual é que acha que seria o impacto do jogo?** *

35. **Outras observações?**

B

Knowledge Assimilation Test A

Avaliação: Game Based Learning Applied to Project Management Professional Certification

Desde já obrigado pelo seu tempo.
Este questionário encontra-se no âmbito da tese de mestrado Game-Based Learning Applied to Project Management Professional Certification e tem como objectivo permitir medir os ganhos de conhecimento após a utilização do jogo.
O questionário é anónimo e o tempo necessário para o preencher é de aproximadamente 10 minutos.

*Obrigatório

Informação Pessoal

1. **Idade** *

   .....

2. **Género** *
   Marcar apenas uma oval.

   - ◯ Feminino
   - ◯ Masculino

3. **Habilitações Literárias (concluídas)** *
   Marcar apenas uma oval.

   - ◯ Bacharelato
   - ◯ Licenciatura
   - ◯ Mestrado
   - ◯ Doutoramento

4. **Experiência na área de gestão de projectos**
   Marcar apenas uma oval.

   - ◯ Sim
   - ◯ Não

5. **É certificado pelo Project Management Institute como Project Management Professional?**
   Marcar apenas uma oval.

   - ◯ Sim
   - ◯ Não

Avaliação

6. **"Develop Project Charter is the process of developing a document that formally authorizes a project or a phase and documenting initial requirements that satisfy the stakeholder's needs and expectations." Com base nesta informação, qual ou quais dos seguintes Inputs pertencem a este processo?**
   Marcar tudo o que for aplicável.

   - [ ] Project Statement of Work
   - [ ] Stakeholder Register
   - [ ] Contracts
   - [ ] Organizational Process (OP) Assets

7. **Tendo em conta o processo referido na alinha anterior, Develop Project Charter, qual ou quais das seguintes Técnicas ou Ferramentas podem ser aplicadas no processo?**
   Marcar tudo o que for aplicável.

   - [ ] Stakeholder Analysis
   - [ ] Interviews
   - [ ] Questionnaires and Surveys
   - [ ] Expert Judgment

8. **"Develop Project Management Plan is the process of documenting the actions necessary to define, prepare, integrate, and coordinate all subsidiary plans." Tendo em conta a lista que se segue, selecione o ou os possíveis Inputs deste processo.**
   Marcar tudo o que for aplicável.

   - [ ] Project Charter
   - [ ] Business Case
   - [ ] Project Statement of Work
   - [ ] Organizational Process (OP) Assets

9. **"Define Scope is the process of developing a detailed description of the project and product. The preparation of a detailed project scope statement is critical to project success and builds upon the major deliverables, assumptions, and constraints that are documented during project initiation." Selecione da seguinte lista os possíveis Inputs do processo Define Scope.**
   Marcar tudo o que for aplicável.

   - [ ] Requirements Documentation
   - [ ] Business Case
   - [ ] Project Scope Statement
   - [ ] Project Charter

10. **"Estimate Activity Resources is the process of estimating the type and quantities of material, people, equipment, or supplies required to perform each activity." Qual, ou quais, das seguintes técnicas e ferramentas as que melhor se adequam a este processo?**
    Marcar tudo o que for aplicável.

    - [ ] Expert Judgment
    - [ ] Interviews
    - [ ] Alternative Analysis
    - [ ] Published Estimating Data

11. **"Develop Schedule is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule." Quais os inputs deste processo?**

Marcar tudo o que for aplicável.

- [ ] Project Schedule
- [ ] Activity Resource Requirements
- [ ] Enterprise Environmental (EE) Factors
- [ ] Activity Duration Estimates

C

Knowledge Assimilation Test B

Avaliação: Game Based Learning Applied to Project Management Professional Certification

Desde já obrigado pelo seu tempo.
Este questionário encontra-se no âmbito da tese de mestrado Game-Based Learning Applied to Project Management Professional Certification e tem como objectivo permitir medir os ganhos de conhecimento após a utilização do jogo.
O questionário é anónimo e o tempo necessário para o preencher é de aproximadamente 10 minutos.

*Obrigatório

Informação Pessoal

1. **Idade** *

   .....

2. **Género** *
   Marcar apenas uma oval.

   - ◯ Feminino
   - ◯ Masculino

3. **Habilitações Literárias (concluídas)** *
   Marcar apenas uma oval.

   - ◯ Bacharelato
   - ◯ Licenciatura
   - ◯ Mestrado
   - ◯ Doutoramento

4. **Experiência na área de gestão de projectos**
   Marcar apenas uma oval.

   - ◯ Sim
   - ◯ Não

5. **É certificado pelo Project Management Institute como Project Management Professional?**
   Marcar apenas uma oval.

   - ◯ Sim
   - ◯ Não

Avaliação

6. **"The Initiating Process Group consists of those processes performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase." Tendo em conta esta informação, qual ou quais dos seguintes processos pertencem a este grupo: Iniciação.**
   Marcar tudo o que for aplicável.

   - [ ] Develop Project Charter
   - [ ] Collect Requirements
   - [ ] Define Scope
   - [ ] Identify Stakeholders

7. **"Identify Stakeholders is the process of identifying all people or organizations impacted by the project, and documenting relevant information regarding their interests, involvement, and impact on project success." Tendo em conta a lista que se segue, selecione o ou os possíveis Inputs deste processo.**
   Marcar tudo o que for aplicável.

   - [ ] Project Charter
   - [ ] Procurement Documents
   - [ ] Stakeholder Register
   - [ ] Requirements Documentation

8. **Tendo em conta o processo referido na alinha anterior, Identify Stakeholders, qual ou quais das seguintes Técnicas ou Ferramentas podem ser aplicadas no processo?**
   Marcar tudo o que for aplicável.

   - [ ] Expert Judgment
   - [ ] Interviews
   - [ ] Stakeholder Analysis
   - [ ] Observations

9. **"Collect Requirements is the process of defining and documenting stakeholders' needs to meet the project objectives." Tendo em conta a lista que se segue, selecione o ou os possíveis Inputs deste processo.**
   Marcar tudo o que for aplicável.

   - [ ] Project Charter
   - [ ] Requirements Documentation
   - [ ] Stakeholder Register
   - [ ] Requirements Traceability Matrix

10. **"Create Work Breakdown Structure (WBS) is the process of subdividing project deliverables and project work into smaller, more manageable components." Selecione da seguinte lista os possíveis Inputs do processo Create WBS.**
    Marcar tudo o que for aplicável.

    - [ ] WBS Dictionary
    - [ ] Organizational Process (OP) Assets
    - [ ] Scope Baseline
    - [ ] Project Scope Statement

11. **"Estimate Activity Resources is the process of estimating the type and quantities of material, people, equipment, or supplies required to perform each activity." Qual, ou quais, das seguintes técnicas e ferramentas as que melhor se adequam a este processo?**
Marcar tudo o que for aplicável.

- [ ] Expert Judgment
- [ ] Interviews
- [ ] Alternative Analysis
- [ ] Published Estimating Data