UNIVERSITY OF SALERNO

DEPARTMENT OF COMPUTER SCIENCE

Master Degree in Computer Science

Curriculum of Software Engineering and IT Management

SERGE — Serious Game for the Education of Risk Management in Software Project Management

SUPERVISOR

Prof. **Filomena Ferrucci**

CO-SUPERVISOR

Prof. **Fabio Palomba**

Dott. **Stefano Lambiase**

CANDIDATE

Giusy Annunziata

Mat. : 0522501051

Academic Year 2021/2022

This thesis work testifies to the end of a long journey,
which has shaped me significantly, especially on a personal level.
I dedicate this thesis work to ***myself****.*
To remind me what I can do to achieve my goals,
and to remind myself never to give up.

Questo lavoro di tesi testimonia la fine di un lungo percorso,
che mi ha formata molto, soprattutto a livello personale.
*Dedico questo lavoro di tesi a **me**, per ricordarmi ogni giorno*
cosa sono capace di fare per raggiungere i miei obiettivi
e ricordare a me stessa di non arrendermi mai.

CONTENTS

Abstract

In the field of software project management, one of the most important process is risk management. It consists of the set of methods and practices that allow project managers to properly handle risks arising during software lifecycle and take the most appropriate mitigation actions. Teaching risk management is of the utmost importance to ensure that future generations of project managers are able to apply it when they will manage software projects. In state of the art in teaching other knowledge areas of management, *Serious Games*—i.e., games designed for the primary purpose of teaching through entertainment—stood out. Such types of games mix both game theory—that serves for pure entertainment—and simulation approaches—used mainly to develop personal skills—to increase the interaction among learners while simulating real-case scenarios. While some previous efforts have been devoted to the definition of serious games to teach various PMBOK's knowledge areas, risk management is still one of the least practiced. Nevertheless, performing incorrect risk management leads to complications and catastrophic impacts on a project. Moreover, state of the art demonstrated that bad risk management cause project failure in 75% of the cases. For such a reason, there is a clear need to have a better teaching methodology, taking advantage of a more interactive environment where students and future project managers can apply—through simulation—the concepts that they learned about risk management. In this thesis, we propose the development and assessment of SERGE—a Serious Game focused on the Risk Management knowledge area defined by PMBOK—, which aims to increase the skills of project managers related to the application of this area. SERGE applies the concept of "Gamification", turning a context of reality, such as risk management in our case, into play and simulation. Starting from a literature analysis on risk management and serious games, we devise a novel methodology to teach risk management. This thesis work aims to realize the methodology behind SERGE, drawing information from a literature review and continuous iteration between the implementation of the method and the testing of its effectiveness. Finally, this method was tested with a validation study—exploiting a controlled experiment method—in a real-world context to ascertain its effectiveness. Through the use of established comparison methodologies (Planning Poker), players are able to compare, listen to and understand different opinions on the nature of risks and how to address and prevent them. Based on the information they learn, they develop their strategy for resource acquisition and project implementation, always taking into account the possible risks and events that lead to the realization of one of them. Concerning the state of the art, we implement SERGE to focus on handling risks in agile software development, which appears to be the most widely used development methodology in the working environment. The results show that after using SERGE, the risk management skills of the participants are more developed than those of the students who did not participate.

Abstract

Nella gestione dei progetti software, uno dei processi più importanti è quello legato alla gestione dei rischi. Si tratta di un insieme di metodi e pratiche che consentono ai Project Manager di gestire correttamente i rischi che si presentano durante il ciclo di vita del software. L'insegnamento della gestione dei rischi è della massima importanza affinchè le future generazioni di Project Manager siano in grado di gestire i progetti software. Nello stato dell'arte dell'insegnamento di altre aree di conoscenza del management, spiccano i *Serious Game*. Questi tipi di giochi mescolano sia la teoria dei giochi—realizza un clima di puro intrattenimento—sia gli approcci di simulazione—usati principalmente per sviluppare le abilità personali e aumentare l'interazione tra gli studenti simulando scenari reali. Mentre alcuni sforzi precedenti sono stati dedicati alla realizzazione di Serious Games per insegnare varie aree di conoscenza del PMBOK, la gestione del rischio è ancora una delle aree meno praticate. Tuttavia, l'esecuzione di una gestione del rischio non corretta porta a complicazioni e impatti catastrofici nei progetti. Inoltre, lo stato dell'arte ha dimostrato che una cattiva gestione del rischio causa il fallimento del progetto nel 75 per cento dei casi. È evidente la necessità di un migliore metodo di insegnamento, che sfrutti un ambiente più interattivo in cui gli studenti e i futuri project manager possano applicare—attraverso la simulazione—i concetti appresi. In questa tesi, proponiamo lo sviluppo e la validazione di SERGE, un Serious Game incentrato sull'area di conoscenza del Risk Management definita dal PMBOK, che mira ad aumentare le competenze dei project manager relative all'applicazione di quest'area. SERGE applica il concetto di "Gamification"e simulazione, per trasformare un contesto reale in gioco. Questo lavoro di tesi mira a realizzare la struttura alla base di SERGE, partendo da un'analisi della letteratura sulla gestione del rischio e sui Serious Games e procedendo con un iterazione tra la definizione del design di SERGE e la verifica della sua efficacia, tramite pilot test. Infine, il metodo è stato testato con uno studio di validazione—sfruttando il metodo dell'esperimento controllato—in un contesto reale per verificarne l'efficacia. Attraverso l'uso di metodologie di confronto consolidate (come il Planning Poker), i giocatori sono in grado di confrontare, ascoltare e comprendere diverse opinioni sulla natura dei rischi e su come affrontarli e prevenirli. Sulla base delle informazioni apprese, sviluppano la loro strategia per l'acquisizione delle risorse per la realizzazzione del progetto, e per mitigare i possibili rischi, tenendo in considerazione gli eventi che portano alla realizzazione di essi. Per differenziarci dai lavori presenri nello stato dell'arte, abbiamo implementato SERGE per concentrarci sulla gestione dei rischi applicata nei progetti sviluppati con una metodologia Agile, che sembra essere la metodologia di sviluppo più diffusa nell'ambiente di lavoro. I risultati ottenuti mostrano che dopo l'utilizzo di SERGE, le competenze relative al risk management dei partecipanti, risultano essere più sviluppate rispetto agli studenti che non vi hanno preso parte, testimoniando così l'efficacia del Serious Game SERGE.

CHAPTER 1

INTRODUCTION

1.1 Motivations and Objectives

In the field of software engineering, one of the most important and impactful aspects is software project management. Good software management contributes to a higher probability of success in project development. However, to best conduct software project management, it is also necessary to best conduct risk management, one of the most essential and delicate practices of software project management. It consists of a set of methods and practices that enable project managers to correctly manage the risks during the software life cycle and take the most appropriate mitigation actions. Unfortunately, this practice is not widely used today, especially considering that the business world is abandoning traditional development models and focusing on Agile ones. Given the very definition of the Agile model, we can deduce that documentation and similar practices requiring much of it are being neglected. Nevertheless, sound risk management can lead to project success. Hence a particular need to train Project Managers and Scum Masters who can better manage the risks that can arise during software project development.

To support the traditional teaching method relating to Software Project Management practices, the state of the art presents Serious Games. These tools integrate Gamification practices—the use of game elements within a real context—and simulation—the reproduction of a real context in a protected manner. Such Serious Games aim to teach knowledge by exploiting games' immersive and fun environment. Using Serious Games mixes both game theory, which is used for pure entertainment, and simulation approaches mainly used to develop personal skills and increase interaction between students by simulating real scenarios. There are many Serious Games in the literature, particularly for areas related to software project management. However, even among

them, we see that the knowledge area of Risk Management is one of the least covered. However, risk management is one of the most important activities to be carried out when managing a software project, as incorrect risk management leads to complications and catastrophic impacts on a project. Moreover, the literature shows that poor risk management causes project failure in 75% of cases.

For this reason, there is a clear need for a better teaching methodology that exploits a more interactive environment in which students and future Project Managers, or Scum Master, can apply—through simulation—the concepts learned about risk management.

1.2 Research Method and Results

In this thesis, we propose the development and evaluation of SERGE, a Serious Game focused on the Risk Management knowledge area defined by the PMBOK, which aims to support the teaching of risk management by increasing the skills of project managers related to the application of this area. SERGE applies the concept of "Gamification", transforming a context of reality, such as risk management in our case, into a game and simulation, going to reproduce a real context related to the management of a software project, providing a scenario and a project to manage.

The training objectives that SERGE sets itself are based on (1) Developing skills related to risk analysis; (2) Developing strategic skills to prevent and mitigate risks; (3) Simulating project management to consolidate the acquired skills; (4) Acquiring skills that can also be applied in a real-life context and not only in an academic context. To realize SERGE, a literature review was conducted based on software project management, especially risk management, and understanding its various methods and applications. Subsequently, a study was conducted on Education and Serious Games in the literature to understand the mechanics and especially the problems present.

The literature survey results extrapolated the characteristics for realizing the SERGE structure. The realized version is not the final one but was achieved utilizing a Simil Iterative Usability Testing process, in which, to refine the original version of SERGE, different "pilot tests" were conducted. The feedback obtained from the pilot tests made it possible to improve the game mechanics and structure of SERGE until a final version was obtained. SERGE fulfills its training objectives by exploiting three game phases: in the first, through an established comparison methodology (such as Planning Poker), players can compare, listen to and understand different opinions on the nature of risks and how to deal with and prevent them. In the second, based on the information learned, they develop their strategy for resource acquisition and project implementation, always taking into account the possible risks and events leading to the realization of one of them. In the third, they put themselves into play and utilized a simulation to understand the effectiveness of the strategies.

Unlike Serious Games in the state of the art, SERGE has been implemented in such a way that it focuses on risk management in agile software development, which seems to be the most widespread development methodology in the working environment.

To validate the effectiveness of Serious Game SERGE, an experiment was carried out. As SERGE was designed to support learning in Risk Management, 20 students in the Software Project Management class were chosen as participants in this experiment. They were divided into groups of 10, Group A (who used SERGE) and Group B (control group). The experiment took place in three phases. The first phase was conducted to check, in a short time, whether there were any changes in the participants' skills. Group A, which took part in the experiment's first phase, completed a questionnaire on risk management skills. Immediately afterward, it participated in SERGE and finally re-completed the same questionnaire, whose answers were compared with those of the first questionnaire. In the second phase, the focus shifted to the emotions and moods that SERGE triggered in the participants and how they influenced the participants; the latter were observed during the game, then filled out a questionnaire to understand what moods it elicited, and finally were interviewed. The third phase of the experiment was aimed at confirming the results obtained from the first and confirming the replicability of the experiment. The participants in the control group filled in the same questionnaire as the risk management skills and the results obtained were then compared with those of group A, both before and after using SERGE.

The results confirmed the validity of SERGE, as the answers to the questionnaires of group A (before using SERGE) and group B were very similar. Both had lower low responses than the questionnaire conducted by group A after taking part in SERGE. In addition, the game had many positive outcomes, and the participants also stated that they enjoyed it. It emerged from the observations and interviews that it stimulated feelings that could be labeled as 'positive'. In conclusion, interesting considerations for future developments emerged from the outcomes of the interviews. One hypothesis is creating a hybrid version (mixture of digital and non-digital), and improvements to the game material, changing some cards and rules.

1.3 Structure of the Thesis

Chapter 2 will explain Risk Management and Serious Games in Software Project Management Education background. . In addition, this chapter also deals with work closely related to our thesis work. Chapter 3 will outline the objectives behind the Serious Game and the research method used. Chapter 4 outlines the literature survey, illustrating the works that come close to ours, the problems they present, and the solutions our thesis work proposes in this regard. Chapter 5 describes the method and criteria by which the SERGE Serious Game was realized and a description of the pilot tests carried out to obtain feedback to improve the structure of SERGE. Chapter 6 details the experiment conducted to validate the Serious Game SERGE. The various threats to the validity of the results obtained from this experiment are explained in Chapter 7. Chapter 8 deals with the discussions and considerations during the thesis process. Finally, conclusions and possible future work are outlined in Chapter 9.

CHAPTER 2

BACKGROUND

This chapter illustrates the background of the art and the works present nowadays in the literature about the research aspects that interested our thesis work.

2.1 Risk Management

2.1.1 Context of Risk Management

A good software product also derives from good management, and in the management practices—present in the PMBOK knowledge areas [1]—it is defined as the practice of Risk Management; it consists of processes, methodologies, and tools used to deal with risk—i.e., an uncertain or not expected event that occurrence could have positive or negative influences on project metrics[1, 2]—in the different phases of the software life cycle [3]. State of the art also demonstrated that poor management or a complete lack of risk management could be the main reason for software project failure in 75% of cases [4].

Furthermore, different issues arising from risk management are highlighted. Although it consists of different methodologies based on the same steps, it is complex to apply as it requires a lot of documentation and attention in risk analysis and monitoring [5]. Given the need to keep track of all risks and how they are dealt with, Risk Management requires much documentation; this is one of the reasons why this area of management is not applied today [6]. Finally, risk management is one of the most delicate areas because a single mistake could cause the project to fail [7]. This is why it is complex to teach and understand, requiring practice and simulation [8, 9].

2.1.2 Different Application of Risk Management

Although there may be different methodologies for performing risk management [10], it can be deduced that they are all based on the same activities. According to Masso et al. [2], essential activities are risk identification, risk analysis, and risk assessment. Despite this, risk management is applied differently according to the development model or project conditions.

Open-Source Software [11]

Lately, the use of OTS components(Off-the-Shelf-components), divided into Commercial OTS and Open Source Software—is becoming increasingly common, especially when time-to-market is to be reduced. However, using such components can lead to an increase/introduction of risks. Hence we understand that Open Source projects may present different risks than those that arise in the software development life cycle. Linh et al. [11] affirms that although open source projects exploit a risk management methodology based on identification, analysis, and validation, they require more knowledge and experience to avoid or resolve many risks, so it is good to fully understand and analyze the advantages and disadvantages of the component to select [11].

Agile [4]

Agile methodologies are based on faster development of software products and go against the heavy paperwork of Software Engineering. Since the agile method is also used to develop critical systems, risks are inevitably encountered. In agile, many formal software development activities are neglected, one of which is precisely risk management, but it should be noted that risks can arise in any project regardless of the development method. There is no formal way in agile methodologies to define and mitigate risks that may arise in the project. A survey shows that planning risks and varying requirements are two of the risks most faced by agile professionals and that most risk prevention and mitigation strategies involve communication with clients [4].

Tools and Approaches

In support of risk management, different approaches are predicated in the literature. In particular, we can see the work of Gonçalves, Kühlkamp, and Wangenheim [12]. DotProject is a tool that aims to support the project manager in the different phases of software project management, one of which is Risk Management. It is managed within the tool by strictly following the indications provided by the PMBOK on this area of knowledge. Experiments were also carried out by Goncalves et al. [13] to see whether the tool could also support the teaching of Risk Management. An alternative version, with feedback, was created for the experiment.

2.2 Education in Software Project Management

Project Management (PM) is the activities of initiating, planning, executing, monitoring, controlling, and closing a software project. Education of students on aspects of software project management is still oriented towards using traditional methods. The teaching of Software Project Management (SPM) has been supported by organizations such as the Association for Computing Machinery (ACM) and IEEE-Computer Society in their joint task force curricula for undergraduate computing courses [14]. In recent years, alternative methodologies related to using educational games are becoming increasingly popular. They are designed to be effective and efficient for SPM education. One of their main features is to provide a fun environment through which students can acquire skills and put them into practice by observing consequences and learning from their mistakes [15, 8, 16].

Serious Game

Among the educational games, the presence of the *Serious Games*—i.e., games designed for the primary purpose of teaching through entertainment—stood out. Serious Games [17] is a proven and effective training method based on the incorporation of gamification and simulation [16, 8]. The term gamification refers to the intention to utilize design elements of games—such as strategic and mechanical design—in activities that do not belong to the world of games [18]. When we speak of simulation, we refer to the reproduction of real-world contexts to exploit them for learning [18]. One of the objectives of the Serious Game is to gain experience and knowledge already during training and not only during work by putting into practice—through simulation—the knowledge acquired in a natural context [16]. According to Kiryakova, Angelova, and Yordanova [18], the characterizing elements of games include (1) players, (2) challenges/tasks, (3) a scoring system, (4) different levels of complexity, (5) badges and (6) ranking of users. They also show us that the process of transforming the real context into an educational game goes through the following steps:

1. Understand the end user to whom it is intended that certain knowledge be acquired;
2. Define what the training objectives that the game must fulfill are;
3. Creating the main educational content and activities;
4. Adding game-related elements within the content created.

2.3 Related Work

The following section illustrates the Serious Games in the literature closest to our goal.

Using Games in Software Engineering Education to Teach Risk Management [9]. The educational game realized by Taran[9] aims to teach Risk Management using the characteristic elements of a board game, such as a board and dice. It features a "free" board on which each player can decide where to go, and the use of dice is limited to crate a random simulation of some event that happened in a given situation. Risk Management is a complex activity, so the game presents the same complexity. On the other hand, SERGE aims to maintain a simple structure while providing adequate information support for players.

Riskware—A game for teaching Software Project Risk Management [19]. Riskware is an original type of Serious Game inspired by Risk Management, created by Jaramillo, Álvarez, and González-Calderón [19]. A particular feature of the game is that gives players total freedom of choice to learn Risk Management in a context as close to reality as possible. This idea, however, gives rise to different problems, such as resource acquisition, status confusion, and inadequate funding. Our work aims to solve these problems by providing anonymous resource purchases, a fictional coin, and total clarity on each player's status.

Scrumia—An educational game for teaching SCRUM in computing courses [20]. The main objective of SCRUMIA [20] is to teach people how to apply the SCRUM framework. The game is very much based on the concept of simulation, there is a particular fantasy scenario describing the user story of a project. The players are divided into teams, in each of which each player will play a different Scrum role. Players will perform the tasks necessary to complete the project in the shortest possible time and with the best result.

ARMI 2.0—An Online Risk Management Simulation [21]. ARMI 2.0[21] is a digital Serious Game aimed at teaching risk management, in which each iteration of the game represents a phase of the software development life cycle, using the waterfall development method. For each phase, players will hypothesize the number of risks they may encounter and proceed to deal with them. The game has no negative points, but players appreciated features such as brainstorming.

All the games considered in the following section were realized by exploiting the waterfall software development methodology. To differ from this, SERGE is based on the Agile development model, particularly by exploiting the Scrum framework.

CHAPTER 3

RESEARCH METHOD

3.1 Objective

The thesis job aims to understand how and whether it improves learning on topics related to Software Project Management, more specifically Risk Management, using approaches such as Serious Games. They exploit the elements of games and simulation to create a productive environment that is also fun and stimulating.

The presence of Serious Games stimulates learning through the use of reality simulation—which allows the student to put into practice what he or she has learned—and gamification —which, through the typical elements of games creates an atmosphere of fun but also competition.

The thesis work has different educational objectives, for the realization of the Serious Game, which it attempts to fulfill through SERGE; they are:

- To provide an environment for communication and exchanging ideas about risks, their analysis, and possible approaches to deal with them to increase their knowledge;
- Develop strategist skills about how to prevent and mitigate risks;
- Reinforce the knowledge learned by putting it into practice in a simulated scenario;
- Notions learned in the game must also be applied also in a work context.

These training objectives are fulfilled through the implementation and validation of the proposed Serious Game, which is realized using the method indicated in section 3.2.

Another objective of this thesis is to analyze and understand the participants' state of mind concerning using the Serious Game realized. In order to conduct this analysis, studies on how human perceptions and moods (negative or positive) influence the idea of participating in a Serious Game were examined. This analysis is conducted in Chapter 4. Following the information obtained, a questionnaire was drawn to investigate which of the moods listed and identified in these studies most represent the participants in our Serious Game.

Thesis Objective

This thesis aims to realize and validate ***SERGE***—**Se**rious **R**isk **G**am**e**— geared to support learning in Risk Management by enhancing related skills. The training objectives underlying SERGE are to enhance skills related to risk analysis and strategies for risk prevention and mitigation by providing a simulation environment that stimulates to put into practice the knowledge that has been acquired, which can also be applied in a work context.

3.2 Research Method

The research method used for this thesis work is illustrated in image 3.1; Different steps were performed to conduct to realize our work.

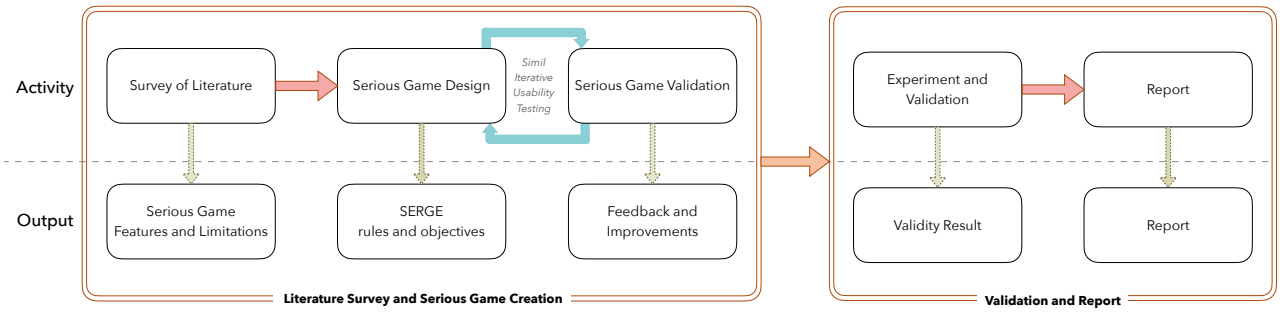

Figure 3.1: Research-Methods approach for the creation and validation of SERGE

Literature Survey. The first step was to conduct a literature survey. Our primary focus was on risk management and education. Many exciting articles were found on Serious Games, their implementation, and experiments conducted to test their effectiveness. Il nostro obiettivo era quello di distinguere SERGE dai lavori esistenti e di migliorare le tematiche del Serious Game presenti in letteratura. Following these objectives, we obtained from the survey a list of characteristics that the proposed Serious Game had to fulfill. In addition, through important considerations, there were exciting thoughts on how the Serious Game should be implemented and validated.

Serious Game Design and Validation. Once the literature survey had been carried out and the characteristics SERGE had to fulfill, with the improvements to be made, a version of the Serious Game was realized. Before verifying the effectiveness of SERGE utilizing an empirical experiment, we wanted to ascertain its correctness and validity. Therefore, the creation process was not immediate but resulted from a *Simil Iterative Usability Testing* process. The features were then analyzed from the literature survey, and a version of SERGE was waxed. This version was tested to ascertain its correctness. Interesting feedback resulted from this test, which led to a modification of the structure of SERGE. These modifications led to the need for a further test pilot. This process iterated until specific stability and satisfaction with the result and feedback was achieved.

Experiment and Validation. Once the structure of SERGE, containing all the rules and material of the game, was obtained, an experiment was conducted with the intention of testing whether the training goals SERGE set itself were met. The leading target group of participants, on which SERGE was based, are the students of the Software Project Management course, which is held at the Master's degree course in Computer Science at the University of Salerno. A sample of 20 students from the Software Project Management course was selected for the experiment. They were divided into two groups, Group A, which took part in the Serious Game SERGE, and Group B, the control group. The conducted experiment was divided into 3 phases. The first one aimed to instantly test whether there were any improvements after using the game. The participants, i.e., group A, filled in a questionnaire on risk management skills. They then participated in the Serious Game SERGE and immediately re-completed the same questionnaire. The results of the two questionnaires were then compared to understand whether there had been an improvement. The second step of the experiment is based on understanding the moods of the participants in the Serious Game and whether they influenced the participants' experience. To carry out this experiment phase, the participants were observed throughout the Serious Game SERGE, after which they were asked to fill in a questionnaire regarding the different feelings SERGE could arouse in them. Finally, they were interviewed for further feedback. The third phase of the experiment aims to affirm the experiment's replicability and confirm the results obtained from the first phase. The control group, or Group B, was subjected to the same questionnaire on Risk Management skills. The results of this questionnaire were compared with those of Group A before and after using the Serious Game.

CHAPTER 4

LITERATURE SURVEY

The first step was to start from the existing literature and study the state of the art of risk management, described in Chapter 2.1. In particular, it can be seen that, given its complexity and delicacy, one of the significant problems is precisely related to the teaching of this practice. In response to this, research was carried out on modern teaching methodologies 2.2, and among them appeared Serious Games, of which a study of the existing literature was conducted. Serious Games was explicitly made for teaching Software Project Management, specifically Risk Management.

4.1 Serious Game

Software project management is a vast and sensitive area of software engineering. It encompasses the knowledge areas of PMBOK [1]. Learning about these topics is increasingly delicate, so a suitable learning method is necessary. To improve such learning, Serious Games [16] were born. They aim to apply elements belonging to the world of games (gamification [18]) to real contexts, also including into them a simulative approach.

4.1.1 Context of Serious Game

Among the articles identified, some laid the foundations for the idea behind our Serious Game, SERGE. In particular, we focused on the following articles:

Using Games in Software Engineering Education to Teach Risk Management [9]. Taran [9] has created a Serious Game for teaching Risk Management that exploits the traditional elements of a board game. In the game, we find a game board that is different from other board games because it is “free”, so each player can decide the direction to use for gaming; The game has 5 stages, which are based on the waterfall development mode: planning, requirements, architecture and design, implementation, and testing; its exploits the randomness of the dice throw to simulate a random verified risk. To prevent such risks, players must acquire appropriate resources; these are not standard but can be purchased, increased, or decreased during the game. The main problem with such a Serious Game is dictated by its complexity. The game has many rules and constraints to best represent a simulative scenario of an environment requiring Risk Management. So, Players need help understanding the game and remembering its rules. Complexity also introduces a “trade-off” in the article, as in the furthest work, one thinks of extending the game with other risks, scenarios, and resources, but this would also lead to an increase in complexity, which is already considered a significant problem in Article [9].

Riskware—A game for teaching Software Project Risk Management [19]. Riskware [19]—a Serious Game for learning Risk Management—although based on the classic elements of a board game. It deviates from the ’constraints’ associated because each player creates their path by deciding the tiles that will form a personal version of the board to be used for the game.
In the first phase, they will acquire Resources to prevent and mitigate the risks they will encounter; At each turn, the players will advance one tile of the realized path and face a risk, which will be drawn according to the result obtained from a dice roll. The completion of the path determines victory in the game. The problems encountered by the game concern: (1) the acquisition of resources; it does not take place in private. Therefore, each player can understand the opponent’s strategy and clone it; (2) the customized path does not make the players aware of their progress, let alone their current status, and (3) the funds need to be improved for the investments to be made.

Scrumia—An educational game for teaching SCRUM in computing courses [20]. Gresse-Von-Wangenheim, Savi, and Borgatto has implemented the Serious Game Scrumia [20] to improve understanding of the Scrum Framework. The game provides a fantasy scenario, which proposes user stories to be realized to complete the realization of a project. Several teams will play simultaneously, and each team will consist of gamers playing the different Scrum roles - Scrum Master, Product Owner, and Team Member. The team that completes the project first will be declared the winner. The presence of a figurative scenario, combined with having to "channel" oneself into a specific role, provides essential elements for simulating a real-world context.

ARMI 2.0—An Online Risk Management Simulation [21]. Unlike the Risk Management-focused Serious Games seen previously, ARMI 2.0 [21] is a digital Serious Game. The game is subdivided into 5 consecutive rounds, each intended to simulate one of the software development life cycle phases, exploiting the waterfall software development methodology. At the beginning of each turn, players will brainstorm about the risk cards present; then, they will purchase the game resources that will be useful to use to prevent possible risks. Subsequently, for each phase of the life cycle of a software product—i.e., a round of the game—any player will indicate how many risks he is likely to encounter in that phase. According to the prediction, the players will go and draw the number of risk cards they will face and check whether they have been able to prevent them or have to pay the contingency amount. There were no negative points or features to be improved in the game. However, good points were considered, like (1) initial confrontation between players to understand risks and (2) splitting the game into precise and equal phases for all players.

4.1.2 Results

Interesting findings have been obtained from Serious Games in the literature.

Using Games in Software Engineering Education to Teach Risk Management [9]. Taran [9] shows that the main problem with the Risk Management Game that was realized is precisely the game's complexity. Many players needed help remembering all the rules and constraints it presents. This factor is also a problem for future developments since integrating different topics into the game could increase the game's complexity, which, according to the game participants, is already relatively high. In response to this, SERGE aims to maintain a simple game methodology with clearly defined stages. SERGE presents an "leaflet" that shows players all the stages of the game and all the rules. To support the participants, there are produced "info card" that summarises the essential concepts of the game and are distributed to all participants for reference.

Riskware—A game for teaching Software Project Risk Management [19]. The problems arising from the Riskware game focus on three main points. (1) The resource acquisition phase is done publicly. Each player understands the strategy implemented by his opponents, so he can imitate it, thus losing one of the game's main objectives. (2) Creating a customized path for each player loses the understanding of each player's status. It needs to be understood at what point of the game the opponents are. (3) The amount allocated to the players is inadequate to implement a strategy. In response to these problems, the Methodology behind SERGE provides a secret resource acquisition phase for each player so that opponents do not understand the strategies developed. Each player devises his or her own and goes into the game, learning whether or not the reasoning has done

leads to good results. All phases of the game are distinct so that players keep sight of the state of their opponents. SERGE provides a token as currency to simplify the resource acquisition and risk cost phase. It is divided into High, Medium, and Low Tokens.

Scrumia—An educational game for teaching SCRUM in computing courses [20]. The idea behind SCRUMIA [20] is to improve understanding of the Scrum Framework. The game provides a scenario through which it will be possible to simulate the realization of a project. SERGE exploits the exact simulation mechanism. Players are given a project to realize and basic information such as time, Sprint number, cost, number of team members, information on a domain, and the number of functionalities to be realized, with a description of those functions.

ARMI 2.0—An Online Risk Management Simulation [21]. ARMI 2.0 [21] received much positive feedback from participants in the experiment. These were taken as inspiration to devise different features for SERGE. Using the Planning Poker method to assign an impact and probability to each risk. Each player will also communicate the idea behind his choice so that he can compare himself with the ideas of others. Use Sprint Scrums to maintain a precise structure, which always clarifies the game's status to each participant of the game.

4.2 Experiment on Serious Game

4.2.1 Context of the Experiment on Serious Game

Other works in the literature were analyzed to understand other characteristics of Serious Games to be attributed to SERGE. These works are experiments conducted to understand the effectiveness of Serious Games in comparison to traditional teaching methods.

Effectiveness of Games in Software Project Management Education: An Experimental Study [15]. Giani Petri et al. [15] conducted a controlled experiment to ascertain the effectiveness of games in learning software project management practices. As many as 11 different games dealing with aspects of software project management were taken into consideration. These games are divided into simulation-based games, which cover the majority of the games examined, and others based on quizzes. The experiment was conducted in two Software Project Management courses - aimed at teaching the understanding of critical concepts and processes in software project management - in the Computer Science and Information Systems degree courses of the Department of Computer Science and Statistics at the Federal University of Santa Catarina, Brazil. The participants in the experiment were found to have similar skills and a similar age and gender distribution. The research questions that this experiment attempts to answer are (1) to verify the existence of a

perceived difference between the experimental group and the control group; (2) is there a difference between the two experiences; (3) is there a difference in learning; (4) is there a difference in experience according to the different types of game (simulation and quiz); (5) is there a difference in learning according to the different types of game. To conduct this experiment, questionnaires were conducted to assess experience and knowledge at different times, the beginning and end of the course, and immediately after dealing and playing with a specific topic.

Games for Teaching Software Project Management: An Analysis of the Benefits of Digital and Non-Digital Games [14]. Considering the literature and experiments conducted to ascertain the efficiency of using games for teaching the notions behind software project management, Petri et al. [14], in the following experiment, wants to analyze the benefits of using traditional games compared to using digital games. The experiment is based on three steps, (1) Using the MEEGA+ model [14] games for teaching software project management, both digital and non-digital, are evaluated, (2) Collect the data, (3) Group the data into a single sample. For the realization of the experiment, 27 case studies were conducted evaluating 11 games to learn software project management, divided into 4 digital and 7 non-digital games. It was conducted using a one-shot post-test only design, where first was applicated the treatment— using the educational game— and after they must answer the questionnaire. To conduct this experiment, two research questions were asked about the player experience and two about the player's perceived learning. (1) Software project management learning games provide a positive experience; (2) There is a difference between the experience provided by traditional and digital games; (3) These games contribute to learning; (4) There is a difference between the learning provided by traditional games and that provided by digital games. The experiment was conducted in two Software Project Management courses - aimed at teaching the understanding of critical concepts and processes in software project management - in the Computer Science and Information Systems degree courses of the Department of Computer Science and Statistics at the Federal University of Santa Catarina, Brazil.

Serious Game in Management Education: An Acceptance Analysis [8]. In addition to the implementation and evaluation of the Serious Game's effectiveness in Risk Management, this thesis work aims to analyze the behavior and experience of the students who had participated in SERGE. To fully understand how to carry out such a study, the experiment conducted by López et al. [8]. It illustrates the experiment conducted to analyze the different moods of participants in a Serious Game for learning Risk Management, as emotions can influence, both positively and negatively, the degree of involvement and experience of a participant in a game. The research questions examined also examine the different feelings a game can arouse. (1) Expectations about the experience positively influence the use of Serious Games; (2) Positive expectations about the

effort positively influence the use of Serious Games; (3) Positive emotions positively influence the intention to use them; (4) Anxiety related to using Serious Games negatively influences the intention to use them; (5) Emotions related to Serious Games negatively influence the intention to use them; (6) Social influence on using Serious Games positively influences the intention to use them; (7) Personal informativeness towards Serious Games positively influences the intention to use them. To obtain the results, 339 surveys of students were examined, the majority of whom were undergraduate students and the remainder master's students, with 69.6% of the respondents female and 30.4% male.

4.2.2 Results

The experiments conducted in the literature on Serious Games have brought us exciting observations on their importance of them and the contribution they make to emotions and didactics. These observations were taken into account for the realization of SERGE.

Effectiveness of Games in Software Project Management Education: An Experimental Study [15]. The results emerged from the experiment conducted by Giani Petri et al. [15], stating that among the Serious Games surveyed, the students preferred those using simulation to those based on quizzes, finding them more engaging. Furthermore, the resulting statistics showed that although the knowledge of the students subjected to the treatment (use of the Serious Game) improved, the statistical difference with the students who did not participate in the treatment was moderate. Taking the work of Giani Petri et al. [15] as a starting point, the empirical evaluation of SERGE aims to ascertain whether knowledge of risk management improves following treatment.

Games for Teaching Software Project Management: An Analysis of the Benefits of Digital and Non-Digital Games[14]. The results emerged from the experiment conducted by Petri et al. [14], stating that among the Serious Games surveyed, the students preferred those using simulation to those based on quizzes, finding them more engaging. Furthermore, the resulting statistics showed that although the knowledge of the students subjected to the treatment (use of the Serious Game) improved, the statistical difference with the students who did not participate in the treatment was moderate. Taking the work of Petri et al. [14] as a starting point, the empirical evaluation of SERGE aims to ascertain whether knowledge of risk management improves following treatment. X experiment to understand the differences between digital and non-digital games. At the end of the experiment, the results state that both digital and traditional games effectively aid students' comprehension. Both have very positive outcomes on all dimensions of the quality factors. The only differences are on the: Rules: Thanks to tutorials or short demonstrations, digital games

make the rules and constraints of the game more accessible to understand than non-digital games. Adaptation: digital games are very 'rigid', so they cannot be modified at runtime according to the needs of the users who are playing them at that moment. Usability and focused attention are the main differences between digital and non-digital games. At the same time, usability was rated more positive in digital games, especially in terms of ease of learning and attractive design. On the contrary, however, non-digital games promote more focused attention on the part of students, as they feel more involved and in touch with others. These considerations were central to the choice of SERGE implementation. Placing more focus on what turns out to be our goal, namely to support and enhance learning in Risk Management, it was realized that the non-digital version is the most appropriate. It fosters communication and involvement on the part of the students, thus providing an environment in which ideas can be exchanged and compared, enriching them.

Serious Game in Management Education: An Acceptance Analysis[8]. From the results of the experiment conducted by López et al. [8], it is stated that of the different emotions and conditions about using Serious Games, the most impact one was the performance experience that positively impacted the students' idea of using a Serious Game. The experiment conducted by López et al. [8] was taken as an example to set up an experiment for SERGE to understand the students' emotions and perceptions when using Serious Games.

4.3 Summary of Results

The table 4.1 summarises the results obtained from the literature study for the various articles. The first 4 concern the Serious Games examined, and the remaining 3 deal with the experiments conducted, leading us to exciting feedback and insights on structuring SERGE.

Table 4.1: Summary Results of the Literature Study

Paper	Problem or Idea	SERGE Solution
Using Games in Software Engineering Education to Teach Risk Management [9]	Excessive complexity of the game and rules	Provide a simple game with supporting material to remind players of the rules quickly
Riskware—A game for teaching Software Project Risk Management [19]	(1) game strategies are publicly displayed, and players tend to copy each other, (2) too much freedom provided creates confusion as to the status of opponents, (3) insufficient funds are provided	(1) game strategies are publicly displayed, and players tend to copy each other, (2) too much freedom provided creates confusion as to the status of opponents, (3) insufficient funds are provided
Scrumia—An educational game for teaching SCRUM in computing courses [20]	Use of a fantasy scenario to describe the user story and the tasks to be accomplished to complete the project (Simulation)	Use of a context through a scenario to simulate the project to be realized, providing the data sheet, requirements, and constraints of the project
ARMI 2.0—An Online Risk Management Simulation [21]	Appreciated the use of brainstorming and the division of phases	Use of Planning Poker to compare ideas and use of Scrum Sprints to create distinct phases
Effectiveness of Games in Software Project Management Education: An Experimental Study [15]	Simulation games were more popular as participants felt more involved than quiz games	The game was designed as a simulation game to increase participation and impersonation of a role
Games for Teaching Software Project Management: An Analysis of the Benefits of Digital and Non-Digital Games[14]	Digital games have better player guidance and support, while non-digital games are more engaging than digital	Realization of a non-digital Serious Game, providing much supporting material to succumb to the flaws of such games
Serious Game in Management Education: An Acceptance Analysis[8]	The performance experience is the factor that most positively influenced the idea of using serious games	Understand which of the moods (illustrated in the article) the use of SERGE elicits

CHAPTER 5

GAME DESIGN AND VALIDATION

From the literature survey results in Chapter 4, important information was obtained on how to go about realizing the structure of SERGE. In particular, it derives from a Similar Iterative Usability Testing process. An initial version of the game was realized after pilot tests tested it to ascertain its effectiveness, clarity, and functionality. Following the feedback obtained from the pilot tests, the structure was modified and subsequently tested. In the following chapter, we will describe how this process was implemented.

5.1 Game Design

5.1.1 Deisgn Realization

Paragraph 3.1 sets out the educational objectives underlying the idea of SERGE. They concern (1) the confrontation of ideas to increase knowledge about risks; (2) the realization of a strategy to prevent and mitigate risks; (3) the simulation of a real context so that each player can put himself at stake to understand whether the strategy he devises brings benefits, and learn from it; (4) Notions learned in the game must also be applied in a work context and not only in an academic context.

In the previous chapter 4, exciting aspects and considerations emerged from the literature survey, which set the ideas and constraints for the realization of the SERGE framework.

To meet the set training objectives, one must consider that one intends to create an educational game that facilitates communication and the exchange of ideas to increase knowledge about risks by comparing them with that of others. Nevertheless, one has to balance communication and exchange of views with secrecy and individuality. Making the whole game too collaborative makes one lose

focus on one of the main objectives, learning. Therefore, it is essential to create a phase in which they collaborate by exchanging ideas and opinions to make the others understand aspects they may have overlooked concerning risk and a hypothetical event. However, it is equally important for each to draw up their plan to defend themselves against risks, respecting cost and resource constraints. Because in a real scenario, each Project Manager or Scrum Master will have to make crucial decisions to prevent and deal with risks, and one of the objectives of the game is precisely to simulate such a scenario to develop organizational skills in the games. From this consideration, we can understand the need for a simulation game. With a simulation game, participants can impersonate themselves in the role of a Scrum Master and face the realization of a project with the various complexities and constraints it entails, thus simulating the occurrence of events that lead to the incumbency of risks to be faced.

Another important consideration is to create a Serious Game that distinguishes itself from those already in the literature by solving the latter presented problems. One goal we set ourselves was to create a simple game; a complex game would be challenging to use, and players would spend more time learning the rules and constraints rather than playing and learning. Focusing once again on what our formative goals—paragraph 3.1—are and what is presently in the state of the art—chapter 2—, we find that all the Serious Games examined and created to educate in the area of Software Project Management focus mainly on traditional development models. Such systems are designed to educate newcomers and should, therefore, better represent the actual working world, which the agile model largely dominates. There has been a greater focus to succumb to this shortcoming, on using an agile development model within the Serious Game.

According to Kiryakova, Angelova, and Yordanova [18], we know that the process of making a Serious Game, starting from a real context, such as Risk Management for Software Project Management, goes through the following steps, which we will consider, together with the information already drawn from the study of art and serious games examined.

1. Understand the end user to whom it is intended that certain knowledge be acquired;
2. Define what the training objectives that the game must fulfill are;
3. Creating the main educational content and activities;
4. Adding game-related elements within the content created.

5.1.2 Results

From the considerations made in paragraph 5.1 and the testing carried out for the correctness of the structure—described in paragraph 5.2—the structure of SERGE emerged.

Different game phases were implemented in response to the different training objectives. To realize the structure of SERGE, we relied on the steps indicated by Kiryakova, Angelova, and Yordanova [14] to transform a real context into a Serious Game. They are:

1. **Understand the end user to whom it is intended that certain knowledge be acquired —** From the outset, it was clear that the end users to whom the aim is to gain more knowledge in the area of risk management are students of software project management course;

2. **Define what the training objectives that the game must fulfill are —** Paragraph 3.1 listed the training objectives underpinning SERGE, and they deal with (1) Improving analysis skills through communication and discussion, (2) Developing organizational skills to implement a risk management strategy, (3) Improving skills by dealing with risks in a simulation, (4) Acquiring skills that are also applicable in the working world;

3. **Creating the main educational content and activities —** The different phases of the game and a scenario comprising the context of a project to be realized and its data sheet were realized. In addition, the risks to be faced during the realization of the project and the events that could change its impact and probability were provided.

4. **Adding game-related elements within the content created —** The main elements of a game that have been added to SERGE include (1) the addition of the use of tokens as money; (2) the possibility of enriching the player by purchasing resources to customize his game; (3) the use of points to determine a player's victory; (4) the use of playing cards and dice.

Enhancing analysis skills through communication and confrontation. The first phase of the game will be devoted to risk analysis. To agree on how to associate an impact and probability to the risks SERGE will propose to the players, he will adopt the strategy of Planning Poker. To increase the educational factor of this phase, each player will also argue the choice made, thus initiating an actual "exchange of ideas".

Developing organizational skills to implement a strategy to deal with risks. Each player will make his purchases without having to communicate with his opponents. The balances out the resources to be purchased (understood as team skills, personal skills, and organization skills).

Each combination of skills corresponds to a different strategy that each player will decide to deal with to tackle and mitigate risks.

Improving skills by addressing risks in a simulation. SERGE provides an ideal scenario to simulate software project development management. This scenario presents the context within which the software project is to be realized, a draft of the functional requirements to be implemented, the project data sheet with the number of team members, and time and resource constraints. In the third and final phase of the game, players can simulate what it is like to develop and manage a software project. Thus, given the randomness provided by a die roll, it is possible to simulate events that trigger the realization of risks. Each player, moreover, has the possibility of incurring an event that can change the impact and probability of a risk, thus giving dynamism to the risks presented by the game. Once a risk is encountered, players can prevent it if they have acquired the necessary resources, mitigate it by paying the contingency amount or succumbing to it.

Acquiring skills that are also applicable in the working world. Today, in the world of work, the most widely used development model is Agile. To ensure that the concepts learned by SERGE participants are also applicable in a working context and not only in the academic sphere, the structure of the Serious Game is also based on the Agile development model. In the project sheet presented in the scenario provided, an Agile team and a project that develops in different sprints are mentioned. Furthermore, the third phase of the game means that each round corresponds to an entire sprint. The considerations made in the first phase of the game concerning the calculation of the impact and probability of risks also draw heavily on the agile model, which makes excellent use of Planning Poker as a method of comparison to go and assigning story points to user stories.

Solution for Literature Problem. In addition to the training objectives, SERGE aims to improve the problems arising from Serious Games in the literature. These include the complexity of the game, which is solved by presenting a Serious Game with distinct phases based on Sprint Scrum. This also keeps a clear status on the game's progress and each player's position. In addition, the presence of supporting material allows players always to have an eye on the rules of the game, thus reducing the game's complexity. The presence of a scenario, which provides the context and the project data sheet, creates the simulation environment in which players can go and impersonate the role of Scrum Master and simulate the management of a software project. In addition, to increase the communication and involvement factor on the part of all the players, the game was realized in a non-digital format. To fill the gaps that distinguish non-digital from digital games, such as the lack of clarity in explaining the rules, by providing support material.

5.2 Game Validation

Paragraph 5.1 outlines the ideas that led us to the creation of the SERGE structure, following the training objectives—paragraph 3.1—and the problems that arose from the papers analyzed in the state of the art—chapter 2—which we aim to improve and overcome.

The results of this analysis—reported in paragraph 5.1— give us the structure of SERGE—described in paragraph 5.3. The process behind realizing the SERGE structure was not immediate but derived from a *Similar Iterative Usability Testing* process. Different versions of SERGE were realized and tested by different players, aiming to analyze its criticalities and give helpful feedback to improve it until a definite version was reached in which players had no difficulty playing and learning from it. Under the objectives and study of the art, a structure for the Serious Game was drawn up, and this structure was then validated through pilot testing. To be precise, no less than two pilot tests were carried out, leading us to SERGE's final structure and rules.

5.2.1 First Pilot Test

The first test was conducted at the SeSa Lab—Software Engineering Laboratory at the Computer Science Department of the University of Salerno). It involved 4 students (all boys), two Ph.D. students, and two Master's students who had taken the software project management course. The structure of the game underpinned by this experiment was very approximate. It was only intended to fill the training objectives and improve on the problems presented by the Serious Games in the literature. Version 0.1 of SERGE, which was used for the following pilot test, used an amount of money in euros for resource acquisition and risk mitigation. Impact and probability were calculated with the standard cards used in the planning poker approach.

Moreover, it did not yet present a scenario and the risks to be addressed were more general. The game's creators were present in this test, interacting with the participants to explain the game and clarify roles and any doubts about the materials.

Result of First Pilot Test

The first pilot test aimed to define the structure of SERGE, as many issues related to it could only be understood through a test. Among the considerations that emerged from the pilot test were the need to add (1) an illustrative scenario to provide a context with which to reason about the impact and probability of risks, (2) a dynamic factor for risks to be able to simulate reality and how they change according to certain situations; (3) an instruction booklet, to reduce interaction with the game creators and make players autonomous. In addition to the addition of new elements, changes to existing ones were found to be necessary, such as (1) modifying the planning poker cards with

percentage cards for probability and High/Medium/Low for impact; (2) using tokens instead of coins to simplify purchases; Given the assiduous presence of the game creators, players took every opportunity to ask for information and thus interrupted the normal flow of the game. Therefore, it was impossible to time the different phases of the game to understand its overall duration of it.

5.2.2 Second Pilot Test

The second pilot test, like the first, was conducted at the e SeSa Lab—Software Engineering Laboratory at the Computer Science Department of the University of Salerno). In contrast to the first, SERGE's facility was more complete than in the first pilot test, and it facilitated the pilot test's conduct. This time, 6 (4 boys and 2 girls) Ph.D. students were chosen as participants and were divided into three pairs, two male-female pairs and one consisting only of males. Picture X shows the pilot test conducted. Each player was also provided with support material through which feedback was noted for improvement. According to the feedback from the first pilot test, version 0.2 of SERGE was produced and used in the second pilot test. In addition to the suggested changes, a game *leaflet* was also produced. This material, therefore, replaced the presence of the game creators explaining the rules and stages of the game to the players, so, during this pilot test, unlike the first, the presence of the game creators was kept to a minimum. To keep track of the relevant information obtained from the players who took part in the second pilot test while maintaining their anonymity, each was assigned an ID. The first pair of players represented by ID C1 consisted of one player with ID C11 and the other with ID C12. The second pair had ID C2 and its members ID C21 and ID C22. Finally, the third pair identified by C3 had ID C31 and ID C32 as its players.

Result of Second Pilot Test

Excellent feedback was obtained with the second pilot test, which led to the realization of the final version of SERGE. In particular, one of the aspects most appreciated by all participants was the choice to play in pairs instead of as single players, it was stated that *"playing in pairs is definitely more productive, as I can discuss with my partner to reach an internal agreement and then discuss with the other players, so there is more feedback"*. Other important considerations were made by player C31, who stated, *"in the case of a small forgetfulness, finding the information in the leaflet is complex, it would be convenient to have boxes or cards that summarise the most important information"*. According to this, info cards were created, which summarise the most important stages of the game and the most complex rules to remember. Among the critical issues that arose during the first phase, participants C11, C12, and C31 stated that *"during the planning poker phase, one could get stuck in the event of a tie, and it is not clear how one should proceed"*. To resolve this issue, we improved the rule of planning poker so that in case of a dispute, the process is iterated again, reducing cards in the range.

Figure 5.1: Second Pilot Test

Regarding game material [22]—also described in paragraph 5.3—all players preferred to have an ID for each risk card to simplify reference. Furthermore, C31 stated *"it would be useful to have a picture for each card so that you can understand its use from the start"*. On the other hand, C21 stated *"to simplify the resource acquisition phase, it would be useful to provide players with a note sheet showing them the essential information they need to work out their strategy"*. Following the statements made, memorable logos were made to be used for the various cards, which are also shown in Table 5.1. Each risk card was associated with a different ID, and a clipboard sheet was created containing the list of resources and the id, name, and description of the risks—simulating a risk register. A final important consideration was made by participants C11, C21, and C22, who stated *"thanks to the event cards, there is a possibility to go and modify the impact and probability of a card, but I have no way of modifying my resources according to some change that has occurred. One could envisage something that would allow me to modify my resources"*. This observation seemed very opportune to fulfill, and the jolly card was devised—illustrated in table 5.1—which allows players to modify resources without abusing this opportunity too much. At the end of the second pilot, players were found to have spent about 10 minutes reading the leaflet. For the first phase, an average of 3 minutes was spent agreeing on the impact and probability of a risk card. As the risk card deck consisted of 9 cards, 27 minutes were estimated for the first phase. The second phase of acquiring resources lasted approximately 10 minutes. The last phase lasted 10 -15 minutes per sprint, thus lasting in total of 30-45 minutes. Ultimately, we estimated the game's duration to be around one and a half hours.

Summary of pilot text

At the end of the two pilot tests, we can say that the game lasted approximately one and a half hours, and according to the feedback obtained, the following changes were made:

- addition of a scenario determining the context of the project;
- addition of event cards to create a dynamic in the risks encountered;
- use of tokens as project currency;
- use of a customized set of cards for the phase of planning poker;
- placing players in pairs instead of individually;
- creation of an illustrative booklet to explain the game;
- creation of info cards to summarise game phases and rules;
- use of logos on cards to quickly understand their use;
- having a note sheet with essential information for implementing a strategy;
- having the possibility to change purchased resources.

5.3 SERGE

Once we analyzed the information from the different pilot—paragraph 5.2—and the considerations made from the literature survey and the objectives-paragraph—3.1 and 5.1.2 and chapter 2—we obtained the SERGE structure. In the following section, we describe the game.

Pre-requisites. (1) Theoretical knowledge of Risk Management; (2) Theoretical knowledge of the Scrum Framework; (3) Knowledge of the Planning Poker approach.

Game. SERGE—**Se**rious **R**isk **G**am**e**—is a Serious Game designed to support the teaching of Risk Management—by providing gamification and simulation approach—to stimulate the fun and creativity of students attending a Software Project Management course. The game's objective is to carry out a Risk Management strategy to the best of one's ability while encountering as little risk as possible. It is divided into three phases:

1. **Risk Analysis —** players give their opinion on the impact and likelihood of the proposed risks using the Planning Poker method;

2. **Procurement —** players will purchase resources that will be used both for project implementation and as "prevention" against risks;

3. **Risk Management —** the realization of the project and the occurrence of events will be simulated; each player will encounter a certain number of risks that he/she will be able to prevent thanks to the resources purchased or to which he/she will have to succumb.

Structure. Image 5.2 summarises the phases and structure of the game, with a particular focus on the training objective of each phase.

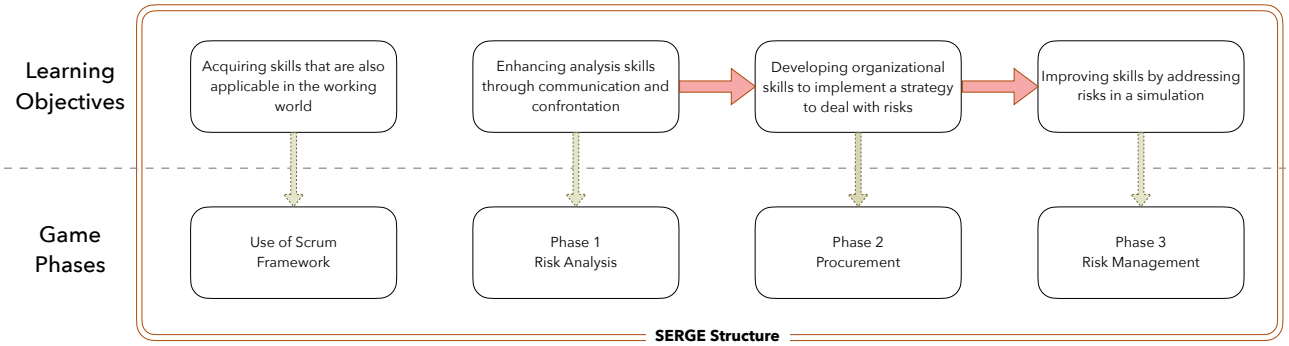

Figure 5.2: SERGE Game Structure

Material. Table 5.1 shows the cards used within SERGE. In addition to these, further material is provided consisting of the following:

- **User Profile** Sheet in which the player is to note down game progress, such as resources purchased and risks encountered
- **Resources** A list of resources that can be used to mitigate risks and implement the project includes skills related to the team, technologies, and the Scrum Master;
- **Notes** A sheet with standard information to be used for noting down one's playing strategies

Further material is present and available in the online appendix [22].

Context. Develop an IT platform for the services offered by the Right to Study Office of the University of Salerno, which are (1) Examination Support and (2) Tutoring Activities. More specifically, the system we propose shall (1) Manage the services offered to students with disabilities; (2) Manage the process of requesting a service from students with disabilities; (3) Manage the contract of tutors responsible for supporting students with disabilities; (4) Track the activities involving each stakeholder, clarifying the responsibilities of them.

Technical Data Sheet.

- Number of Team Members: 7;
- Time frame: 3 months
  - 3 Sprints lasting 3 weeks each;
- Cost: 13,500 €;
- Approach used: Agile, specifically the Scrum framework;
- Deliverables to be realized: Every possible document required for the development of the system;
- Contingency Funds: 7% of the total amount, which corresponds to € 900, divided into 2 High Tokens, 1 Medium Token, 1 Low Token;
- Resource Funds: 3 High Token, 3 Medium Token, 4 Low Token.
- Token Value: High = €250, Medium = €200, Low = €150

Table 5.1: Cards of SERGE

Card	Name	Description
	**Risk Card**	Risk cards have (1) id, (2) name, (3) description, (4) prevention plan (list of resources to have to prevent that risk), and (5) contingency plan (impact of the risk).
	**Event Card**	When an event card is drawn, it is necessary to re-evaluate the impact and probability of one or more risk cards
	**Impact Card**	Used in Planning Poker to indicate the impact (High, Medium, or Low) that a given risk has on the project should it occur
	**Probability Card**	used in Planning Poker to indicate in percentages (from 0% to 100% on a scale of 20%) the probability that a given risk has of occurring
	**Jolly Card**	Using the Jolly card (only once in the whole game) is a possibility to reverse the level of two purchased resources
	**Info Card**	Set consisting of 6 guide cards, which are provided to each player to remember the rules and stages of the game quickly.

CHAPTER 6

EXPERIMENT AND VALIDATION

As explained in section 3.1, the thesis work has two fundamental objectives. (1) to support the learning of Risk Management through the realization of a Serious Game that enhances these skills; (2) to understand the emotions aroused by players who participate in the aforementioned Serious Game. A validation experiment was conducted in several stages to fulfill these two objectives. The first phase aims to measure whether there is any change in the student's level of knowledge immediately after using the Serious Game. The second phase also occurs immediately after using SERGE, and participants are asked to fill in a questionnaire to communicate the emotions that the Serious Game has created. In the last phase, the results obtained in the first phase, relating to risk management skills after using SERGE, are compared with results obtained from a control group to obtain further feedback on the effectiveness of the Serious Game. Image 6.1 describes the various stages of the experiment with the corresponding steps. Phase 2 and 3 appear to be independent, and the priority between them is indifferent, but both need to be performed after the 1.

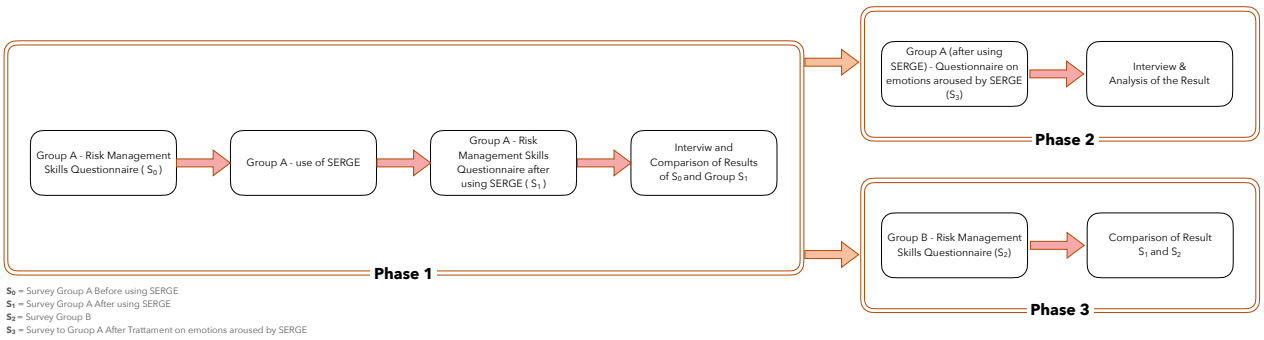

Figure 6.1: Phases of Experiment

6.1 Description of the Experiment

We are going to describe the experimental process and the various steps, according to the steps illustrated by Fenton and Bieman [23] and Wohlin et al. [24].

Definition of the experiment The experiment's main objective is to ensure that the realized Serious Game fulfills its objectives to support the learning of Risk Management by increasing skills.

6.1.1 Experiment's Context

Chapter 2 explains the background of Risk Management. In particular, it is emphasized how complex it is to transmit this knowledge in the learning environment. To support this, Serious Games have been created; they utilize elements of simulation and gamification to make learning fun and engaging. Therefore, we want to validate SERGE, the Serious Game created, to analyze whether the risk management skills of the game participants increase after its use.

Participants. SERGE—described in paragraph 5.3—targets students attending a software project management course. Thus, students from the software project management course held in the department of Computer Science at the University of Salerno were chosen for the experiment. A sample of 20 students was chosen (of which 40% female and 60% male); they already formed project manager pairs for a single project, so a total of 10 pairs (3 female-female pairs and 7 male-male pairs). Of these ten pairs, 5 were selected to be part of Group A (2 female-female pairs and 3 male-male pairs). While the remaining 5 pairs (one female-female and the other 4 male-male pairs) were chosen to represent Group B (i.e., the Control group). Participants were chosen *no-probabilistically*, specifically in a **Convenience Sampling** manner—as also illustrated by Corbin and Strauss [25]—were contacted to take part in the experiment, in return they received a small participation fee as an incentive.

Location and Material. The first and second phases of the experiment were held in the SeSa—Lab-Laboratory of Software Engineering Salerno—at the University of Salerno, to isolate the participants in a quiet place without external distractions. In contrast, the third phase was held in the Software Project Management course room before the relevant lesson. The participants used SERGE and all materials [22] provided by it—described in the paragraph 5.3. The questionnaires,realized with multiple answers, proposed to the participants were carried out on the google forms platform. To realize the questions in the questionnaire, we relied on the topics outlined in the PMBOK [1]. The questions from the summary questionnaires of Goodrich [26] and Schwalbe [27] were taken as a starting point for the realization of our questions.

The completed questionnaire consists of 6 multiple questions (worth 6 points, one point for each correct answer) and two sets of quantitative answers. Was describing the scenario of a project, in the first set, you are asked to associate a value with the 7 listed risks (ranging from low probability to high probability). In the other set, you are asked to identify how indispensable the 7 proposed resources are (ranging from not very necessary to very necessary). Each correct answer is worth one point, and a maximum of 14 points is possible. The questionnaire proposed to the participants has a maximum score of 20 (6 for the multiple questions and 14 for the quantitative). The questions in questionnaires S_0, S_1 and S_2 are the same, we will consider them as 3 different questionnaires because different groups complete them at different times, so we expect a different result. In particular, we have that questionnaire S_0 was realized for group A before using SERGE, S_1 for group A after using SERGE, S_2 for group B, and S_3 on the emotions aroused by game of group A after using the Serious Game created, SERGE.

Exemple of Questions. Here are some significant examples of questions in the questionnaire.

- *During a project progress check, one realizes that the delivered artifacts have ambiguities and conflicting elements/components. This case may be due to the:*
  - Lack of competence of team members
  - Inadequate technology
  - Conflicts within the team
  - Lack of domain knowledge
- *We are approaching the final delivery of the project (the last sprint of two weeks). We will check the artifacts our Team Members produced and realize that some are incomplete. How do we prevent delays in delivering the artifacts for the final sprint?*
  - Increase the number of Team Members (more team members = more parallelisation of work)
  - We focus only on the most important artefacts to deliver at least those
  - We ask the Product Owner and Customer for an extension of the delivery date
  - We carry out a new resource and time schedule with the aim of getting back on schedule.
- *We are in the Risk Identification phase. We are going to consider as Triggers factors such as (1) General discontent and fatigue on the part of team members due to the stress of the job; (2) Artefacts made with delays on the schedule; (3) Artefacts of poor quality due to excessive stress on the part of Team Members; What is the risk we are considering, given the combination of the explicit Triggers?*

- Delivery delays
- Low competence of team members
- Poor customer presence
- Error in scheduling activities and allocation of resources

6.1.2 Formulation of Hypotheses and Definition of Variables

To prove that the realized game fulfills the set objective. The null hypothesis was formulated:

Hn_0 *The risk management skills of **group A** after using SERGE (results of S_1) were very similar to those of the control group B (results of S_2) and also to group A before using SERGE (results of S_0). (results of $S_0 \cong$ results of $S_1 \cong$ results of S_2)*

On the other hand, we aim to reject this null hypothesis, thus showing the validity of the Serious Game. For this reason, the following alternative hypotheses have been identified:

Ha_0 *The risk management skills of group A before using SERGE (results of S_0) are higher than those of group A after using SERGE (results of S_1) and group B (results of S_2), which are very similar to each other. (results of $S_0 >$ results of $S_1, S_2 \wedge$ results of $S_1 \cong$ results of S_2)*

Ha_1 *The risk management skills of group B (results of S_2) are higher than those of group A both before (results of S_0) and after using SERGE (results of S_1), which are very similar to each other. (results of $S_2 >$ results of $S_0, S_1 \wedge$ results of $S_0 \cong$ results of S_1)*

Ha_2 *The risk management skills of group A after using SERGE (results of S_1) are higher than those of group A before using SERGE (results of S_0) and group B (results of S_2), which are very similar to each other. (results of $S_1 >$ results of $S_0, S_2 \wedge$ results of $S_0 \cong$ results of S_2)*

As also illustrated in the book by Wohlin et al. [24]. The dependent, independent, and cofactor variables were identified to conduct the experiment. We intend to understand the level of risk management knowledge of the participants and how it varies after using the Serious Game. Thus, we posed as an **independent variable** for our experiment is the use of Serious Games. The variables considered as **variable dependent** for our experiment are: (1) the answers to the questionnaire, and (2) knowledge about risk management; A **cofactor** that could exist for our experiment is related to the participants' prior experience in risk management.

Multiple-choice questionnaires were used to quantify risk management knowledge; they were evaluated by counting the number of correct answers given in total and calculating a mean and median for each questionnaire completed (S_0, S_1, and S_2).

In addition to using the questionnaires, interviews were conducted with the participants in group A_{AS} to obtain further feedback regarding it and their perceptions of using the Serious Game.

6.1.3 Experiment's Design

First Phase. We go on to identify, as a factor for our experiment, the risk management skills of the participants. Our aim is always to assess whether these competencies change after using SERGE. We can use the **Completely Randomised Design** [28] as the design for the experiment. By identifying risk management skills as a factor and as treatments:

1. **Treatment 1 —** Fill out the knowledge questionnaire;
2. **Treatment 2 —** Use the Serious Game and fill out the knowledge questionnaire.

The table 6.1 will show the distribution of treatments for the same Group A, which will be divided into Group A_{BS} (Before using the Serious Game SERGE) and Group A_{AS} (After using the Serious Game SERGE) to identify that they are the same group. However, we can refer to them by different names because they represent the same Group bat at two different times. The first treatment will be the performance of the first questionnaire (labeled as S_0) at the SeSa Lab. The second treatment will be using the Serious Game SERGE and then carrying out the questionnaire (labeled as S_1), also at the SeSa Lab.

Prior to experimenting, the participants in group A all attended the Risk Management lecture in the Software Project Management course. The material provided to the participants for this phase of the experiment included (1) the link to the questionnaire on Google Forms, (2) the SERGE game material, (3) additional sheets and pens for further notes;

After using SERGE and realizing the questionnaire, labeled with S_1 the participants were interviewed to collect their thoughts on SERGE and the experience. These interviews took place separately for each participant immediately after using the game and at the SeSa Lab.

Table 6.1: Design of the First Phase of the Experiment

Group	Treatment 1	Treatment 2
Group A_{BS}	Questionnaire S_0 — SeSa Lab	
Group A_{AS}		SERGE & Questionnaire S_1 — SeSa Lab

Second Phases. This second phase aims to understand the states of mind aroused by using the Serious Game SERGE. This phase was conducted in the SeSa Lab—Software engineering laboratory—at the University of Salerno. The design [29] of the experiment to conduct this investigation is based on gathering information in three steps. (1) Participants were observed during the game in the first step, (2) A questionnaire was then conducted, (3) Finally, interviews were conducted. The participants in this phase were those belonging to group A. The experimental material provided to them included the link to the questionnaire on Google Forms.

Third Phase. The third phase of the experiment turns out to be similar to the first phase. Our aim here is to confirm the results obtained from the first phase by repeating the experiment with a control group labeled as Group B and compare the results obtained with those of the first phase in Group A_{AS}. We applied the Completely Randomised Design [30] as the design. As a factor in the experiment, we always have our objective, i.e., risk management skills. The treatments to which we subjected the participants are (1) filling in the questionnaire on risk management skills; (2) using SERGE and filling in the questionnaire on risk management skills. The place where the second treatment took place was the SeSa Lab, and the participants were those labeled as group A (first phase of the experiment). The first treatment took place in room F5, building F2 at the University of Salerno, Department of Computer Science, before the Software Project Management lesson. Table 6.2 summarises the design of the experiment's third phase. As experimental material, the participants were provided with Google Forms for questionnaires, SERGE 5.3 game material, additional sheets, and note pens.

Table 6.2: Design of the Third Phase of the Experiment

Group	Treatment 1	Treatment 2
Group B	Questionnaire S_2 — room F2	
Group A_{AS}		SERGE & Questionnaire S_1 — SeSa Lab

6.2 Execution of the Experiments

The following section illustrates how the experiments covered in section 6.1 occurred.

6.2.1 First Phase

The experiment was conducted at the SeSa Lab (Salerno software engineering laboratory) at the University of Salerno. All participants in the experiment had the same background knowledge of Risk Management, having attended the relevant lecture given during the Software Project Management course. The participants went to the laboratory and were sent the link to the first questionnaire, the answers to that questionnaire are those labeled S_0. After completion of the latter, the participants used SERGE. They were divided into pairs (according to the pairs already formed for the software project management). To maintain the participant's anonymity, each was assigned an ID, following the number of the pair and participants within it. The IDs vary in A11, A12, A21, A22, A31, A32, A41, A42, A51 and A52. After conducting the questionnaire, the participants viewed the material provided by the Serious Game SERGE (described in section 5.3). Participant A41 played the role of 'game presenter,' reading the leaflet to the others. Afterward, the participants started to take part in the game. Once that SERGE had been completed, the participants were again given the same questionnaire. The answers to that questionnaire are those labeled S_1. After completing the questionnaire, the participants were uniquely called for a further interview regarding their experience and thoughts on SERGE. Below are some of the questions that were asked:

- *Do you find the Serious Game SERGE complex to use?*
- *Would a digital version be better than the non-digital version you used?*
- *What aspects did you enjoy most about using SERGE?*
- *Which aspects would you change in SERGE, and why?*

6.2.2 Second Phase

The second phase was conducted immediately after the execution of the first, in part, even simultaneously. The participants in the experiment were group A, who were already at the SeSa Lab— Software Engineering Laboratory—at the University of Salerno. The second phase aims to understand the states of mind that the use of SERGE triggers in the participants. In order to understand which feelings to go and analyze, we focused on the positive and negative moods analyzed by López et al. [8]. During the first phase, while the participants were using SERGE, they were observed by the game's creators to see how the participants reacted to it.

Each was given an ID according to the number of the pair and the number of participants within it. These IDs were A11, A12, A21, A22, A31, A32, A41, A42, A51, and A52.

After the conclusion of the game and the first phase of the experiment, the participants were provided with the Google Forms link to fill in the questionnaire concerning the emotions aroused during the game. The type of questions provided was in a range format. Following the various moods to be analyzed, the participants were asked how much they reflected themselves in them, ranging from 1 (few) to 5 (much). After the end of the questionnaire, interviews were conducted individually with the participants to understand their moods further. Below are some of the questions that were asked of the participants.

- *Did you feel involved and enticed to participate in SERGE?*
- *Did the climate create, while using the game, influence your performance and the outcome?*
- *Does your perception of SERGE provoke positivity or negativity in your use of Serious Games?*
- *Are you inclined to use a Serious Game again? Would you recommend it to others?*

6.2.3 Third Phase

In the third phase of the experiment, a control group (labeled as group *B*) is used to replicate the results and confirm the outcome of the first phase. In order to carry out this comparison, the results obtained by group B were compared with those already obtained in the first phase by group A_{AS}, i.e., group A after it had undergone treatment 2, use of SERGE, and completion of the Risk Management skills questionnaire. As the control group only had to complete the questionnaire, it was unnecessary to provide them with an identifier to ensure their anonymity. Before being subjected to the experiment, the participants in group B also attended the Risk Management lesson held in the Software Project Management course at the University of Salerno.

The participants (group B) went to room F5 in building F2 of the Computer Science Department at the University of Salerno. Before attending the Software Project Management lesson, they were asked to participate in the experiment. The 10 participants isolated themselves from the rest of the class. They were provided with the Google Modules link and logged in to the questionnaire using the appropriate devices. At the end of the questionnaire, the conductors of the experiment confirmed the arrival of the ten completed questionnaires.

6.3 Results of the Experiment

In the following section, we will illustrate the results obtained from our experiment.

6.3.1 First Phase

We obtained the answers given by Group A_{BS} (Group A before using SERGE), labeled S_0, concerning their competencies in Risk Management. These responses were compared with those of Group A_{AS} (Group A after using SERGE), labeled S_1. Image 6.2 shows, in broad terms, the metrics indicating the distribution of votes between the two questionnaires.

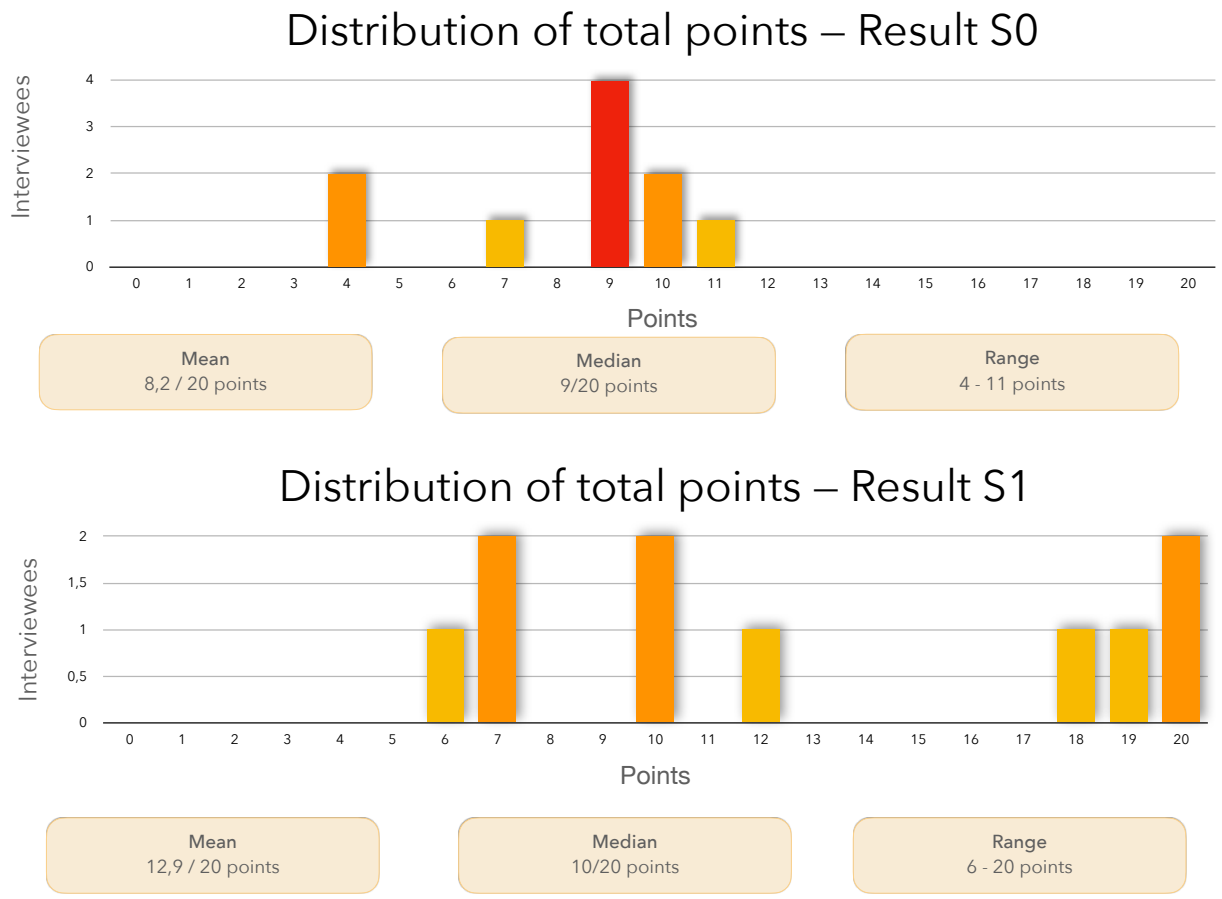

Figure 6.2: Comparison and distribution of S_0 and S_1 questionnaire scores.

It is immediately evident how the scores improved. We can see how the average went from 8.2 to an impressive 12.3. The median value is also higher, although only by one point. However, above all, the range increased significantly, from a minimum of 4 to a maximum of 11. We obtain a minimum of 6 and a maximum of 20, i.e., the maximum score achieved by no less than two participants. We analyzed the individual questions, and two cases particularly caught our interest, blatantly demonstrating how the use of SERGE immediately increased their knowledge.

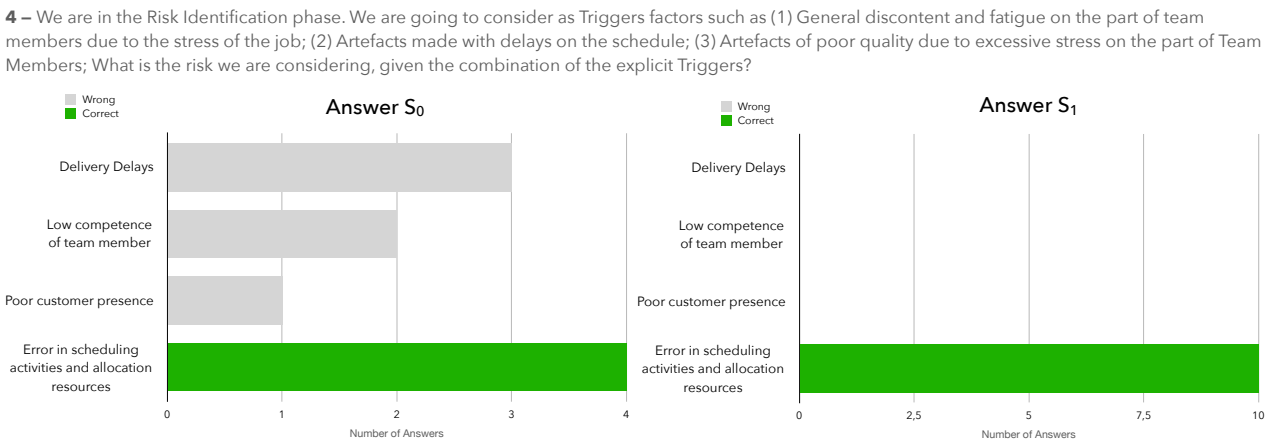

Figure 6.3: Comparison of the answers in questionnaire S_0 and questionnaire S_1 to question 4.

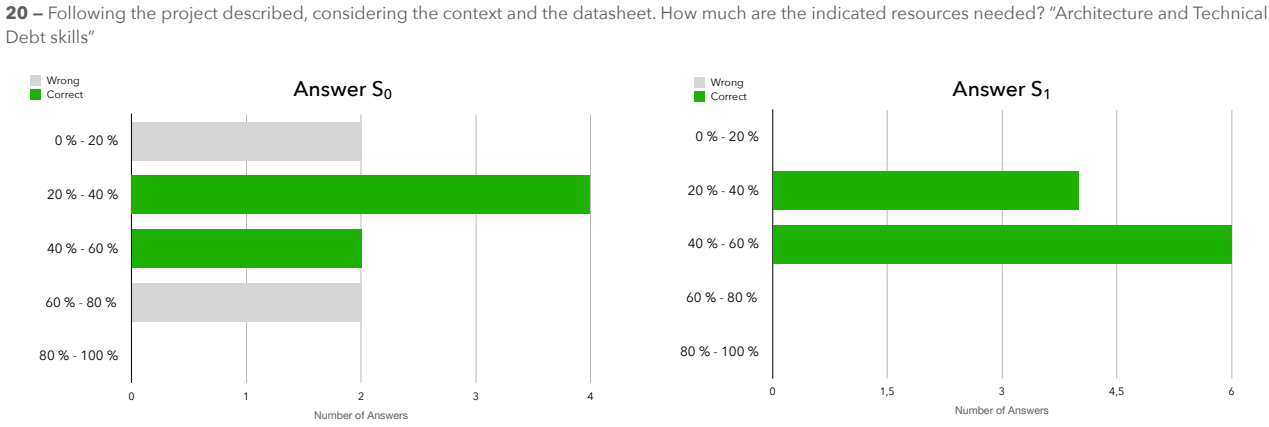

Figure 6.4: Comparison of the answers in questionnaire S_0 and questionnaire S_1 to question 20.

Both answers state how after using SERGE, all participants were to give the correct answer. Image 6.3 shows the question in which, given a list of triggers, one is asked to understand what risk they are associated with. We note how, initially, the answers were very confusing and distributed among the various choices. However, after using SERGE, unanimity was reached on the correct answer. After using SERGE, the answers to question 20, image 6.4 is also unanimously correct. Whereas, before the Serious Game, they were essentially correct, but with a slight distribution among the wrong answers. In contrast to the previous question, question 20 illustrates a project by describing its context and technical data sheet and asking the participants to understand how necessary are the resource in exam. We can therefore be satisfied with the analysis of these responses. In addition to these highly positive cases, there were also negative cases, in figures 6.5 and 6.6. Both questions with an effect that can be considered "negative" are of the same type as question 20. The number of correct answers remains the same in question 14, image 6.5, and 16, image 6.6, also the distribution of answers varies between the two questionnaires.

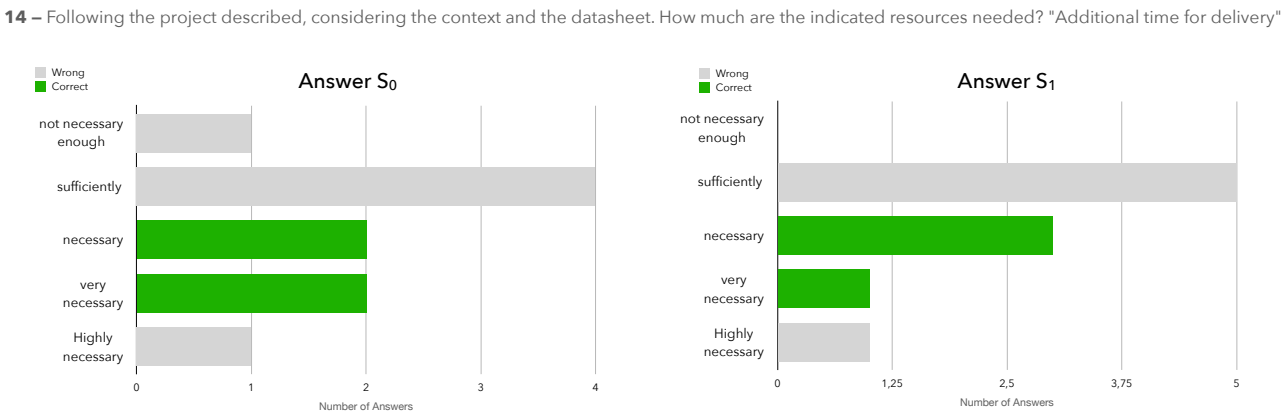

Figure 6.5: Comparison of the answers in questionnaire S_0 and questionnaire S_1 to question 14.

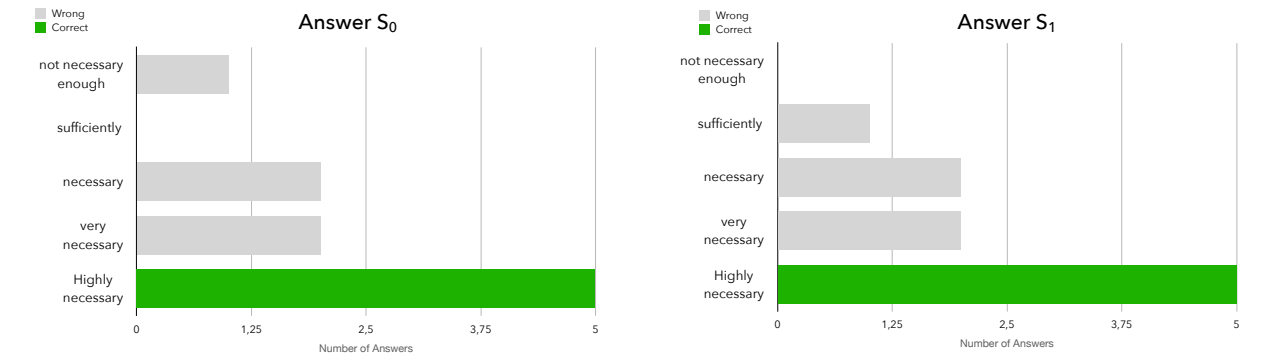

Figure 6.6: Comparison of the answers in questionnaire S_0 and questionnaire S_1 to question 16.

Despite these two responses, we can be extremely satisfied with the results.

From the interviews conducted at this stage, exciting insights were found from the participants. Participant A32 said *"The presence of the info cards made it much easier to use the game. They were an excellent idea"*. *"Of course, digital is nice and simplifies many things, but you lose the game's beauty. In that, everything becomes too detached, and there will be no more communication and involvement, the interaction between the various players will be lost"*.

Also essential were the considerations of participants A12, A22, and A42, who said *"the first phase was much fun. We felt involved and encouraged to participate. The reasoning we did to agree on the values to assign to the risks was stimulating; it made us realize so many things that we did not consider before when we were thinking about risks"*. All participants agreed that by reading the leaflet, the game turned out to be complex, but once the game started, everything was very simple. Another point of agreement among all the players was that some of the game's mechanics (especially in the

third phase, given the changes in impact and probability due to unexpected events and the control over risks) would be simpler if handled digitally. Therefore, everyone agrees that a digital version would be great for these reasons but would lose a lot of the involvement and exchange of ideas factor given by the first phase. Regarding this, A21 expresses itself with *"Of course, digital is nice and simplifies many things, but you lose the game's beauty. In that, everything becomes too detached, and there will be no more communication and involvement, the interaction between the various players will be lost"*. Another important observation was made by player A51, who states that *"the jolly card, even though it was meant to be a support to change resources and thus be able to mitigate some of the risks that I have often encountered, turns out to be equally risky. Many of us have been afraid to use it because its use would lead us, yes, to be able to mitigate risks that we may have already faced and been unable to prevent, but it would also lead us to fail to prevent risks that we were previously able to do"*. A final but significant point was raised by players A41, A32, and A51, who argued *"the use of 0% and 100% as extremes of the range for the probability of risks is incorrect, as 0% indicates 'never' while 100% indicates 'definitely'. This is unrealistic; it would be more appropriate to indicate 1%, which would indicate 'a rare case but still possible', and 99%, which indicates 'almost certainly can occur, but I might have that 1% of salvation' "*.

6.3.2 Second Phase

To conduct this phase, information was received using observation, a questionnaire survey, and individual interviews. Observing the SERGE participants, it was evident that some players stood out from the start. In particular, player A41, due to his powerful and charismatic personality, took the reins of the game, introducing positivity and negativity. Some more shy players, such as A11, A12, and A22, felt more comfortable with someone who shifted the focus away from them, also finding it easier to open up with other players and get involved. While other players, such as A52, felt somewhat excluded and demotivated, as they felt belittled. During the first phase of the game (Risk Analysis), all players collaborated by peacefully agreeing on the impact and probability of being associated with them. While in the third phase (Risk Management), the climate almost completely changed. By drawing lots for the risks and finding out who could mitigate them and who was not, competitiveness and resentment towards others flared up. The outcome of the game observation yielded very positive results and expectations. The questionnaire met these expectations. As image 6.7 shows, we can see that as many as 8 out of 10 players gave the highest score on interest in the game. The competitivity was almost equally distributed among the participants; none related in a hostile manner to the game.

The sentiments deemed as *positive*, including Interest, Exaltation, Competitiveness, Satisfaction, Participation, and Determination, were rated highest by others. In contrast to feelings deemed as

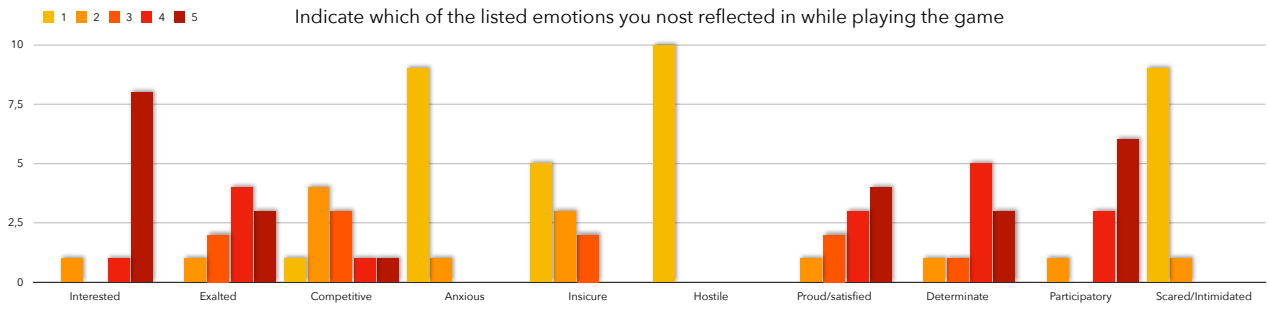

Figure 6.7: Results questionnaire S_3 on emotions triggered by SERGE

negative such as Anxiety, Hostility, Fear, and Insecurity, which scored many low faces.

The interviews conducted further confirmed these findings. In particular, we mention some statements such as that of A21, who stated *"I got very involved in the game, and I would do a similar experience again"*. Player A31 stated *"the game ignited my competitive spirit, but it also gave me much useful information. I had much fun and enjoyed comparing myself with others"*. Of particular importance were also the statements of A52, who said *"Initially, I felt that I was not up to it, that I was not suitable to participate in this Serious Game, but as the game progressed, my doubts and fears slowly disappeared. I would do a similar experience again"*.

6.3.3 Third Phase

The third phase of the experiment was aimed at verifying whether the skills acquired by Group A_{AS} (Group A, after using SERGE), labeled with S_1, were better than those of the control group, Group B, with the responses labeled with S_2. Image 6.8 summarizes the distribution of the marks found from the two questionnaires. We can see that the scores are significantly better for the participants in SERGE. The mean score is an impressive 12.9, in contrast to Group B's 7.9. The median is also two points higher, from 8 to 10. Nevertheless, the most striking difference is the range. It varies from a minimum of 5 to a maximum of 10, to a minimum of 6, and a maximum of 20, with as many as two students scoring the highest.

Below are some questions and the answers that best highlight the results obtained. In particular, let us see question 4, illustrated in figure 6.9, in which, given a list of triggers, the participant is asked to identify the risk they are associated with. We note that the answers of those who took part in SERGE turn out to be unanimously correct, unlike the answers given by group B, which are

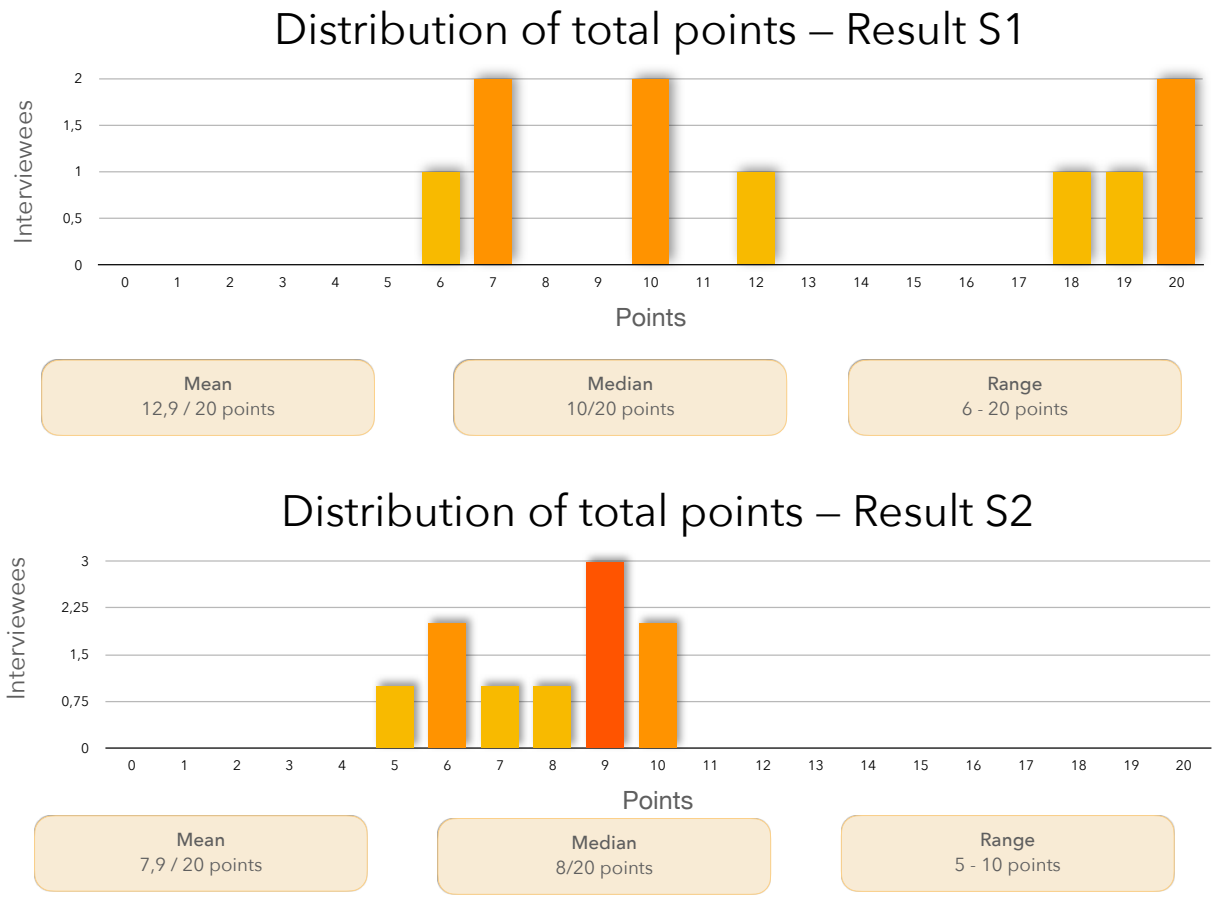

Figure 6.8: Comparison and distribution of S_1 and S_2 questionnaire scores.

distributed. Similarly, answer 20, shown in image 6.10, is also answered unanimously correctly by those who took part in SERGE, while for group B, we see good results and some wrong answers.

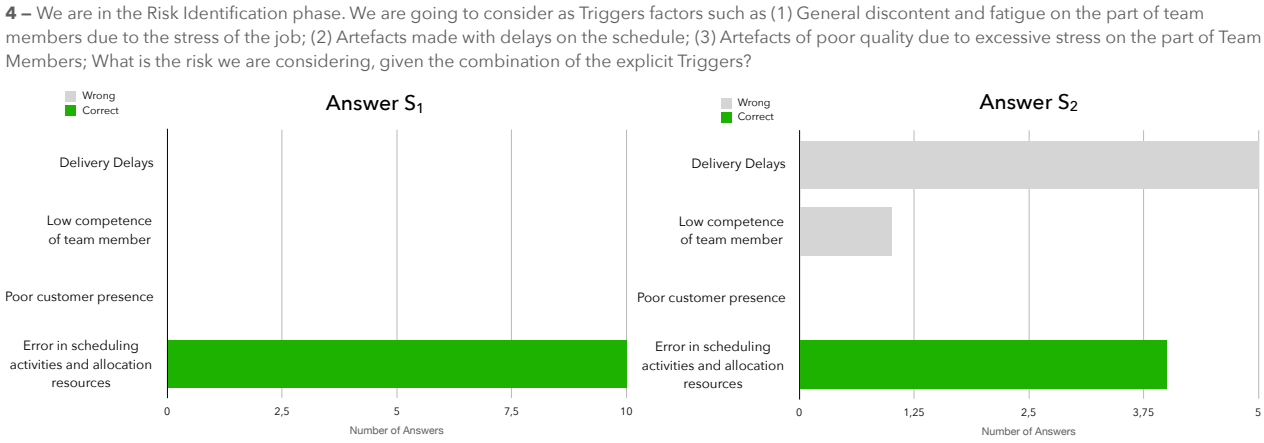

Figure 6.9: Comparison of the answers in questionnaire S_1 and questionnaire S_2 to question 4.

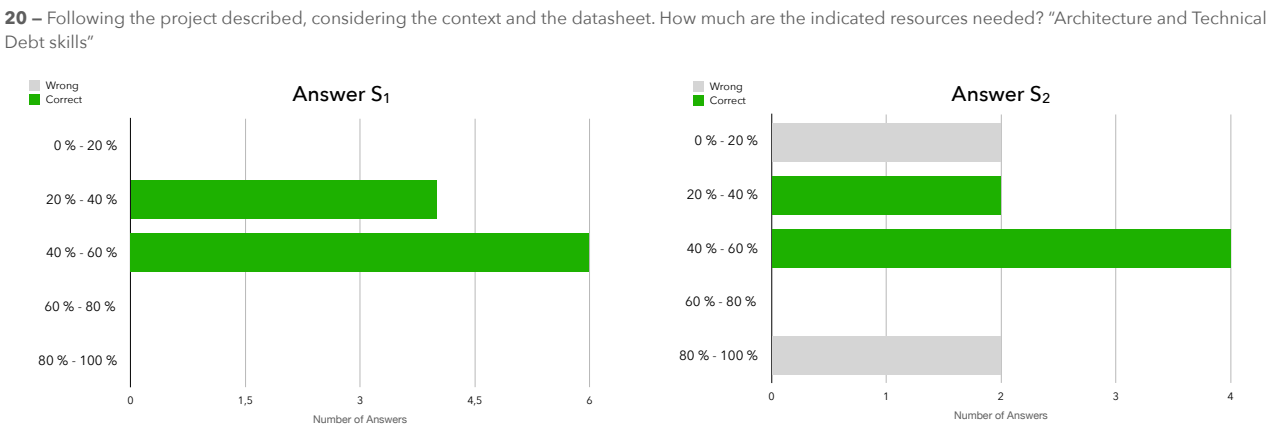

Figure 6.10: Comparison of the answers in questionnaire S_1 and questionnaire S_2 to question 20.

We can be satisfied in confirming the results of the experiment's first phase, even in this third phase. Nevertheless, even in this phase, plenty of cases left us wanting. Below are two questions whose answers did not meet our expectations. In particular, we can see no improvement in response to question 6, Figure 6.11, and the distribution of responses also seems almost unchanged.

What aroused our doubts most was question 12, Figure 6.12, whose number of correct answers was higher for group B, even if only by one point. This might lead us to hypothesize that the Serious Game created confusion in the participants' ideas regarding the question's subject matter. This could be interesting food for thought for future work.

Leaving aside the two episodes illustrated, but based on the general trend of the questionnaires, shown in figure 6.8, we can be extremely satisfied with the outcome of this phase.

Figure 6.11: Comparison of the answers in questionnaire S_1 and questionnaire S_2 to question 6.

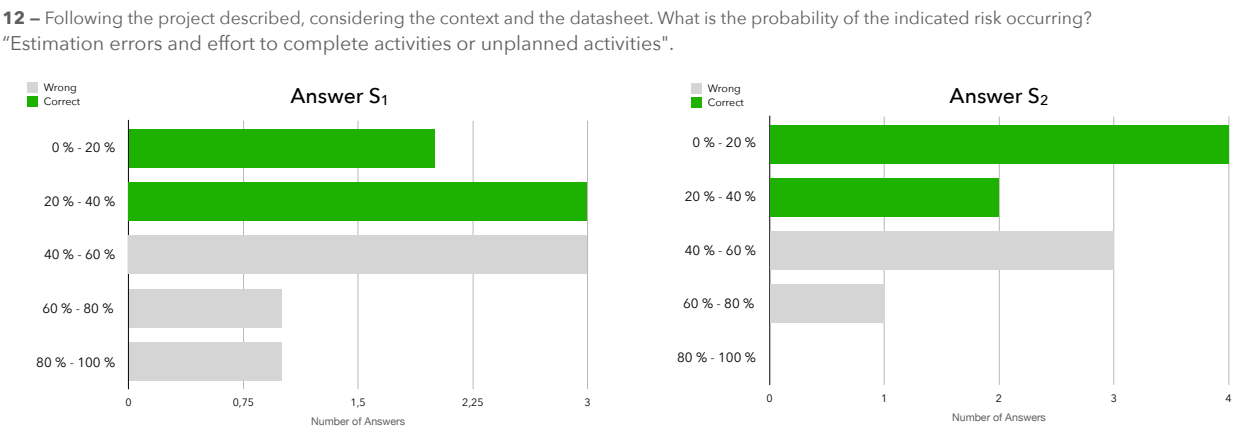

Figure 6.12: Comparison of the answers in questionnaire S_1 and questionnaire S_2 to question 12.

6.3.4 Final Results

From the considerations made in the previous sections, we can state that our goal has been achieved; that is, to demonstrate that the use of SERGE to support learning in risk management leads to improved skills. Figure 6.13 shows the distribution of questionnaire scores from Group A_{BS} (Group A before using SERGE), labeled S_0; Group A_{AS} (Group A after using SERGE), labeled S_1; Group B, the control group, labeled S_2.

It is clear from the results obtained that using SERGE improved the participants' skills. The mean of the S1 questionnaire (12.9) was higher than that of the S_0 (8.2) and S_2 (7.9) results. The same applies to the median; in S_1 result is 10, whereas in S_0, it is 9, and in S_2, 8, thus undoubtedly lower. However, the most striking comparison is in the range of results. Whereas S_0 and S_2 ranged from 4/5 to 10/11, S_1's results ranged from 6 to 20, even reaching the highest score.

To show how the distribution of the answers varies across the three phases of the experiment, we have reported some questions that show us these answers. In particular, in question 4, figure 6.14, those who participated in the Serious Game SERGE answered the correct item unanimously. In contrast, the answers are randomly distributed in the other two cases (S_0 and S_2).

Another interesting observation was made by question 12, figure 6.15. As illustrated in the previous paragraph, the number of correct answers in S_2 is one point higher than in S_1. However, comparing these numbers of correct answers with questionnaire S_0, we see that those of S_1 are higher. Thus, the hypothesis that the game may have confused the players concerning this question and led them toward a wrong answer can be rejected.

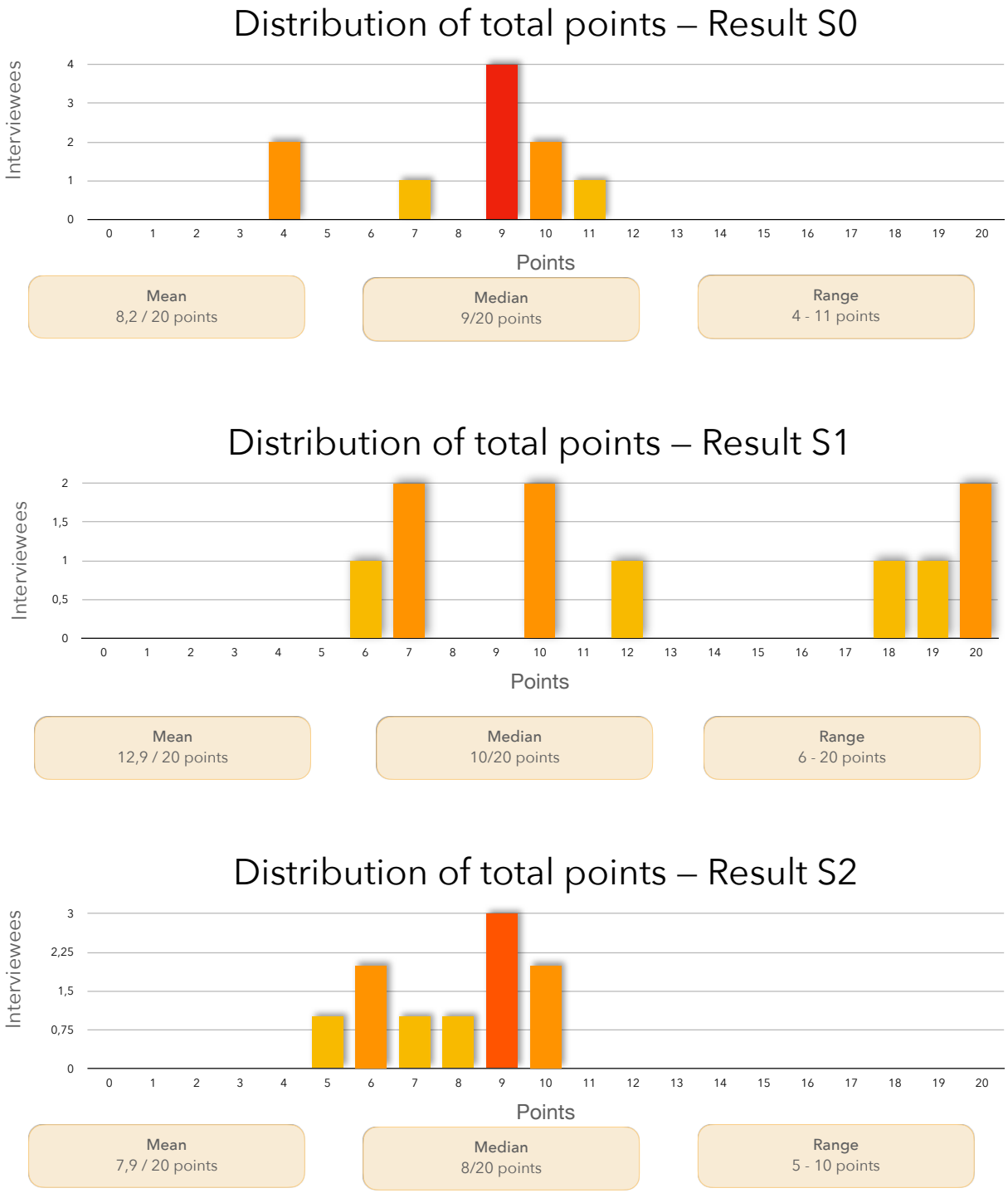

Figure 6.13: Comparison and distribution of S_0, S_1 and S_2 questionnaire scores.

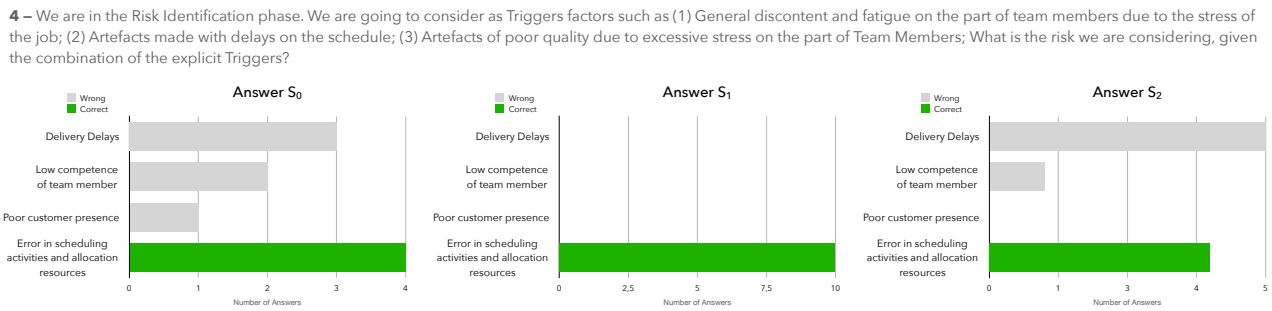

Figure 6.14: Comparison of the answers in questionnaire S_0, S_1 and S_2 to question 4.

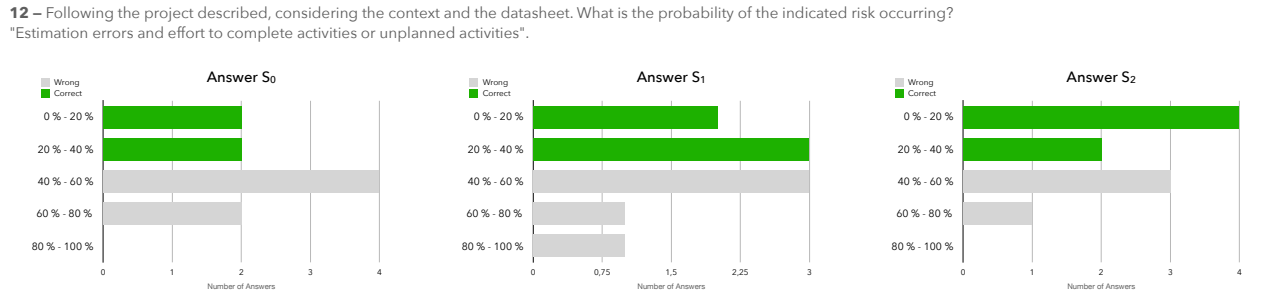

Figure 6.15: Comparison of the answers in questionnaire S_0, S_1 and S_2 to question 12.

From the results shown in image 6.13, we can state that the number and distribution of responses from questionnaires S_0 and S_2 are very similar. Moreover, both are lower than the value of the results of S_1. Given this conclusion, it is clear that the null hypothesis we had set ourselves is rejected (i.e., Hn_0 : The risk management skills of **group A** after using SERGE (results of S_1) were very similar to those of the control group B (results of S_2) and also to group A before using SERGE (results of S_0). ($S_0 \cong S_1 \cong S_2$)). The alternative hypothesis that is accepted is Ha_1 which states The risk management skills of group B (results of S_2) are higher than those of group A both before (results of S_0) and after using SERGE (results of S_1), which are very similar to each other. ($S_2 > S_0, S_1 \wedge S_0 \cong S_1$).

Finally, following the results of the second phase, it was evident to understand that the moods analyzed and resent during SERGE fall within those as positive feelings, through which the Serious Game left a positive impact on the experience of the participants who stated that they would like to repeat a similar experience.

CHAPTER 7

THREATS TO VALIDITY TO THE EXPERIMENT

This chapter illustrates experiment's threats to the validity and the way we mitigated them.

7.1 Threats to Conclusion Validity

Threats to *conclusion* validity concern the relation between treatment and outcome and are related to issues that affect the ability to draw the correct conclusions at the end of the work. Two different conclusion threats to validity were identified:

1. Random Irrelevancies in experimental setting;
2. Reliability of measures.

Random Irrelevancies in experimental setting. One of the main threats to the experiment's validity may be determined by the environment in which it is conducted. Undoubtedly, an environment exposed to the presence of others could influence the participants, as they could become distracted or communicate with people from outside the experiment, which would influence the answers that the participants would submit. To avoid this risk, the experiment was conducted at the SeSa Lab - Software Engineering Laboratory of Salerno- at the University of Salerno. At the same time, the third phase was conducted in lecture hall F5 of building F2 of the Computer Science department at the University of Salerno before the students attended the software project management lesson.

Reliability of measures. One of the indispensable objectives when experimenting is ensuring the results' replicability. At the same time, one of the greatest threats is not being able to obtain the same results by applying the treatment twice, even if I take two samples from the same population. To ascertain the validity of the results and the replicability of the experiment, we experimented ourselves twice. A first run was in the first phase, in which group A was used for both treatments, dividing them into A_{BS} (Group A before using SERGE) and A_{AS} (Group A after using SERGE). While a replication occurred in the third phase, in which we used group A_{AS} for the second treatment and group B (control group) for the first. Recall that the two treatments are (1) answering the Risk Management skills questionnaire; (2) using the Serious Game Serge and answering the Risk Management skills questionnaire.

7.2 Threats to Internal Validity

Threats to *internal* validity concern factors that might have influenced the obtained results without the researcher's knowledge. Three different internal threats to validity were identified:

1. Maturation;
2. Selection;
3. Testing.

Maturation. The first phase of our experiment is to take a sample of 10 students from the software project management class and present them with a questionnaire on risk management skills. After using SERGE Serious Game, they repeated the questionnaire to see if there was an increase in skills. The famous learning factor may be a threat to validity at this experiment stage. By filling out the questionnaire twice in a row, the participants' answers could be influenced by memorizing the questions the first time or thinking about them. To mitigate this issue, a further validity check of the results was conducted, comparing them with those of a control group consisting of another sample of students also belonging to the Software Project Management class.

Selection. The chosen players are a sample selected from the students in the GPS class. They were personally contacted to ask them to participate in the experiment. Given how the selection was made, some participants may have felt 'forced' to participate in the experiment and, therefore, may have adopted a hostile behavior towards it, taking part in the Serious Game with little participation. To prevent such situations, an attempt was made to stimulate the participants, perhaps even by means of a small fee for participating in the experiment.

Testing. One of the threats to the validity of the results could be the erroneous provision of feedback to participants after specific tasks. Such feedback could influence the participants' ideas about what they are doing or give them little information about what we expect from the experiment, thus influencing them to complete the questionnaire following such feedback. To avoid the occurrence of such a situation, great care had to be taken in the way the questions in the questionnaire were asked and the way the questionnaire was carried out, avoiding an implicit statement of purpose.

7.3 Threats to Construct Validity

Threats to construct validity concern the relation between theory and observation and are mainly due to imprecision in performed measurements. Three different construct threats to validity were identified:

1. Interaction of Testing and Treatment;
2. Evaluation Apprehension;
3. Confounding constructs and level of constructs.

Interaction of Testing and Treatment. One of the probable threats to validity is the possibility that the participants may realize, perhaps through the description of the Serious Game, that the experiment aims to understand their competencies relating to the aspect of Risk Management. Given this consideration, they might respond to the questionnaire by paying particular attention to these competencies. This threat was mitigated by being careful in how the Serious Game and the experiment were presented; It is essential to remain general in the questions of the questionnaire and not give away any information about our 'objective.

Evaluation Apprehension. Considering that the experiment is based on using a Serious Game and exploits the main elements of a game, this could increase the competitiveness of the participants. Thus, participants may feel obliged to show themselves to be better than others when using SERGE and to carry out the questionnaire. To mitigate this threat, extraordinary steps were implemented, into SERGE, to increase cooperation and communication. In particular, the first phase, the risk analysis phase, is where the players have to cooperate, each giving their opinion to agree on the impact and probability value to be assigned to the risks. This phase stimulates everyone's involvement and emphasizes the importance of communication. Furthermore, to avoid further competition, no prize will be awarded to the winner, letting them know that the important thing is to participate, have fun and learn.

Confounding constructs and level of constructs. For the experiment, a sample of students from the GPS course who participated in the Risk Management lecture is taken. Considering such a selection, one of the possible threats to validity could be to have selected a participant who has already had the opportunity to interface with Risk Management topics and, thus, prior knowledge on the subject. For such a threat not to occur, the experiment participants were selected by asking each of them whether they had already had experience with such a topic or had already studied it elsewhere. In this way, we ensured that all experiment participants had the same risk management background.

7.4 Threats to External Validity

Threats to *external* validity are conditions that limit our ability to generalize the results of our experiment to the real world.

Interaction of Selection and Treatment. A threat of external validity was identified and concerned the possibility of choosing participants with poor pre-requisites. As was described in the experiment, the participants in the experiment turned out to be a sample chosen from the students of the Software Project Management course. There might be a possibility of choosing from the participants someone who did not take part in the Risk Management lecture given in the course. Such a choice could negatively affect the experiment, as the feedback, he or she would provide in the comparison phases might not be appropriate and negatively influence the considerations of others. To mitigate this issue, before selecting the participants, we ensured that each of them had attended the Risk Management lecture given at the course and, therefore, all had the same background on the subject.

CHAPTER 8

DISCUSSIONS

This chapter will outline all the observations made during our work, providing consideration.

Digital VS No-Digital Version of SERGE. One of the first considerations we focused on was the realization of the Serious Game, which could be realized in a non-digital or a digital version. When analyzing the literature and the experiments [14] that had already been carried out comparing these game versions, it became clear that there were no distinct differences between them. What is highlighted is that digital games provide more support by automating many game steps; at the same time, they can provide many examples and guides to simplify their use.

On the other hand, they are very 'rigid' in that they have a well-defined structure, with well-established constraints and rules that must be fulfilled to participate in the game. In contrast, non-digital games enjoy flexibility and inclusiveness, as players can adapt the game according to the number of participants or particular needs of the moment. More importantly, with a non-digital game, there is more interaction between the participants, something that is lost by using the cold mechanisms of a digital game.

In the case of SERGE, a non-digital version was chosen precisely following the 'involvement' factors. One of our goals was to improve their risk management skills by providing a stimulating learning environment and continuous reflection, and above all, due to confrontation with others. With a digital version, this factor of confrontation and communication would have been cold and detached and might not have had the same effect. Specific aspects of the game must be considered very mechanical, such as the third phase, which requires continuous monitoring and constant changes to the game material. This phase would be appropriate to digitize to simplify its use.

Considering the results of the interviews in the first phase of the experiment, the participants

confirm our opinion. The no-digital version finds more positive outcomes from each of them, creating a more engaging environment. Nevertheless, it is also true that automating certain game phases through them would be appropriate. We, therefore, consider it interesting to create a hybrid version that provides the cooperation and communication of the first phase, given by the no-digital version, and the practicality and mechanics in the third phase, given by a digital version.

Serious Game VS Quiz Game. Another point of reflection arose from the literature [15] by using Serious Games and Games, particularly those that exploit Quizzes for learning. From the definition of Serious Games, we know that they encompass Game and Simulation practices. On the other hand, games are the sole factor in exploiting the main elements of games within real contexts. The literature shows that both methods are very effective for teaching purposes. The discussion on this point, therefore, focuses mainly on the type of experience intended for the participants. Considering our objectives, it was more appropriate to use Serious Game and deal with a simulative aspect so that the participants could play the role of a project manager and put themselves to the test. Nevertheless, it would have been interesting to create a game based on quizzes and see, through an experiment, if it also supported the same SERGE teaching.

Serious Game VS Tools for Risk Management. According to the literature, in addition to Serious Games, tools have also been used to support the teaching of Risk Management or to automate this practice. The tool saw, DotProject+, provided simple feedback to users whenever they made mistakes in applying Risk Management so that they could learn how to improve. Serious games, on the other hand, aim to train participants differently. They participate in a simulation, through which they learn notions they can apply in a real context. Developing a Serious Game instead of a tool seemed appropriate when considering the learning factor. In a serious game, the skills that are improved are global in all aspects. In a tool that provides feedback on mistakes and helps the project manager to improve, skills can only be learned if a specific situation occurs. Another important consideration is that it is challenging to find online datasets that deal with information on how to carry out risk management or a risk history that can be used to support users. By this consideration, it is very complex to realize a tool or even a conversation agent (BOT) to support project managers in risk management. One of the discussions before the decision to realize SERGE was about the decision to realize a conversation agent. The objective of such an agent would be to support the project manager by alerting him to possible risks, triggers, and the technical description and factors of the project. The main problem encountered was the database to be used, which took much work to identify. For this reason, our focus was on the educational environment, providing support beforehand and improving the skills already being acquired.

Outcome of question 12 of the questionnaire. As shown in the experiment conducted in Chapter 6, three questionnaires were conducted. The first was conducted by a sample of 10 software project management students, who were subjected to a questionnaire concerning their risk management skills (Group A_{BS}, Group A before using SERGE, results are reported as S_0). Three questionnaires were conducted; the first was conducted by a sample of 10 software project management students, who were subjected to a questionnaire concerning their risk management skills (Group A_{BS}, Group A before using SERGE, results are reported as S_0). Finally, another sample of 10 software project management students was taken, and they, too, were asked to fill in the questionnaire on risk management competencies (Group B, questionnaire reported as S_2). According to the results and expectations, the answers of S_1 were better than those of S_0 and S_2, which were very similar. However, a unique case was presented in which these expectations still needed to be fulfilled. In fact, for question 12 of the questionnaire, it was verified that the answer given by the control group (Group B) was one point higher than that given by the group subjected to the use of SERGE. This made us suspicious, raising the doubt that the game may have confused the participants. Nevertheless, dispelling this hypothesis were the results of the A_{BS} group questionnaire. Before being subjected to SERGE, the participants in group A gave lower-scoring answers for that question than those given after using the Serious Game. This may have been an isolated case. To confirm this theory, it would be appropriate to carry out further tests by repeating the various experiments that were not conducted further due to time constraints but postponed as reflections for future work.

Considerations on SERGE. Following the use of SERGE, the participants made some interesting comments. One of the significant points of reflection was to change the probability maps to be associated with risks. Currently, SERGE ranges from 0% to 100%, scaled by 20. The participants proposed using 1% and 99% as the extremes of the range, as there is no impossibility of a risk occurring, but there may be a rare case. Similarly, there may be no certainty that a risk will occur, but near certainty. Another consideration was the wild card, which was not used because it was risky. Ideas for future developments of the application can be taken from these considerations.

CHAPTER 9

CONCLUSIONS AND FUTURE WORK

This chapter provides a summary of the work done and its prospects for the future.

9.1 Conclusions

Teaching Risk Management for an agile project management methodology is a very delicate and important practice that is necessary to enrich the skills of future software professionals. In this thesis work, we have dealt with the presentation of a no-digital game to support the teaching of Risk Management in the context of project management courses in computer science degree programs, to enhance the learning process.

In addition to providing support for learning risk management, the main objectives of the game include (1) Enhancing analysis skills through communication and confrontation; (2) Developing organizational skills to implement a strategy to deal with risks; (3) Improving skills by addressing risks in a simulation; (4) Acquiring skills that are also applicable in the working world; (5)Understanding the different states of mind of the participants in SERGE and how their state of mind affected the experience. To meet these objectives, SERGE relies on several steps. The first is when players carry out a risk analysis using planning poker; the second is when they acquire resources by devising their risk prevention strategy; the third is when they simulate the realization of a project and deal with the various risks, preventing, mitigating, or succumbing to them. One of our objectives was to provide knowledge that SERGE participants could exploit in a work context, for which SERGE is based on the SCRUM framework. A sample of 20 students from the software project management class of the computer science department of the University of Salerno was drawn to experiment. These students were divided into groups A and B (control group).

We submitted a questionnaire on risk management knowledge to Group A, obtaining answers S_0. They then participated in SERGE and recompiled the questionnaire, obtaining S_1 answers. To reconfirm the results obtained from the comparison of the two questionnaires, a further experiment was conducted, asking the control group to complete the same questionnaire on risk management skills, obtaining S_2 answers. The results of the three questionnaires were compared, obtaining a very positive response for the results of S_1, which has higher scores than questionnaires S_0 and S_1, which are similar. The only point of discussion was raised by the outcome of a single question in which the answers of the control group were better, albeit by only one point than those of the group subjected to SERGE. A further experiment was conducted by observing and interviewing SERGE participants to understand their moods during the game and how they affected their experience. We found a high concentration of moods considered 'positive', which led the participants to be friendly, cooperative, and, above all, communicative toward others. In conclusion, our objectives for the previous thesis work were all met.

9.2 Future Work

According to the results of the interviews on SERGE and interesting feedback left by the participants, interesting improvements were proposed.

- The first consideration is that the non-digital version is very successful precisely because of the communication and involvement it generates. However, some of the mechanics are very complex, so automating them in a digital version is recommended. To this end, a hybrid version is proposed, which maintains the physical presence of the participants but provides a digital medium. Thus one device act as Game Master and individual devices for the players.

- Another consideration received concerned the game material. Therefore, a modification to it is proposed, reducing the probability range of risks to 1% - 99%. In addition, it is intended to remove the use of the wild card, as it has raised many doubts among players.

- We propose a final change to shorten the third phase of the game. Each player, in turn, rolls the dice, draws a card, and faces that risk. To speed up this phase, it is proposed that the risk drawn be faced by all players, not just the one who drew it. Thus speeding up such a phase. This modification could, however, lead to much monotony in the game, without differentiation between strategies and risks faced, and thus lead to not fully satisfying the training objectives. Therefore, it is proposed that such a version and a possible experiment comparing the current version to the one proposed to be implemented.

REFERENCES

[1] Project Management Institute. *A Guide to the Project Management Body of Knowledge*. 7th ed. Aug. 2021, p. 250. ISBN: 1628256648.

[2] Jhon Masso, Francisco J. Pino, César Pardo, Félix García, and Mario Piattini. *Risk management in the software life cycle: A systematic literature review*. Aug. 2020. DOI: 10.1016/j.csi.2020.103431.

[3] Hooman Hooda and Hassan Rashidi. "Classification and Analysis of Risks in Software Engineering". In: *World Academy of Science, Engineering and Technology* (2019).

[4] Muhammad Hammad, Irum Inayat, and Maryam Zahid. "Risk management in agile software development: A survey". In: Institute of Electrical and Electronics Engineers Inc., Dec. 2019, pp. 162–166. ISBN: 9781728166254. DOI: 10.1109/FIT47737.2019.00039.

[5] Maruf Pasha, Ghazia Qaiser, and Urooj Pasha. "A critical analysis of software risk management techniques in large scale systems". In: *IEEE Access* 6 (Feb. 2018), pp. 12412–12424. ISSN: 21693536. DOI: 10.1109/ACCESS.2018.2805862.

[6] Luigi Buglione, Christiane Gresse von Wangenheim, Alain Abran, Fergal Mc Caffery, and Jean Carlo Rossa Hauck. "Risk Management: Achieving Higher Maturity & Capability Levels through the LEGO Approach; Risk Management: Achieving Higher Maturity & Capability Levels through the LEGO Approach". In: *2016 Joint Conference of the International Workshop on Software Measurement and the International Conference on Software Process and Product Measurement (IWSM-MENSURA)* (2016). DOI: 10.1109/IWSM-Mensura.2016.33. URL: http://www.semq.eu..

[7] Haneen Hijazi, Thair Khdour, and Abdulsalam Alarabeyyat. *A Review of Risk Management in Different Software Development Methodologies*. 2012, pp. 975–8887.

[8] Fernando Rodríguez López, Mario Arias-Oliva, Jorge Pelegrín-Borondo, and Luz María Marín-Vinuesa. "Serious games in management education: An acceptance analysis". In: *International Journal of Management Education* 19 (3 Nov. 2021). ISSN: 14728117. DOI: 10.1016/j.ijme.2021.100517.

[9] Gil Taran. *Using Games in Software Engineering Education to Teach Risk Management*. 2007.

[10] Thair Khdour, Al Balqa, and Haneen Hijazi. *A STEP TOWARDS PREVENTIVE RISK MANAGEMENT IN SOFTWARE PROJECTS*.

[11] Nguyen Duc Linh, Phan Duy Hung, Vu Thu Diep, and Ta Duc Tung. "Risk management in projects based on open-source software". In: vol. Part F147956. Association for Computing Machinery, 2019, pp. 178–183. ISBN: 9781450365734. DOI: 10.1145/3316615.3316648.

[12] Rafael Queiroz Gonçalves, Elisa Kühlkamp, and Christiane Gresse Von Wangenheim. *Enhancing dotProject to support Risk Management aligned with PMBOK in the context of SMEs*. URL: http://omg.org/spec/SPEM.

[13] Rafael Queiroz Goncalves, Christiane A.Gresse Von Wangenheim, Jean C.R. Hauck, and Andreia Zanella. "An Instructional Feedback Technique for Teaching Project Management Tools Aligned with PMBOK". In: *IEEE Transactions on Education* 61 (2 May 2018), pp. 143–150. ISSN: 00189359. DOI: 10.1109/TE.2017.2774766.

[14] Giani Petri, Alejandro Calderón, Christiane Gresse-Von-Wangenheim, Adriano F Borgatto, and Mercedes Ruiz. *Games for Teaching Software Project Management: An Analysis of the Benefits of Digital and Non-Digital Games*. 2018, pp. 1424–1451.

[15] Christiane Gresse-Von-Wangenheim Giani Petri, Jean Carlo, Rossa Hauck, and Adriano Ferreti Borgatto. *Effectiveness of Games in Software Project Management Education: An Experimental Study*. 2015.

[16] Etiane Marcelino and Luísa Domingues. "An analysis of how well serious games cover the PMBOK". In: vol. 196. Elsevier B.V., 2021, pp. 1013–1020. DOI: 10.1016/j.procs.2021.12.104.

[17] Rafael Oliveira Chaves, Christiane Gresse von Wangenheim, Julio Cezar Costa Furtado, Sandro Ronaldo Bezerra Oliveira, Alex Santos, and Eloi Luiz Favero. "Experimental Evaluation of a Serious Game for Teaching Software Process Modeling". In: *IEEE Transactions on Education* 58.4 (2015), pp. 289–296. DOI: 10.1109/TE.2015.2411573.

[18] Gabriela Kiryakova, Nadezhda Angelova, and Lina Yordanova. *GAMIFICATION IN EDUCATION*.

[19] Carlos Mario Zapata Jaramillo, María Clara Gómez Álvarez, and Guillermo González-Calderón. *Riskware: A Game for Teaching Software Project Risk Management*. 2013.

[20] Christiane Gresse-Von-Wangenheim, Rafael Savi, and Adriano Ferreti Borgatto. "SCRUMIA - An educational game for teaching SCRUM in computing courses". In: *Journal of Systems and Software* 86 (10 Oct. 2013), pp. 2675–2687. ISSN: 01641212. DOI: 10.1016/j.jss.2013.05.030.

[21] Pontakorn Sonchan and Sakgasit Ramingwong. "ARMI 2.0: An online risk management simulation". In: Institute of Electrical and Electronics Engineers Inc., Aug. 2015. ISBN: 9781479979608. DOI: 10.1109/ECTICon.2015.7207043.

[22] Giusy Annunziata. *SERGE - material for the experiment - online appendix*. URL: https://drive.google.com/drive/folders/17f0NNZyF89QznS2AadR1DnJ4Thg2TCXq?usp=share_link.

[23] Norman Fenton and James Bieman. *Software Metrics: A Rigorous and Practical Approach, Third Edition*. 3rd. USA: CRC Press, Inc., 2014. ISBN: 1439838224.

[24] Claes Wohlin, Per Runeson, Martin Hst, Magnus C. Ohlsson, Bjrn Regnell, and Anders Wessln. *Experimentation in Software Engineering*. Springer Publishing Company, Incorporated, 2012. ISBN: 3642290434.

[25] Juliet Corbin and Anselm Strauss. *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications, 2014.

[26] B. Goodrich. *CAPM Exam Prep Study Guide: Belinda's All-in-One Program for Exam Success*. Goodrich Fremaux Publishing, 2019. ISBN: 9781732392847. URL: https://books.google.it/books?id=YvCbvwEACAAJ.

[27] K. Schwalbe. *Information Technology Project Management, Revised*. Cengage Learning, 2010. ISBN: 9781133172390. URL: https://books.google.it/books?id=TYMIAAAAQBAJ.

[28] John W Creswell and J David Creswell. *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications, 2017.

[29] Massimiliano Di Penta and Damian Andrew Tamburri. "Combining quantitative and qualitative studies in empirical software engineering research". In: *2017 IEEE/ACM 39th International Conference on Software Engineering Companion (ICSE-C)*. IEEE. 2017, pp. 499–500.

[30] R Burke Johnson and Anthony J Onwuegbuzie. "Mixed methods research: A research paradigm whose time has come". In: *Educational researcher* 33.7 (2004), pp. 14–26.

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

This thesis work is the fruit of five long years at university, carried out during a period that I found more difficult than usual. This journey has helped me grow and mature in terms of skills and personality. The essential lesson learned was to understand my capabilities, prove that I am capable of achieving my goals and that by putting myself before everything else, I can do great things. I want to thank all the people who have stood by me during these last two university years, especially in the last few months.

Special thanks go to ***my family****, who supported me throughout this journey. In particular, I want to thank my* ***mum****, my* ***sister****, and little* ***Birba****, who supported me more than anyone else and gave me the strength to continue on this path. I owe them all my personal growth and the strength to go on my way.*

A special thank you goes to ***Lorenzo****, who, most of all, noticed my value and managed to spur me on by making me notice it too. Thank you for your continuous support and for always believing in me.*

I am grateful to Professor ***Filomena Ferrucci*** *for being my supervisor and allowing me to put my skills to work on this thesis. My special thanks go to Professor* ***Fabio Palomba*** *and Dr.* ***Stefano Lambiase****, for all their support and availability during these months.*
Furthermore, I would like to thank all the members of the SeSa Lab—Professor ***Dario di Nucci*** *and Dr.s* ***Carmine****,* ***Dario****,* ***Francesco****,* ***Giammaria****,* ***Gilberto****,* ***Giulia****,* ***Manuel****,* ***Valeria****, and* ***Vincenzo****—for receiving me every day in the lab and for their continuous support and support.*

*I would never have achieved this without **Sabato**'s presence. To you, I owe everything. You have been my rock, my colleague, and my outlet. I will never have enough words to thank you for your essential presence on this journey.*

*I thank all my fellow students and project partners—**Anna**, **Claudia**, **Ciccio**, **Coccia**, **Cosimo**, **Giovanni**, **Marco**, **Roberto**, **Sapo**, and **Siano**—for the days we spent at the university together. You are the most beautiful university memory, which I will cherish forever.*

*A great thank you to my "**Fressuriello Gang**"—**Alessandro**, **Anna**, **Armando**, **Biagio**, **Brian**, **Carolina**, **Luca**, **Lucia**, **Nicola**, **Nunzio** and **Rosa**—Thank you for the magical evenings we spent together, the joy you brought into my life, and for always being there whenever I needed a break.*

*I thank my sweet EasyAid Team Members, **Giovanni**, **Mariagiovanna**, **Martina**, **Riccardo**, **Roberto**, **Serena**, and **Stefano**. Thank you for sharing the anxiety about one of the most challenging exams of my entire career and for the laughs and good times we had together. Our experience together has changed me so much and thanks to you I have understood the importance of working in a team, and that when you are in good company work is less tiring ... or almost.*

*I want to thank my lifelong friends—**Matilde**, **Salvatore Tramontano**, **Simona**, **Salvatore Tetti**, **Elio** and **Simone**—for always being there and always listening to all my dramas and complaints, for sharing with me the joys and sorrows of this long journey.*

*I want to thank all the staff of the "**Sole Rosso**"—**Anna**, **Gennaro**, **Mario** and **Salvatore**- who were always available to me and could give me valuable advice. To my colleagues—**Antonio**, **Marco**, **Diego**, **Pietro**, **Vincenzo** and **Luigi**—who always brightened my days.*

*Finally, I want to thank all the people I have met along this long university journey who have contributed to making the time spent here memorable. Thanks to **Carlo**, **Maria**, **Rosario** and **Baldi**. To my GPS colleagues - **Davide Bottiglieri**, **Gaetano**, **Gianluca**, **Salvatore** and **Vincenzo**. Finally, to all the guys from **ASS1972** and **CoScienze**.*

RINGRAZIAMENTI

Questo lavoro di tesi è il frutto di 5 lunghi anni universitari, realizzata in un periodo che personalmente ho ritenuto più difficile del solito. Questo percorso mi ha aiutata a crescere e maturare, sia a livello di competenze che personale. La lezione più importante appresa è stata comprendere le mie capacità, dimostrando di essere in grado di raggiungere i miei obiettivi, e che, mettendo me stessa prima di tutto il resto sono in grado di fare grandi cose. Voglio ringraziare tutte le persone che, in questi ultimi due anni universitari, in particolare negli ultimi mesi, mi sono state accanto.

*Un ringraziamento speciale va alla mia **famiglia**, che mi ha supportato per tutto questo percorso. In particolare voglio ringraziare mia **mamma**, mia **sorella** e la piccola **Birba**, che più di tutti mi hanno supportato e dato la forza di andare avanti in quasto percorso. A è loro devo tutta la mia crescita personale in questi anni e la forza di andare avanti per la mia strada.*

*Un ringraziamento speciale va a **Lorenzo**, che più di tutti ha notato il mio valore ed è riuscito a spronarmi facendolo notare anche a me. Grazie per il tuo continuo sostegno e per aver sempre creduto in me.*

*Sono grata alla Prof.ssa **Filomena Ferrucci**, per essere stata la mia relatrice e avermi dato la possibilità di mettere in gioco le mie competenze per la realizzazione di questo lavoro di tesi. Un ringraziamento speciale va al Prof. **Fabio Palomba** e al Dottor. **Stefano Lambiase**, per tutto il supporto e la disponibilità durnate questi mesi. Inoltre ringrazio tutti i membri del SeSa Lab—Prof. **Dario Di Nucci** e i Dottori **Carmine**, **Dario**, **Emanuele**, **Francesco**, **Giammaria**, **Gilberto**, **Giulia**, **Manuel**, **Valeria** e **Vincenzo**—per avermi accolta ogni giorno in laboratorio e per il continuo supporto e sostegno durante il mio lavoro.*

*Non avrei mai raggiunto questo traguardo senza l'aiuto di **Sabato**. A te devo tutto. Durante questi due anni sei stato la mia roccia, il mio collega, la mia valvola di sfogo. Non avrò mai abbastanza parole per ringraziarti per la tua essenziale presenza in questo percorso.*

*Ringrazio tutti i miei compagni di studio e di progetti—**Anna**, **Claudia**, **Ciccio**, **Coccia**, **Cosimo**, **Giovanni**, **Marco**, **Roberto**, **Sapo** e **Siano**—per le giornate passate all'università insieme. Siete il ricordo dell'università più bello, che conserverò per sempre.*

*Un grandissimo ringraziamento alla mia "**Fressuriello Gang**"—**Alessandro**, **Anna**, **Armando**, **Biagio**, **Brian**, **Carolina**, **Giuseppe**, **Luca**, **Lucia**, **Nicola**, **Nunzio** e **Rosa**—grazie per le magiche serate passate insieme, per l'allegria che portate e per esserci sempre stati ogni volta che avevo bisogno di staccare.*

*Ringrazio i miei dolci Team Member di EasyAid, **Giovanni**, **Mariagiovanna**, **Martina**, **Riccardo**, **Roberto**, **Serena** e **Stefano**. Grazie per aver condiviso con me l'ansia in merito ad uno degli esami più impegnativi di tutta la carriera, per le risate e per i bei momenti vissuti insieme. L'esperienza vissuta insieme mi ha cambiata tantissimo e grazie a voi ho capito l'importanza di lavorare in un team, e che quando si è in ottima compagnia il lavoro risulta meno faticoso ... o quasi.*

*Voglio ringraziare i miei amici di sempre—**Matilde**, **Salvatore Tramontano**, **Simona**, **Salvatore Tetti**, **Elio** e **Simone**— per esserci sempre stati in ogni momento, per aver ascoltato tutti i miei drammi e le mie lamentele, per aver condiviso con me gioie e dolori.*

*Un ringraziamento va alle persone che mi sono state vicine nell'utlimo perido, allo staff del "**Sole Rosso**" —**Anna**, **Gennaro**, **Mario** e **Salvatore**— che sono sempre stati disponibili e in grado di darmi prezioni consigli. Ai miei cari colleghi—**Antonio**, **Marco**, **Diego**, **Pietro**, **Vincenzo** e **Luigi**— che hanno sempre alleggerito il lavoro rallegrandomi le mie giornate.*

*Infine, voglio ringraziare tutte le persone che ho incontrato in questo lungo percorso universitario e che hanno contribuito a rendere speciale il tempo speso qui. Un ringraziamento a **Carlo**, **Maria**, **Rosario** e **Baldi**. Ai miei colleghi di GPS - **Davide Bottiglieri**, **Gaetano**, **Gianluca**, **Salvatore** e **Vincenzo**. Infine a tutti i ragazzi dell' **ASS1972** e **CoScienze**.*