The International Journal of Management Education 22 (2024) 100969

Contents lists available at ScienceDirect

The International Journal of Management Education

journal homepage: www.elsevier.com/locate/ijme

Improving project management skills by integrating a boardgame into educational paths

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ARTICLE INFO

Keywords:
Serious game
Management education
Project management
Interactive learning environment
Boardgame
Design-based research

ABSTRACT

The increasing demand for practical project management skills makes crucial the adoption of innovative educational approaches. This study presents an experiment carefully designed to assess the effectiveness of an innovative project management educational boardgame named PMBoG. Two samples from a class of university students, enrolled in a bachelor's degree management course, participated in the experiment. One sample joined PMBoG sessions playing with and against other colleagues, the other sample did not participate in the sessions. After game sessions, both groups took a project management test to evaluate their capacity to make decisions or countermeasures based on classical project management issues. The test also included a questionnaire about game evaluations and peer feedback. Preliminary analysis using multiple statistical tests (*t*-test, ANOVA, Tuckey and Effect Size) indicates that participants in the experimental group demonstrated statistically significant higher performance compared to those who did not participate in the game sessions. The results suggest that the adoption of PMBoG positively impacts on increase of students' project management competencies. The study underscores the importance of incorporating experience-based and student-centered education tools in project management education, enhancing students' readiness for real-world project scenarios.

1. Introduction

Project management (hereafter, PM) is an indispensable culture for businesses and proposes a set of methodologies and tools to secure a competitive edge and achieve success (Alvarenga et al., 2019), as it is one of the most widely used transformation methods in the realm of management (Lenfle & Loch, 2010). Projects are, in fact, very complex environments where time, budget, and resources have to be managed very accurately. Despite these essential prerequisites for project success, project managers often encounter challenges in delivering successful outcomes (Loufrani-Fedida & Missonier, 2015), due to intrinsic and structural problems connected to the presence of human variables like misperceptions of delays and feedbacks. Several researchers, in fact, relate project failure to human factors (Chipulu et al., 2011; El-Sabaa, 2001; Gal & Hadas, 2015). Achieving project effectiveness and success goes beyond enhancing processes and products; it necessitates a focus on the individuals involved and their competencies. In fact, project success is strongly linked to the project management competencies, which have been extensively discussed in the literature (Alvarenga et al.,

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https://doi.org/10.1016/j.ijme.2024.100969
Received 19 September 2023; Received in revised form 21 February 2024; Accepted 21 March 2024

2019; Bredillet et al., 2015; Geoghegan & Dulewicz, 2008). Specifically, the competencies (or capabilities) necessary for successful projects are divided into soft, human, and social skills, and hard, technical skills (Pant & Baroudi, 2008). Several studies support that technical skills are a necessity, but they are not enough for successful projects (Müller & Turner, 2010; Skulmoski & Hartman, 2010): social skills and attitudes, including communication abilities, participation, collaboration, and leadership must also be improved (Zaman et al., 2019).

Recognizing the vital role of soft skills and attitudes in shaping future project managers, the significance of educational and training initiatives becomes evident within both organizational settings and educational institutions at the high school and university levels. Nonetheless, there are instances where current approaches to educating and training project management professionals may fall short of addressing the requirements of contemporary enterprises, not adequately preparing managers to deal with the complex realities of the real world (Ramazani & Jergeas, 2015). This could be worsened by the potential refusal from students of PM courses, who could consider the courses to be too abstract and misaligned with reality. Traditional classes, in fact, are generally educator-centered activities in which educators divide their lessons into two elemental parts, i.e., delivering a presentation in class and assigning extra activities as homework. This approach is not always viewed favorably by students anymore due to its lack of efficacy (Scafuto et al., 2017). Rather, PM courses should be more devoted to experiential and practical activities in order to be more adherent to real-world issues (Ashleigh et al., 2012; Kerzner, 2022). In other words, there is a gap between the professional engineering industry needs today and the vision of traditional education; therefore, increased emphasis should be given to educational strategies able to stimulate, incentivize, and meet the needs of students, harnessing the power of technology, their perseverance and dedication to build collaborative and communicative abilities (Magano et al., 2021).

For many years, extant literature has emphasized the potential of games within management education and training contexts in various forms, for educational and training purposes, thereby providing potentially powerful "spaces" (the so-called *Interactive Learning Environments* - ILE) where learners and educators can interact boosting learning. Notably, such interactive learning environments can be based on various and different typologies of games and technologies or a combination of them. For example, ILEs can make use of computer-based simulation games or more traditional boardgames, however always with the ultimate goal of favoring learning through entertainment, group experience, and also mechanisms of cooperation or competition (Lòpez et al., 2021). Notably, depending on how such interactive learning environments are designed and on which typologies of games are employed, various forms of interactions and labels can be found and used. In this scenario, for example, previous literature has already used the terms *edutainment* (e.g., Billsberry, 2014), *business games* (e.g., Faria, 1998; Freeman et al., 1989), and *serious games* (e.g., Abt, 1970), just to name a few. Overall, the use of some kind of interactive education in class has become increasingly popular, as educators, parents, and students alike recognize the potential of using educational entertainment and gaming to aid learning and encourage pupils to take part in various activities (Steinkuehler et al., 2012).

Starting from these considerations and notwithstanding the fact that a number of studies have already investigated the potential of games for educational purposes and also referring to their various typologies, such as business games, role-playing games, edutainment interventions, and serious games (as will be seen in detail in section 2) just to name a few, further research is still required and advocated (e.g., Calderón & Ruiz, 2015; Rumeser & Emsley, 2018; Manzano-Leòn et al., 2021).

Consequently, this study suggests that the designing and employing training interactive learning environments, having at their core a serious game, may enhance students' performance and facilitate the transfer of knowledge and competencies in the specific domain of PM. By incorporating serious games, in fact, educators can create immersive and engaging experiences that simulate real-world project scenarios (Rumeser & Emsley, 2019). This approach not only captures students' attention but also provides them with a dynamic platform to apply theoretical concepts in practical settings. Additionally, serious games facilitate knowledge transfer by providing a context-rich learning experience (Wittrin et al., 2021). Learners can directly apply theoretical knowledge to practical situations, reinforcing their understanding of PM concepts.

The research developed inside the EU Project named "PMBoG - Project Management Boardgame" represents a good example of such an innovative educational paradigm, as it combined the latest advances in PM theory and practice with the entertainment and engaging features of boardgames, whose added values in education are manifold. Above all, boardgames provide a social environment where cooperation and/or competition allow the application of managerial skills; in fact, by visualizing how the opponents/partners are behaving, the player (the learners, in this case) can adapt their strategies and anticipate moves and mistakes (Taspinar et al., 2016). In other words, the combination of theory and simulated practice within a limited and controlled environment aims to facilitate learning concepts behind PM by means of an environment where players interact in a common space, hence being endowed with a marked social component.

To achieve the project's research goals, the project team adopted a blended approach during the educational path's design by including formal and non-formal education processes with the ultimate purpose of avoiding the classical dry, analytical style of teaching and thus allowing the learners to be at the center of their education, learning the theory in practice in a consequence-free setting (Baeten et al., 2010). In this way, learners can draw their own conclusions based on their individual experience of PM, allowing them to transfer the acquired skills to their own lives and jobs in a faster and more structured way.

Leveraging on the project results, our aim was to investigate the stand-alone educational value of the boardgame developed and to understand whether the use of the game even in a single spot could instill new project management skills or enhance existing skills in the player. Therefore, we empirically tested the difference in PM knowledge and skill between two samples of individuals taken from a homogeneous population, that was a university class. One of the two samples received the treatment (i.e., playing the boardgame), and the other was the control sample. Both groups faced the same multiple-choice test about project management issues and finally, their performances were analyzed by using several statistics methods, proving the difference in results and assessing the relevance of such a skill gap. Notably, the research design also allowed for testing the effect size (Cohen, 1988, 1992) of the educational instrument, and

for demonstrating that it is free of gender learning bias (see the specific hypotheses described in Section 2.2).

The article is organized as follows. Section 2 provides a brief literature review on the use of games for management training and in particular for project management training, which was used to contextualize the research scope and to develop the research question, as well as the hypotheses to be tested. Section 3 describes the design and functioning of PMBoG. Subsequently, Section 4 illustrates the methodology, i.e., sample data, procedure of treatment, and measurement of performance. After that, Section 5 reports the main results from descriptive statistics as well as the *t*-test, ANOVA, Tukey test, and Effect Size on the sample. Finally, we discuss the results and provide some conclusions, at the same time identifying the main limitations of the work.

2. Literature review on the use of games for management training

2.1. Using interactive learning environments in class

Games have been used to support and foster experiential learning in management education and training for many years to date for a number of good reasons (Crookall, 2012; Lane, 1995; Faria et al., 2009); they provide an engaging and interactive way for learners to gain hands-on experience and develop relevant competencies and skills such as decision-making, communication, and problem-solving. Games may include a variety of typologies, spanning from traditional boardgames to more technologically advanced simulation models, and even comprehensive computer management flight simulators (Armenia et al., 2020; Barnabè, 2016; Sauvé et al., 2007).

Previous literature has emphasized that one of the main benefits of using games for experiential learning (Kolb, 1984; Kolb & Kolb, 2012) in management education and training is that they allow learners to practice skills in safe, free-risk, and controlled environments (e.g., Peters et al., 2012). In such contexts, learners can make decisions and carry out actions being free to make mistakes, test their own beliefs and mental models (Senge, 1994), and, subsequently, learn without any real-world consequences. This is especially important in management education and training where decisions can have a significant impact on a company's success or on the interaction with relevant stakeholders (e.g., Salas et al., 2009).

Moreover, games provide the learners with an opportunity to cooperate and develop teamwork skills, i.e., skills that are recognized as essential for success in the workplace (e.g., Goltz et al., 2008).

Additionally, games are also regarded as tools that can be used to enhance learning within specific groups of users - for example employing gender-specific games (e.g., Scanlon, 1994) or developing and using games that can be tailored considering gender differences in learning style (e.g., Garber et al., 2017) or to favor interaction and cooperation in groups without any specific distinction of gender, therefore sustaining inclusion (see Romrell, 2014, pp. 170–182 for a comprehensive literature review).

Interestingly, games also provide a fun and engaging way to learn (e.g., Kangas, 2010; Pitic & Irimias, 2023). Previous research has underlined that learners are more likely to be motivated, engaged, and enthusiastic about learning new topics when they are having fun (Bado, 2022). Stated differently, games can be seen as, and provide for, an alternative way of teaching and training when compared with more traditional educational techniques like lectures and classroom activities (Tokac et al., 2019).

Another benefit of using games in management education and training is that they can help learners develop critical thinking, as well as systems thinking skills. Specifically, the former (critical thinking) can be defined as "the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Scriven & Paul, 1987); the latter (systems thinking) can be defined as "a way of seeing and talking about reality that helps us better understand and work with systems to influence the quality of our lives. (…). It also involves a unique vocabulary for describing systemic behavior, and so can be thought of as a language as well" (Kim, 1999, p. 2). Jointly, these skills are said to be particularly relevant in modern managerial contexts, often characterized by complex, dynamic, and wicked problems to be addressed and, more specifically, when considering this study, also in teaching and training programs that are increasingly required to teach, transfer, and enhance such skills to and in learners (e.g., Bezanilla et al., 2019). More specifically, among the main categories of skills frequently mentioned by relevant literature, educational programs are nowadays asked to enhance some abilities in learners, like breaking down a problem into its constituent parts to reveal its underlying logic and assumptions; recognizing and account for an individual's biases in judgment and experience; collecting and assessing relevant evidence from either personal observations and experimentation or by gathering external information; adjusting and re-evaluating one's own thinking in response to what she/he has learned; forming a reasoned assessment in order to propose a solution to a problem or a more accurate understanding of the topic at hand.

Notably, relevant literature has emphasized that the acquisition and development of critical thinking and systems thinking skills is particularly facilitated when the learners can develop skills through a process where personal experience plays a relevant role, and where interaction is facilitated (e.g., Kolb, 1984; Kolb & Kolb, 2012). Overall, acquiring the aforementioned skills through games will facilitate learners to analyze, evaluate, and use the data and information at disposal to self-regulate, make decisions, and take action (e.g., Cicchino, 2015).

In this context, this study specifically employs three additional concepts.

The first one is that of an "interactive learning environment" or ILE. In broad terms, an ILE is an environment where the interaction (Atkinson & Renkl, 2007) between a user (sometimes referred to as the «player» or the «learner») and the learning environment is primarily devoted to knowledge acquisition (i.e., learning, Kim, 1993), specifically through an interactive process whereby knowledge is created through the transformation of experience (i.e., what we have already mentioned as «experiential learning», Kolb, 1984; Kolb & Kolb, 2012).

The second one refers to the employment of so-called "serious games" as the core part of the ILE designed for education and

training.

The concept of serious games was first coined by Abt (1970 p. 27) and described as follows: "We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement". Serious games are typically designed to mimic real-world situations and use game-like mechanics to teach players valuable skills, such as problem solving, decision making, and emotional intelligence. They have been used by organizations in many different verticals from military and government to healthcare, education, and beyond (Ullah et al., 2022). The appeal of serious games lies in the fact that they can cover a wide variety of topics and can be used to deliver engaging educational experiences. Serious games are popular also because of their ability to be deployed anywhere and anytime. This makes it easy for individuals to access the learning content on the go, while also allowing organizations to provide employees with training at any location (Ávila-Pesántez et al., 2017). Serious games have also been shown to improve learners' performance and to make them achieve proficiency levels significantly higher than those who used traditional methods like lectures, especially when multiple training sessions were involved, and when players worked in groups (Wouters et al., 2013). Briefly, from an educational point of view a "serious game" pursues a serious business purpose, i.e., it is developed with a primary focus other than entertainment (Barnabè et al., 2017; Dörner et al., 2016), being aimed at pursuing specific educational purpose or objective, specifically engaging players in interactive and immersive experiences that are designed to teach specific skills or knowledge (Bellotti et al., 2010).

The third and last concept employed in this study refers to the modalities through which the games are designed and actually played. In this context, previous literature (e.g., Greco et al., 2013; Maier & Größler, 2000) has emphasized how games can be played in many different forms, e.g., as online games, boardgames, or even assisted by virtual reality or augmented reality devices.

Specifically, our research is focused on the use of boardgames in class, as they have emerged as effective tools for enhancing education across various subjects and age groups. These games provide an interactive and engaging learning experience, promoting critical thinking, problem-solving, collaboration, and subject-specific knowledge acquisition. The potential of this category of games has been analyzed in various contexts (e.g., see Khan & Pearce, 2015; Taspinar et al., 2016). Research by Steinkuehler & Duncan, (2008) highlights how educational boardgames can improve learning outcomes. By integrating game mechanics with educational content, these games create an enjoyable environment that encourages repeated practice and information retention. Furthermore, the social aspect of boardgames cultivates communication skills, as noted by Connolly et al. (2012).

Overall, the three above mentioned concepts (ILEs, serious games and boardgames) can be seen as complementary pieces of an integrated methodological approach when designing and using such tools in a class (e.g., Armenia et al., 2020; Papathanasiou et al., 2019). It is noteworthy to add that this approach is also said to favor cooperation and of co-production of information, thus helping to overcome the traditional barriers to teacher-student and academic-practitioner learning (Barnabè et al., 2017; Jean et al., 2018). Specifically, relying on such game-based experiences and interacting with the facilitators/educators, learners can receive immediate feedback, thereby further fostering their understanding about the issues and contexts under investigation and, subsequently, adjusting their approach accordingly (Crookall, 2014). This "virtuous cycle" is said to eventually enhance not only the learners' motivation and engagement, but also their confidence and performance and, ultimately, their ability to share the new knowledge acquired and transfer it into the real world what they learned in the simulated environment (Allal-Chérif & Makhlouf, 2016).

With this said, we emphasize that, whereas numerous pieces of research have already presented the potential, the strengths and also the limitations of business games, serious games and edutainment-based products for various learning goals and about various contexts (e.g., Charsky, 2010; Fox et al., 2018; Hart et al., 2020; Pérez-Pérez et al., 2021; Pojani & Rocco, 2020; Reginato et al., 2022), extant literature is still advocating for more research in the field, particularly to understand how these games are effective tools to enhance learning and increase skills in learners - even in presence of different learning styles and learners' characteristics (e.g., Aksakal, 2015; Zubek, 2020), and to analyze specific operational and decision-making contexts, such as the project management field that is considered in this study (e.g., Rumeser & Emsley, 2018).

2.2. Using games in the field of project management

Considering management and management education literature, games have been receiving attention for a long time to date (e.g., Lane, 1995) and have even become more popular in recent years (e.g., Billsberry, 2014; Katsaliaki & Mustafee, 2015; Lòpez et al., 2021). This is a trend visible also in the field of project management, where these tools and approaches revealed the potential to transform for the better the way in which educators, facilitators, and learners approach learning and skills development.

Games can be specifically used to address some of the challenges that are commonly associated with PM. As we also mentioned in the introduction to this study, the field of PM is complex and multifaceted. It involves coordinating and deploying resources, managing timelines, overseeing budgets, and interacting with a wide range of stakeholders (Lock, 2017). Subsequently, PM interventions often require the simultaneous use of different skills, including soft skills such as communication, problem-solving, and leadership (Gunarathne et al., 2021; Ravindranath, 2016). For many, it can be a daunting and overwhelming task. However, recent advances in management education (e.g., Jaccard et al., 2022) have shown that it is possible to teach project management skills in an engaging and entertaining way, making the learning process more accessible and enjoyable for all. In this context, the design and use of ILEs, specifically centered on and/or embedding serious games in the form of boardgames, can provide a more holistic approach to learning by integrating the different aforementioned skills into a single learning experience, thereby breaking down silos and fostering a more collaborative and integrated approach to project management.

Within this context, whereas previous literature and the examples cited above show that various games have the potential to effectively support learners in the broad field of project management by making their learning experiences more engaging, tailored, and accessible, further research is still required and advocated (e.g., Calderón & Ruiz, 2015; Rumeser & Emsley, 2018). Therefore,

considering the existing limits on this topic, the research question pursued in this study is the following:

RQ: "Can PMBoG be considered an effective tool for improving project management skills?".

2.3. Active engagement in a boardgame and PM learning performance

It is important to highlight that previous research in the field has already demonstrated that through interactive simulations and games, participants can learn, develop, practice, and test different PM skills, facing an array of potential challenges, issues, and scenarios – however always in a safe and controlled environment (e.g., Ford & Lyneis, 2020; Jaccard et al., 2022), given by the characteristics of the specific ILE being used for the purpose. As examples, Rumeser and Emsley (2019) used serious games to test if these tools are able to improve players' decision-making skills in contexts characterized by various levels of complexity, Petri et al. (2018) compared how digital and non-digital games could be used as educational tools to teach software project management, and Barbosa and deÁvila Rodrigues (2020) analyzed how games and gamification tools may be used to support portfolio project management. Given such evidences and proposals from literature, the following hypothesis was set:

H1. Active engagement in a PMBoG playing session predicts different performance in learning

This was divided in the next two sub-hypothesis, in order to evaluate whether and how much the performance in learning of students participating in PMBoG playing session is superior compared to those who did not partake.

2.4. Effectiveness of active engagement in a PM boardgame

Kolb's (1984) Experiential Learning Theory posits that individuals learn best through direct experience and active engagement. By actively participating in a PMBoG playing session, individuals are immersed in a simulated project management environment where they can apply theoretical knowledge, make decisions, and experience the consequences of those decisions. This hands-on, experiential learning approach is likely to result in deeper understanding and superior performance compared to passive learning methods. There is a growing body of research supporting the effectiveness of game-based learning in enhancing learning outcomes. Games have demonstrated to improve motivation, engagement, and knowledge retention. A meta-analysis by Hamari and Koivisto (2015) found that game-based learning significantly improves learning performance across various domains.

In case the experiment verifies the H1, it was considered interesting to quantify the effect size of the educational treatment using the Cohen index (Cohen, 1988, 1992). Cohen index is a commonly used measure of effect size in educational research, indicating the magnitude of the difference between two groups. While effect sizes can vary depending on the context and intervention, a medium to substantial effect size is generally considered to be meaningful in educational settings. For instance, Hattie (2008) suggests that effect sizes above 0.40 are associated with significant improvements in learning outcomes.

Based on this discussion, we put the following two sub-hypotheses.

H1a. Active engagement in a PMBoG playing session predicts superior performance in learning

H1b. Active engagement in a PMBoG playing session predicts medium to substantial effect size on the participants in learning

2.5. Educational games and gender adaptation in learning

In the realm of educational games, Steiner et al. (2009) also emphasize the importance of gender adaptation; in this context, it is crucial for a learning technology to ensure equal opportunities and chances for all students. Certainly, literature contains instances discussing the presence of gender distinctions in the experiences of game-based learning. In their study, Stege et al. (2011) explored the effectiveness of using a serious game compared to traditional text-based instruction for imparting electrical engineering theory to high school students. The results indicated that the serious game was more effective in teaching the theory to male students when compared to the text-based approach. However, no significant advantage was observed for female students when exposed to the game compared to the text. Conversely, Khan et al. (2017) argue that the game-based learning application, in secondary school science, not only appeared to be more effective in increasing engagement for girls compared to boys but also had a more positive impact on the learning outcomes of girls, aligning with other studies (see Chang et al., 2014; Klisch et al., 2012) which demonstrate that girls tended to outperform boys in terms of learning outcomes when utilizing game-based learning and gamification learning approaches. Given such evidences and proposals from literature, the following hypothesis was set as well:

H2. There is little to no discernible disparity in learning performance between men and women among participants of the PMBoG

The presented hypotheses collectively propose an investigation into the educational efficacy of PMBoG, focusing on the relationship between active engagement (independent variable), learning performance (dependent variable), and potential gender differences (moderator). They suggest that active participation in the game could lead to improved learning outcomes, with varying degrees of effect size. Furthermore, the hypotheses indicate that gender may not play a significant role in determining learning performance within the context of PMBoG. In synthesis, the study aims to assess how engagement during gameplay influences learning effectiveness and whether this impact differs based on gender.

3. PMBoG description

Before presenting the research design, it is worth briefly describing the game and its mechanics to better understand the challenge the participants faced and therefore better appreciate its educational value.[1]

In PMBoG, the players are wedding planners who are trying to set up a wedding. Each player has a special couple's card to consider, with requests to fulfill with activities to carry out, risks to face, and deadlines to respect. Task cards are the main topic of the game and represent activities needed to successfully complete the wedding. In detail, each couple is represented by a card (equal to the one used in PMBoG) that contains several icons and information, as described in Fig. 1.

The number of players goes from 2 to 4 and the game duration is about 1 hour and a half when 4 players are in the game. There are no specific educational requirements to understand and play the game, as it was designed for a wide audience. Nevertheless, there are gameplay add-ons, that can be either included or excluded before the match, that make the game experience more challenging; in this way, the players, or the teacher who proposes the game to the class, can adjust the level of difficulty based on the players' ability.

Players must compete with other players to make the best wedding possible, following a project management approach. The main idea at the core of the game is to stimulate the participants to develop PM skills, through the completion of a set of activities, with a given budget, and despite a few constraints (e.g., deadlines and human resource capacity) to take into consideration. At the end of the game, each player is evaluated for the work done and the player with the best rating is declared as the best project manager.

PMBoG lasts 6 rounds representing the six months of work that is needed to complete the given "project" (i.e., to organize the wedding ceremony). During each round players execute two steps, i.e., 1. Preparation, and 2. Action. Through these two stages the players are asked to plan the activities to be completed, and subsequently carry out them in the proper sequence and in consideration of the constraints they have (i.e., in terms of budget, time, customer satisfaction, precedence constraints).

The first stage takes place at the beginning of each round and is designed to fix the game board (see Fig. 2), precisely "preparing" it for the coming round. In the action phase, starting with the player with the first player counter, each player takes turns clockwise making an action. When a player doesn't want to take another action, he must pass, exiting the round. When all players have passed, the round is over. The main actions are: Plan a task to be done, Hire a temporary worker, Prevent a risk, Execute tasks, Train your workers, Pass turn (for more gameplay details, please see Appendix A).

At the end of the sixth round each player reveals their secret couple's card and score points, according to the following rules:

- 3 points per Request Symbol in your completed task cards that matches the Preferred couple card
- 1 point per Request Symbol in your completed task cards that matches the Liked couple card
- -1 points per Request Symbol in your completed task cards that matches the Unliked couple card
- 5 points per perfect marriage bonus if you have all the Request Symbols on your completed task cards that match your Perfect Request on your couple card
- -3 points per not completed/absent task Type
- 3 points to the player who has the most remaining coins
- -1 point for each out of budget token.

4. Methodology

In order to address the main research question (RQ) of this study, specific game sessions were organized to test the effects of the experience between individuals who took part in and individuals who did not participate in PMBoG.

The players involved in the sessions were the students of the third year of the Bachelor's Degree in Management Engineering. The motivation behind this choice was to try to replicate the scenario for which this game was born, that is, people who did not have robust experiential skills in project management, but who were still able to understand concepts, words, and guidelines, without any kind of obstacle. Project management is indeed a course offered inside the university, but it is provided exclusively in Master's Degree, so the prerogative of students' practical inexperience in this discipline was almost indisputable. The second purpose of this choice was to have a sample as homogeneous as possible, in terms of age, education and instruments for dealing with certain scenarios and challenges.

The extraction of the sample to be, submitted to the EU Project game session took place on a voluntary basis. An internet link to a questionnaire was provided to register for the game sessions through the Google Classroom of a Laboratory course of the same degree, in which it was specified that only the first twenty people who would register will participate in the game, accepting further applications only in case of impossibility of the first selected group. Within the questionnaire, dealing with the theme of gaming sessions, it was also asked to choose the preferred dates among those proposed and if the respondent was part of a study group. These two additional criteria were chosen for organizational purposes, but also to provide a more enjoyable gaming experience, since people in a group would compete in the same game session.

The final choice regarding the planning of the game sessions was the division of 19 students into 4 groups of 4 players and a group of 3 players (see Fig. 3), in two distinct days (three sessions on the first day, two sessions on the second).

Each game session lasted about 75 min and took place in the premises of the university department of one project partner. Each

[1] The full game manual as well as the print&play version of PMBoG can be found at: https://ec.europa.eu/programmes/erasmus-plus/project-result-content/b211d273-9e58-406e-98a8-fdb27e7ec85c/IO6_-_PMBOG_Board_Game.pdf

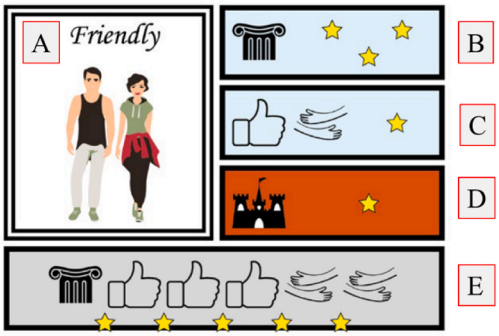


Fig. 1. Description of a "couple card".

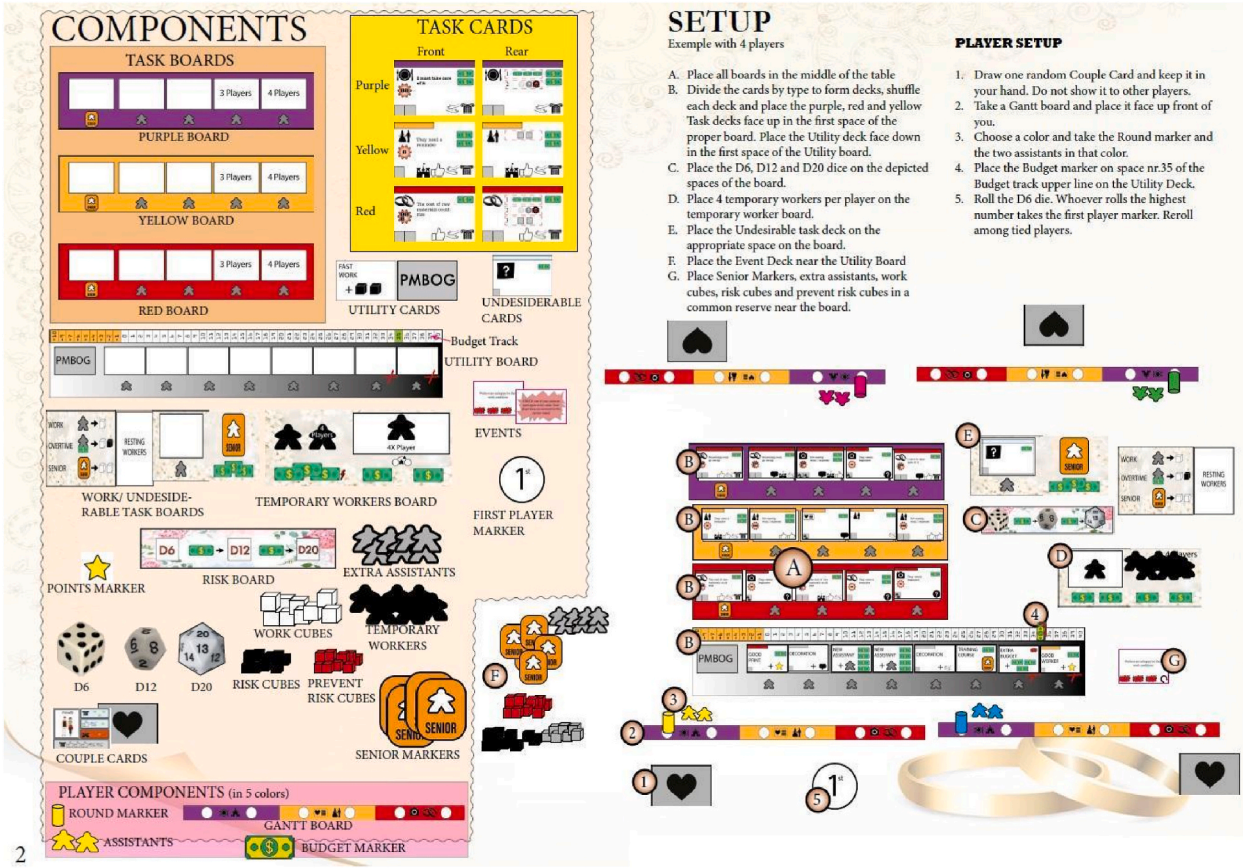


Fig. 2. The game board and the main page of PMBoG's handbook.

game was organized according to the following lineup: Explanation of the rules by a senior student who had previously worked on the project; Answers to participants' questions; Start of the game; End of game.

In the same week in which the sessions were organized, a second questionnaire was submitted to the students after each of the sessions. A total of 44 students took part in this module, divided into EU Project group (the 19 students participating in the sessions) and Control group (25 students who did not participate).

The second questionnaire was divided into three sections. The first section registered demographic data and also previous potential contacts of respondents with PM discipline; the second section was about the feelings and the impressions that students (only those who played) had during the game session; the third section was structured as a brief test composed of 14 multiple choice questions on PM topic.

General information was requested regarding those who took part in the session (hereafter, referred to as the "EU Project Group") and those who did not participate ("Control Group"), i.e. gender, age, secondary education, and previous knowledge on PM. The results

Fig. 3. A picture taken during one of the sessions.

are shown in Fig. 4.

As can be seen, there is a good balance between male and female gender inside the pool, while "other" gender option is under-represented (only one participant). In terms of age, the pool is quite homogeneous, as well as it is homogeneous when considering the education level of the participants (in this case, secondary education). Another important aspect to highlight is that these same distributions are observed in the two groups of participants and non-participants. In brief, from a demographic point of view, the pool is well-equipped and suitable for the analysis.

About the previous experience/knowledge in project management, we opted for the use of two types of questions: the first asks how much the respondent is familiar with Project Management and its meaning on a scale of 5 levels (never heard, unfamiliar, known, familiar, good knowledge); the second if the respondent has ever deepened the discipline independently and voluntarily. The results are divided for the students who did not participate in the game session (Fig. 5a) and EU Project participants (Fig. 5b).

Analyzing the graphs shown in Fig. 5, it seems that the two pools had in general familiarity with PM discipline; in fact, the majority in both cases indicates the neutral value of "known". Incidentally, questioning if they had had autonomous research about the discipline, the percentage of respondents of the EU Project group is slightly higher than the counterpart. The distributions did not indicate excessive knowledge bias, the two groups are similarly distributed, therefore the analysis of the test was considered justified.

Before being submitted to the students, the PM test was subjected to at least two revisions, as it was essential the covering of the various topics touched during the game sessions, as well as the understandability of questions for both groups of students. The drafting style of the test followed the style of the exam for the achievement of the PMP certification of the Project Management Institute. In fact, the PMP exam questions mainly test the candidates' knowledge not on a "technical" basis, i.e. through purely theoretical and notional questions, but evaluate more the situational aspects, i.e. the project manager's capacity to take decisions or countermeasures based on classical project issues. On such basis, this style of testing was considered the most suitable as the population of students had no real theoretical skills on the topic, so it would have been useless to test them with technical questions; PMBoG, on the other hand, offers a project management experience and the development of a "sensitivity" for classical project situations/challenges that can be better evaluated with questions related to the "soft" knowledge.

The composition of questions is described in Table 1. Each question can cover one or more PM sub-topics. The presence of more or less accentuated subtopics inside the questions has been designed according to the aspects most present in the game (e.g. time and risk management were very present in the game design).

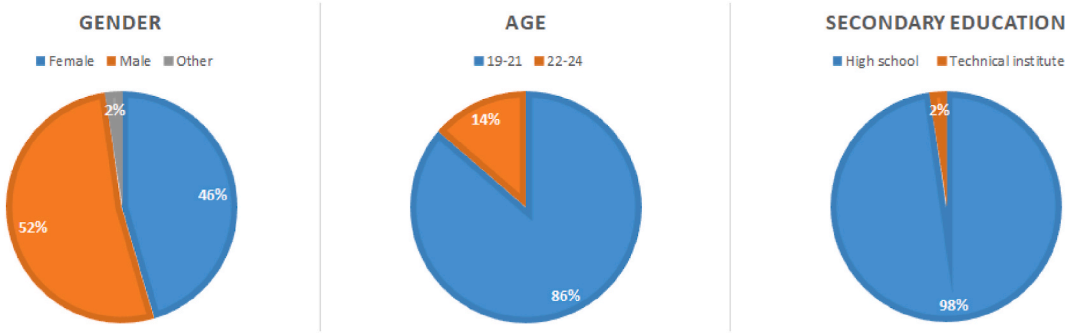


Fig. 4. Demographic data of students' total pool.

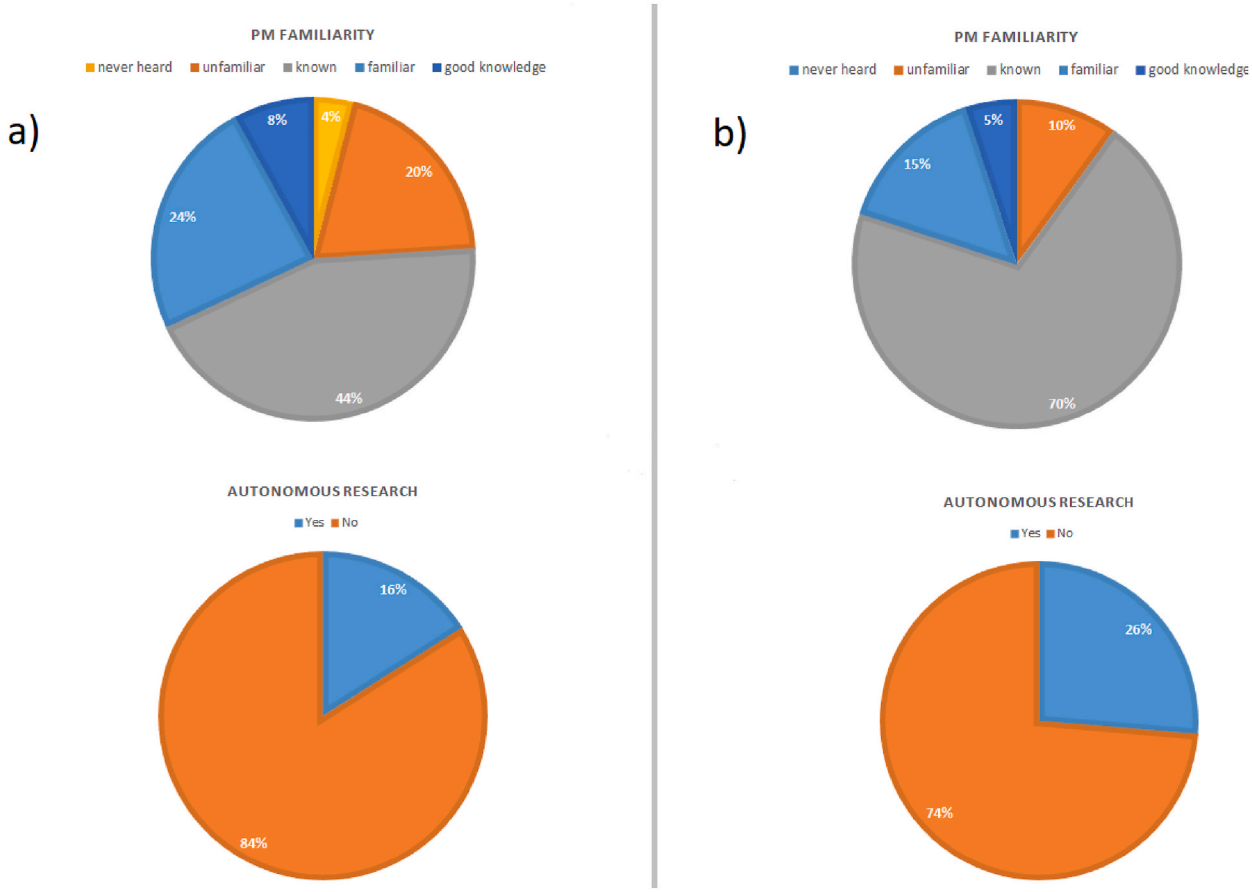


Fig. 5. Familiarity with PM discipline of students' total pool.

Table 1
PM test questions' composition.

Question n° Sub-topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOT
General principles and variables															5
Communication															3
Quality management															1
Time management															6
Cost management															1
Risk management															4
Project phases															4

The answer method provided for each question allowed for choosing among four possible options, of which only one was correct. The scoring system was 1 point per correct question, 0 points per wrong question or left blank.

Such design of experiment allows to test the aforementioned hypothesis (i.e. H1a, H1b and H2) about the effect of participating in the PMBoG playing session for the selected students.

To test all the hypothesis, the research implemented several statistics: *t*-test to compare the means of two groups (Student, 1908), ANOVA test to analyze the difference between the means of more than two groups (Fisher, 1970), Tukey test to determine which specific pairs of groups are significantly different from each other (Tukey, 1949) and Effect Size to quantify the magnitude of the difference between groups (Cohen, 1988).

5. Results

The results are presented throughout two different sub-paragraphs, to reflect the two sections in which the final questionnaire was structured. Firstly, the results of the test submitted to the entire pool are shown; finally, the impressions and feelings from the participants of the game sessions are described.

5.1. Project management test

Following this premise, we enter the core of the study, where we evaluate whether the game session has brought a statistically different score difference in the test, thus denoting a significant difference in learning the concepts of PM. Therefore, the purpose of the test was to evaluate the learning effects of PMBoG, comparing the averages of the two groups to establish whether their difference was significant or not. All the following tests followed a 95% value of accuracy.

First of all, the Anderson Darling's test of the students' scores was performed, which in turn allowed to affirm that the scores were Gaussian. This type of verification was chosen because it is reliable even with a small number of data, also, according to Arshad et al. (2003), this test is the most powerful empirical distribution function tests; moreover, according to the method followed during the experiment, it is possible to affirm that it is a case study in which the data belong to two different classes of subjects, and therefore are not matched. Finally, the variance of the population is unknown and therefore the variances of the scores of the two samples of 19 and 25 units have been estimated.

These premises are fundamental for the tests performed on the results and presented subsequently in this study. Table 2 presents a schematic overview of the main data obtained:

The next step was to check the homoscedasticity of $\widehat{\sigma}^2_{X_1}$ and $\widehat{\sigma}^2_{X_2}$. The hypothesis to verify is the following:

$$\{H_0 : \sigma_1^2 = \sigma_2^2 \quad H_1 : \sigma_1^2 > \sigma_2^2$$

Thanks to the initial hypotheses, it was possible to affirm that the variables:

$$\frac{\sum_{i=1}^{n_1} \left(x_i - \widehat{\mu}_{X_1}\right)^2}{\sigma_1^2} = \frac{(n_1 - 1)\,\widehat{\sigma}^2_{X_1}}{\sigma_1^2} \sim \chi^2_{(n_1-1),\varepsilon_{\%}}$$

$$\frac{\sum_{j=1}^{n_2} \left(x_j - \widehat{\mu}_{X_2}\right)^2}{\sigma_2^2} = \frac{(n_2 - 1)\,\widehat{\sigma}^2_{X_2}}{\sigma_2^2} \sim \chi^2_{(n_2-1),\varepsilon_{\%}}$$

So, if the null hypothesis H_0 had been true, the variable:

$$F_{v_1,v_2} = \frac{\widehat{\sigma}^2_{X_1}}{\widehat{\sigma}^2_{X_2}} = \frac{2,08}{1,56} = 1,33$$

would follow Fisher's distribution with $v_1 = n_1 - 1$ and $v_2 = n_2 - 1$ degrees of freedom. Consequently, the critical level set $\varepsilon_{\%}$ for which the null hypothesis would have been rejected would have resulted:

$$F_{v_1,v_2} > F_{v_1,v_2,\varepsilon_{\%}}$$

Therefore, from the statistical tables we obtained by approximation $F_{24,18,5\%} \simeq F_{25,24,5\%} = 1,96$, value greater than $F_{v_1,v_2} = 1,33$. Consequently, it was possible to affirm that F_{v_1,v_2} did not belong to the critical set and therefore the data were homoscedastic.

Given the homoscedasticity and the Gaussian hypothesis of the data, the following hypothesis test has been defined:

$$\{H_0 : E[\widehat{\mu}_d] = 0 \quad H_1 : E[\widehat{\mu}_d] > 0$$

with the relevant statistics of the mean comparison test:

$$\frac{\widehat{\mu}_d}{\sqrt{\frac{n_1 * \widehat{\sigma}^2_{X_1} + n_2 * \widehat{\sigma}^2_{X_2}}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

which follows a t-Student distribution with $n_1 + n_2 - 2$ degrees of freedom. The unilateral critical set, of $\varepsilon_{\%}$ significance, has therefore been defined:

Table 2
Main data statistics for mean test.

"Control" X1	Sample size	$n_1 = 25$
	Sample average	$\widehat{\mu}_{X_1} = 5,2$
	Sample variance	$\widehat{\sigma}^2_{X_1} = 2,08$
"EU Project" X2	Sample size	$n_2 = 19$
	Sample average	$\widehat{\mu}_{X_2} = 7,32$
	Sample variance	$\widehat{\sigma}^2_{X_2} = 1,56$
Difference between averages of the two groups		$\widehat{\mu}_d = \widehat{\mu}_{X_2} - \widehat{\mu}_{X_1} = 2,12$

$$\frac{\widehat{\mu}_d}{\sqrt{\frac{n_1*\widehat{\sigma}^2_{X_1}+n_2*\widehat{\sigma}^2_{X_2}}{n_1+n_2-2}\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}} > t_{n_1+n_2-2,2\varepsilon}$$

$$\frac{2,12}{0,42} = 4,98 > t_{42,0.1} \simeq t_{40,0.1} = 1,682$$

with which the null hypothesis was rejected, and it was possible to assert that the EU Project group had significantly different (better) results in the test compared to the case of the non-participants group.

A further analysis conducted in this work was the evaluation of the Effect Size (ES), an index that evaluates the impact of a given treatment (Cohen, 1988, 1992), which is, in this case, the participation in a PMBoG playing session. In contrast to significance tests, these indices are independent of sample size. Given the premises of the case study, we opted for measuring the effect in the case of two independent groups, using the standardized difference between two groups. The objective was to calculate the Cohen factor d, which is the ratio between the mean of the two classes and the standard deviation of the two joint groups. According to Cohen, this type of variance can only be used in the case of homoscedastic groups, an element that has already been verified before the mean difference test. It was then possible to translate the concepts into formulas:

$$d = \frac{\widehat{\mu}_{X_2} - \widehat{\mu}_{X_1}}{\widehat{\sigma}^2_{TOT}}$$

where the values $\widehat{\mu}_{X_2}$ and $\widehat{\mu}_{X_1}$ were already calculated previously and the element $\widehat{\sigma}^2_{TOT}$ is the sample variance of the entire population:

$$d = \frac{7,32 - 5,2}{2,94} = 0,72$$

An ES of 0.72 is therefore obtained, a factor which, consulting the interpretation of tables of the Cohen index, confirms a medium-high impact of PMBoG, an element that further strengthens the considerations examined so far.

Once the results of the mean and effect size test were obtained, the research went deeper into the analysis, investigating possible relationships with the information available on the sample. Unfortunately, the answers related to the study education and age were not of interest for subsequent tests, since they presented a strong homogeneity. It was then chosen to analyze whether there were gender differences in skills as a result of the gaming experience. Unfortunately, the "other" gender option is underrepresented (only one participant), therefore it is not going to be included in this gender bias analysis.

An ANOVA test was therefore performed, with which it is possible to analyze the variability of subcategories that may seem random in nature, but which in reality are of a systematic nature (see Table 3).

The first step of ANOVA is to identify the available data, which, given the initial test, we know are Gaussian. It was then chosen to have groups that were balanced in size. In order to have so, nine elements for each of the four categories were randomly extracted, using random extraction software. The categories were:

- MaleParticipant (MP)
- FemaleParticipant (FP)
- MaleControl (MC)
- FemaleControl (FC)

Then follows the writing of the test statistics:

Table 3
Main data statistics for ANOVA.

Groups number		$k = 4$
Groups dimension		$n_i = 9\ \forall i = 1,..,4$
Pool dimension		$n = 36$
Groups means	Mean MP	$\widehat{\mu}_1 = 7,33$
	Mean FP	$\widehat{\mu}_2 = 7,11$
	Mean MC	$\widehat{\mu}_3 = 5,44$
	Mean FC	$\widehat{\mu}_4 = 5,33$
	Mean total pool	$\widehat{\mu}_{TOT_C} = 6,31$
Groups sample variances	Sample variance MP	$\widehat{\sigma}^2_1 = 1,25$
	Sample variance FP	$\widehat{\sigma}^2_2 = 1,86$
	Sample variance MC	$\widehat{\sigma}^2_3 = 2,53$
	Sample variance FC	$\widehat{\sigma}^2_4 = 2$

$$F = \frac{\frac{W}{(k-1)}}{\frac{V}{(n-k)}} \sim F_{k-1,n-k,\varepsilon\%}$$

where:

$$V = \sum_{i=1}^{k} (n_i - 1)\widehat{\sigma}_i^2 = (9-1)\sum_{i=1}^{4} \widehat{\sigma}_i^2 = 61,11$$

$$W = \sum_{i=1}^{k} n_i \left(\widehat{\mu}_i - \widehat{\mu}_{TOT_C}\right)^2 = 9\sum_{i=1}^{4} \left(\widehat{\mu}_i - 6,31\right)^2 = 33,92$$

Following this it was possible to define the critical set of data, setting a level of significance of the test equal to $\varepsilon_{\%} = 5\%$, with which it comes to determine when to reject the null hypothesis H_0 :

$$S_\varepsilon = \left\{F > F_{k-1,n-k,\varepsilon_{\%}}\right\} = \left\{F > F_{3,32,0,05}\right\} \simeq \left\{F > F_{3,30,0,05}\right\} \Rightarrow F_{3,30,0,05} = 2,92$$

In this case, the test statistic is equal to:

$$F = \frac{\frac{W}{(k-1)}}{\frac{V}{(n-k)}} = \frac{\frac{33,92}{(4-1)}}{\frac{61,11}{(36-4}} = 5,92$$

With this, it was possible to assert that $\in S_\varepsilon$, then the null hypothesis H_0 was rejected; therefore, at least one class has a significantly different average.

Having reached this result, it was considered interesting to analyze what the relationship between classes was, i.e. to establish whether there were better performing groups. To this end, the Tukey's HSD (Honestly Significant Differences) test was conducted (Tukey, 1949). The test (see Table 4) exploits the comparison between the deviation of the averages of two pairs of different groups, examining all possible combinations, with a threshold, precisely called HSD (Abdi & Williams, 2010).

Firstly, the HSD value has been identified:

$$HSD = q_\alpha(a,f) * \sqrt{\frac{MSE}{n^\circ}} = 3,85 * \sqrt{\frac{1,91}{9}} = 1,77$$

Then the table for this test was designed and the values that satisfies the condition:

$$\left|\Delta\widehat{\mu}_i - \Delta\widehat{\mu}_j\right| > HSD \quad i,j \in \{MP, FP, MC, FC\}$$

were highlighted.

The difference between participants and non-participants of PMBoG sessions (valid for both genders considered) was significant ($\Delta\widehat{\mu}_2 > HSD, \Delta\widehat{\mu}_5 > HSD$), thus strengthening the results of the mean test carried out previously. This difference is even more marked between men who took part in the game and women who took only the test directly ($\Delta\widehat{\mu}_3 > HSD$).

There was no significant difference between men and women who attended PMBoG sessions. ($\Delta\widehat{\mu}_1 < HSD$), as well as between men and women who have been subjected directly to the test ($\Delta\widehat{\mu}_6 < HSD$). The results, although in a different way from the two previous cases, showed that the difference between women who participated in the gaming sessions and men who were not part of it, did not record a significant difference ($\Delta\widehat{\mu}_4 < HSD$) (although this value is very close to the threshold).

5.2. Participants' feelings and evaluation about the game

This section briefly describes the participants' feedback in terms of game experience and learning perceptions. Participants were asked to rate the playing experience and the fun they had on a scale 1–10. Fig. 6 shows the results for individual participants (19 in total).

Table 4
Means' difference for Tukey test.

	MP mean 7,33	FP mean 7,11	MC mean 5,44	FC mean 5,33
MP mean 7,33	0	$\Delta\widehat{\mu}_1 = \lvert\widehat{\mu}_{MP} - \widehat{\mu}_{FP}\rvert = 0.22$	$\Delta\widehat{\mu}_2 = \lvert\widehat{\mu}_{MP} - \widehat{\mu}_{MC}\rvert = 1.89$	$\Delta\widehat{\mu}_3 = \lvert\widehat{\mu}_{MP} - \widehat{\mu}_{FC}\rvert = 2$
FP mean 7,11	0	0	$\Delta\widehat{\mu}_4 = \lvert\widehat{\mu}_{FP} - \widehat{\mu}_{MC}\rvert = 1.67$	$\Delta\widehat{\mu}_5 = \lvert\widehat{\mu}_{FP} - \widehat{\mu}_{FC}\rvert = 1.78$
MC mean 5,44	0	0	0	$\Delta\widehat{\mu}_6 = \lvert\widehat{\mu}_{MC} - \widehat{\mu}_{FC}\rvert = 0.11$
FC mean 5,33	0	0	0	0

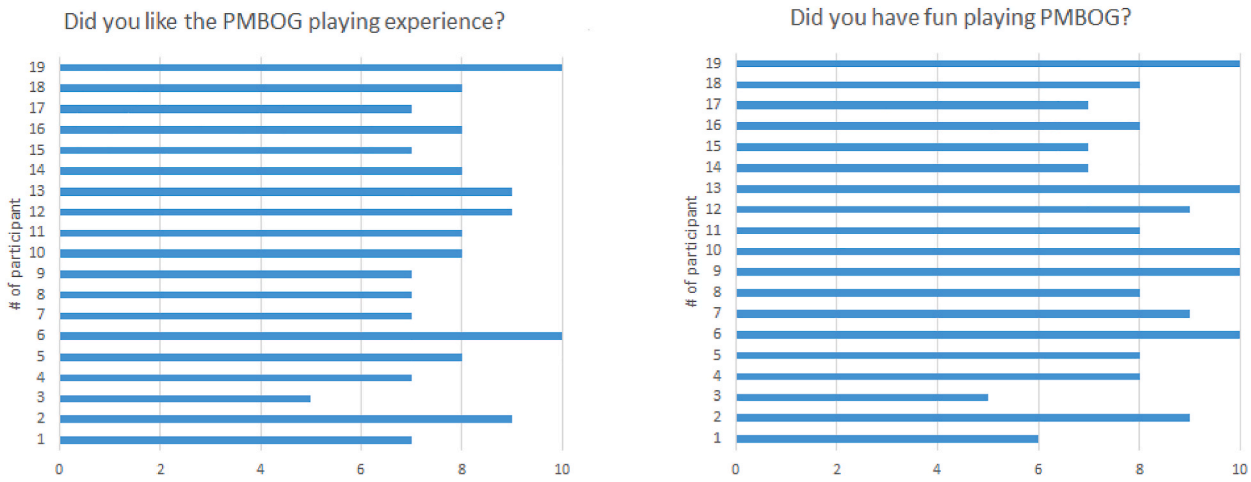


Fig. 6. PMBoG participants' general experience.

The graphs reported in Fig. 6 show a mean value equal to 7.8 for the first question and a mean value of 8.3 for the second question. Fig. 7 shows the learning perception of participants about PM skills acquired.

Fig. 7 shows that although the participants enjoyed the game, they were a little bit skeptical about its benefits in terms of PM skills acquired, as clarified by the mean value equal to 6 for both questions here considered. This preliminary result could demonstrate (in the light of the analysis of test's results) that the power and effectiveness of a boardgame in delivering hard notions and soft skills within a certain discipline is generally underrated even by the game users.

Finally, in order to better understand the participants' playing experience and to give them the possibility of arguing their impressions, at the end of the questionnaire candidates were also invited to express a personal opinion about the game summarizing the points of strength and weakness of the game. All the collected feedbacks are reported on Table 5.

The feedback gathered from students regarding the game provides a comprehensive insight into its strengths and weaknesses. Overall, the game was received positively, with several notable strengths highlighted by the participants. Firstly, the game was described as "fun" and "interesting," indicating that it successfully engaged the players and captured their interest throughout the experience. Moreover, students appreciated the game's structure, praising its clear and simple rules, as well as its well-thought-out design. The balance between the duration of the game and its goals was also commended, suggesting that the game provided a satisfying and enjoyable experience without feeling overly long or short. Furthermore, students noted that the game offered valuable opportunities for learning and skill development. Many participants highlighted how the game allowed them to work on their strategic and organizational skills, indicating its potential educational value. Additionally, the detailed nature of the game's concept was praised, suggesting that students found the game to be rich in content and depth, providing them with a fulfilling gaming experience.

However, despite its strengths, the game also exhibited several areas for improvement as indicated by the feedback. One common

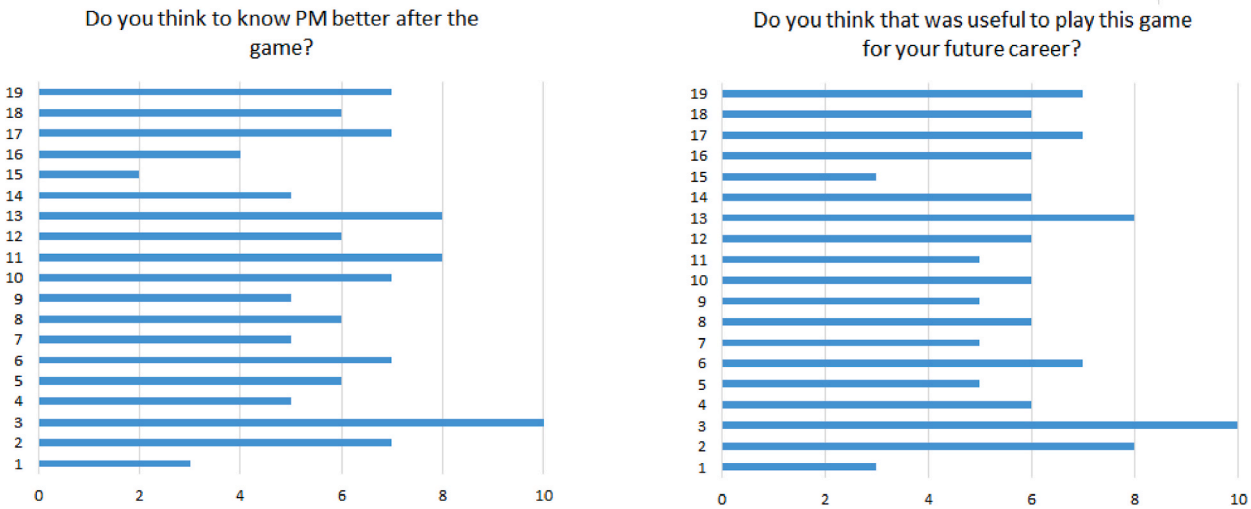


Fig. 7. Participants' opinion about PM knowledge improvement.

Table 5
Players' feedback in terms of perceived strengths and weaknesses of the PMBoG.

Strengths	Weaknesses
"Fun"	"Game explanation a bit difficult to follow"
"Well structured with clear and simple rules"	"From the point of view of the game itself, it is not possible to counter the opponents"
"Great idea, very well detailed"	"Maybe you should have the ability to interfere more with your opponents"
"Well thought out"	"A bit chaotic"
"Excellent balance between game duration and goals to be achieved"	"Perhaps too much flexibility in the period in which projects can be planned"
	"A bit cumbersome at first"
"Interesting"	"Not very intuitive, i.e. too cumbersome and not very fluid"
"Fun, well thought out and inspiring to learn"	"At times some information seemed confused or fractional to me and clarified only after the start of the game"
"It allowed me to work on my strategic and organizational skills"	

criticism was the difficulty in following the game explanation, suggesting that the instructions may need to be clarified or simplified to enhance the overall understanding and enjoyment of the game. Additionally, some students felt that the game lacked opportunities to counter opponents or interfere with their actions, potentially limiting the strategic depth and competitiveness of the experience. Other concerns included the perceived chaos at times during gameplay, as well as issues with intuitiveness and fluidity, indicating that certain aspects of the game's mechanics may need refinement for a smoother gaming experience.

Overall, while the game received praise for its entertainment value and educational potential, there are clear areas where adjustments could be made to enhance the overall gameplay experience. By addressing the identified weaknesses while building upon its strengths, the game has the potential to provide an even more engaging and rewarding experience for future players.

6. Discussion

The main objective of this study was to establish whether the gaming experience with EU Project could be considered an effective learning tool for project management skills.

The potential of business games to act as educational tools able to enhance students' learning experiences (Kolb, 1984; Kolb & Kolb, 2012), also about specific discipline-related fields of knowledge (e.g., Bellotti et al., 2010) - in this case project management - is a topic at the center of a lively debate, and further research is advocated (e.g., Calderón & Ruiz, 2015; Rumeser & Emsley, 2018; Manzano-Leòn et al., 2021). Notably, we remember that even though the EU Project entailed the development in parallel of a boardgame and a computer-based simulator, this study focused on the use in class of the boardgame - similarly to other studies (Khan & Pearce, 2015; Taspinar et al., 2016) - centered on a "serious" task (Abt, 1970) assigned to the players, i.e., the organization of a wedding ceremony to be carried out using project management tools and principles.

Based on the results obtained that we presented in Section 5.1, it is possible to confirm this hypothesis with a reliability of 95% (H1a is verified).

In addition, the Effect Size (ES) measured in this case study confirms the validity of PMBoG for educational purposes, attributing to it an impact on individuals that can be considered "medium-high" (H1b is verified).

The second analysis conducted wanted to show if there were categories that differed from others in terms of performance, e.g., considering the gender of the students, something recently addressed also by extant research (e.g., Garber et al., 2017). As noticed in the previous test, this hypothesis is true for both genders (male and female) participating and not participating in the game, going into detail: there was a statistically significant difference between individuals of same gender who took part in PMBoG and individuals of same gender who did not. This strengthens the result we got in the first test of means (H1a is verified again). There is no significant difference in the scores achieved by different genders who took part in playing sessions. This confirms that the participants belonging to different genders actually learn the PM notions with the same effectiveness (H2 is verified).

Furthermore, the second analysis highlighted some additional information which do not cover any hypothesis, but they are still worthy of being noted. Firstly, the difference of performance between men and women who did not take part in the game is not statistically relevant. This also confirms that the gender groups were homogenous in terms of project management knowledge. Secondly, the difference between the score obtained by the men who participated in the gaming sessions and women who did not take part was significant. Finally, the difference of score achieved by men who did not take part in the game and by women who played PMBoG was not relevant (even though the value was very close to the threshold). It would be interesting to carry out a test on a larger population, to better investigate and verify such results.

Our study also investigated if the gaming experience was able to provide a fully immersive interactive learning environment (e.g., Papathanasiou et al., 2019) and, specifically, if the participants felt engaged and had fun (e.g., Kangas, 2010; Pitic & Irimias, 2023), thereby also considering the entertainment-related side of the use of serious games (Abt, 1970) for educational purposes.

Specifically, the data shown in Fig. 6 demonstrate that almost the entirety of participants were satisfied in terms of playing experience as well as the fun component of it (with a mean value equal to 7.8 for the first question and a mean value of 8.3 for the second question). Notably, all the players (except one of them) rated the game with 6 or more in both questions categories.

Additionally, the results from the feedback questionnaire allowed gauging the learning perception of the participants in terms of PM skills acquisition, as clarified by the data portrayed in Fig. 7. By analyzing the answers, although the participants enjoyed the game, they were a little bit skeptical about the benefits in terms of PM skills acquired (a mean value equal to 6 for both questions).

By also analyzing Table 5, the feedbacks indicate that the gaming experience was on average very satisfactory for the participants, proving that the game is actually fun (a fundamental requirement for the effectiveness of such a tool), even though it proved to be more complex than only-for-fun traditional boardgames. However, the participants were slightly skeptical about their own improvement in PM knowledge and capability, probably believing that the game was too little notional and too much focused on game design mechanics.

Despite this feeling from part of the participants, it was thought that the most suitable way to evaluate an incremental effect in project management skills was to submit a test with questions related to PM principles to the participants and, at the same time, to a control sample taken directly from the same class of game participants, to ensure the homogeneity of basic knowledge. The various statistical tests conducted on performance have clearly proven how the sample subjected to the treatment (game session with PMBoG) has achieved a performance superior to the control sample, demonstrating the effectiveness of the instrument. Moreover, additional tests showed that women and men participating in the game had a very similar performance, clarifying the absence of gender learning bias in the game. On the other hand, the results of the performance of the men in the control sample do not seem to be statistically different from those of the women in the treated sample, however this value is very close to the threshold, so this statement should be better investigated.

Moving to the overarching research question, i.e. "Can PMBoG be considered an effective tool for improving project management skills?", this is supported by the positive outcomes of the hypotheses. H1 suggests that participating actively in playing PMBoG leads to varied learning outcomes. The implication is that the game indeed has an impact on learning, which aligns with the idea of it being an effective tool for improving project management skills. H1a goes further to posit that active engagement in PMBoG results in better learning outcomes. H1b indicates that the game has a meaningful influence with a medium to substantial effect size on learning outcomes, further supporting its effectiveness as a tool for improving project management skills. H2 explores gender differences in learning outcomes resulting from participation in PMBoG. If there is no significant difference between men and women in their scores, it suggests that the game is equally effective for both genders, reinforcing its potential as an inclusive tool for skill development in project management.

Taken together, the collective positivity of all hypotheses provide strong support for the overarching research question. They indicate that active engagement in PMBoG is associated with positive learning outcomes, potentially leading to improved project management skills. However, it's essential to conduct further empirical research and analysis to validate these claims and provide concrete evidence supporting the positive impact of the game on project management skill development.

7. Conclusions and limitations

This study explored the effects of a boardgame, developed within a European project called EU Project, on a sample of university students, to verify its effectiveness in transmitting the fundamental concepts underlying project management, which is a very relevant discipline in management, which has now become a basic skill within any organization.

The research allowed collecting many interesting data about this tool, from various points of view: first, from an experiential point of view, since the players were asked to provide feedback about their gaming experience; second, from a point of view of awareness of post-game learning, and, third, from a point of view of knowledge acquisition and enhancement about the discipline under analysis (without any frontal teaching or imposed theoretical study).

Overall, the results of this study suggest that boardgames (in this case, PMBoG), especially if designed as serious games and embedded into tailored interactive learning environments, may have high potential and effectiveness in enhancing performances and increasing skills about a certain discipline (in this case, PM).

In more detail, going beyond the proven effectiveness of the tool in better explaining what the PM is and what its principles are, it is important to emphasize all the other advantages present in the game. The participants, in fact, can enhance their knowledge and competences in the field of project management (like time management, budget management, negotiation skills, relationship management, risk management, etc.), but also general soft skills, like enabling improved self-monitoring, problem recognition and solving, as well as decision making; filtering out details, highlighting and extrapolating to better understand and control the outcome; following-up long-term strategy decisions by making short-term tactical decisions that exploit the current conditions; enhancing critical thinking adoption in a continuously changing environment, and improving reflexive skills; applying systems thinking skills in complex decision-making domains; creating a context of communication, collaboration and sense of belonging.

In addition to the previous considerations, it is noteworthy that PMBoG is highly scalable according to the skill of the participants. There are some elements of the game that have been deliberately designed to be included at will, to make the gaming experience more challenging or, on the contrary, to allow those less accustomed to management issues to fully enjoy the game without difficulty.

Finally, the boardgame was developed in a print & play format, allowing a dissemination to a wider audience. Anyone can download the game from the Erasmus+ platform, print all the game elements and cut them, and then play and learn something more about project management. The open availability of the final project materials, developed during the whole duration of the project, was a key determinant for the diffusion of the project concepts and educational message and approach across different professional sectors and beyond the countries of the consortium members. As the training material is student-centered, it can be easily adapted to different contexts.

The most important limitations of this study concern the restricted pool of students who participated in the game and in the performance evaluation test: for logistical reasons, related to the maximum number of players for the boardgame, and also for lack of additional volunteers, the sample treated does not exceed 20 individuals (the control sample reaches 25). Repeating the test on larger pools could further confirm the results acquired in this case study, strengthening the proposed theses. Another aspect to take into

account is the background chosen for this study: all 44 participants are university students in management engineering, the course of study they have chosen and undertaken is densely made up of arguments that closely deal with business management and organizations in general, so despite being unprepared in the specific theme of PM, during the game (and then in the test) they could find useful notions in their management educational background for understanding project dynamics. Conducting a comparative study involving participants from various academic disciplines, such as engineering, computer science, liberal arts, or natural sciences, could provide insights into how individuals with different educational backgrounds perceive and engage with PMBoG. Future research could shed light on whether the game's effectiveness varies across disciplines and identify any unique challenges or advantages for participants from non-management backgrounds.

The second limitation concerns the project management test used for the evaluation of students' performance in PM, which may not comprehensively measure all aspects of project management competencies. Using a single test may overlook certain skills or abilities relevant to project management, potentially limiting the study's ability to capture the full range of impacts from participating in PMBoG sessions. To provide a more comprehensive evaluation, future research could consider employing multiple assessment methods, including performance-based tasks, observation, self-assessment, and peer evaluation. This multifaceted approach would allow for a more holistic understanding of participants' development of project management competencies and provide richer insights into the effectiveness of the PMBoG as an educational intervention.

Finally, another limitation is about long-term effects and transferability. The study suggests that participation in PMBoG sessions led to higher performance on the project management test. However, the present study is actually unable to verify whether these improvements represent lasting changes in students' project management competencies or if they are limited to the immediate context of the game sessions. Additionally, as the participants in this study are undergraduate bachelor students lacking any experience working as project managers, the transferability of skills learned through PMBoG to real-world project scenarios is not directly addressed. Future research could involve longitudinal studies to assess the long-term impact of participating in PMBoG sessions on students' project management competencies. By conducting follow-up assessments at multiple time points after the game sessions, researchers can track changes in participants' skills and abilities over an extended period. This would help determine whether the improvements observed immediately after playing the game are sustained over time or diminish over time.

In conclusion, further exploration of the identified limitations presents an opportunity for future research to deepen our understanding of the efficacy and applicability of educational boardgames in fostering project management competencies. Leveraging a game meticulously crafted to be freely accessible across academic, professional, and public spheres would facilitate broader investigations into the sustained impact of game-based interventions. By embracing inclusivity and accessibility, future studies can delve into the enduring effects of such educational tools on learners' abilities to navigate real-world project scenarios.

CRediT authorship contribution statement

Stefano Armenia: Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization. **Federico Barnabè:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Conceptualization. **Fabio Nonino:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Conceptualization. **Alessandro Pompei:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization.

Data availability

Data will be made available on request.

Acknowledgement

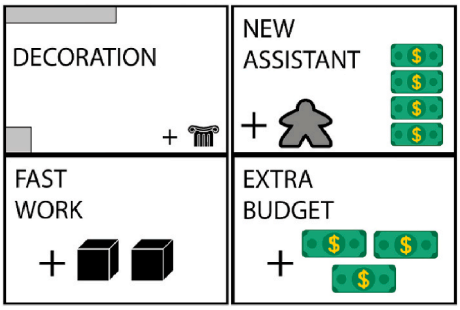
PMBoG (Project Management BoardGame – project reference: 2020-1-IT02-KA204-079724) is a European project carried out by Sapienza University of Rome, as coordinator, together with six project partners, with the support of the Erasmus+ program of the European Union. The PMBoG project lasted two years (from 2020 to 2022) and its goal was to leverage the intrinsic educational value of gaming which can be exploited for empowering the creation of individual hard and soft project management skills, hence exploiting the potential of game-based interactive learning environments.

More info here: https://erasmus-plus.ec.europa.eu/projects/search/details/2020-1-IT02-KA204-079724.

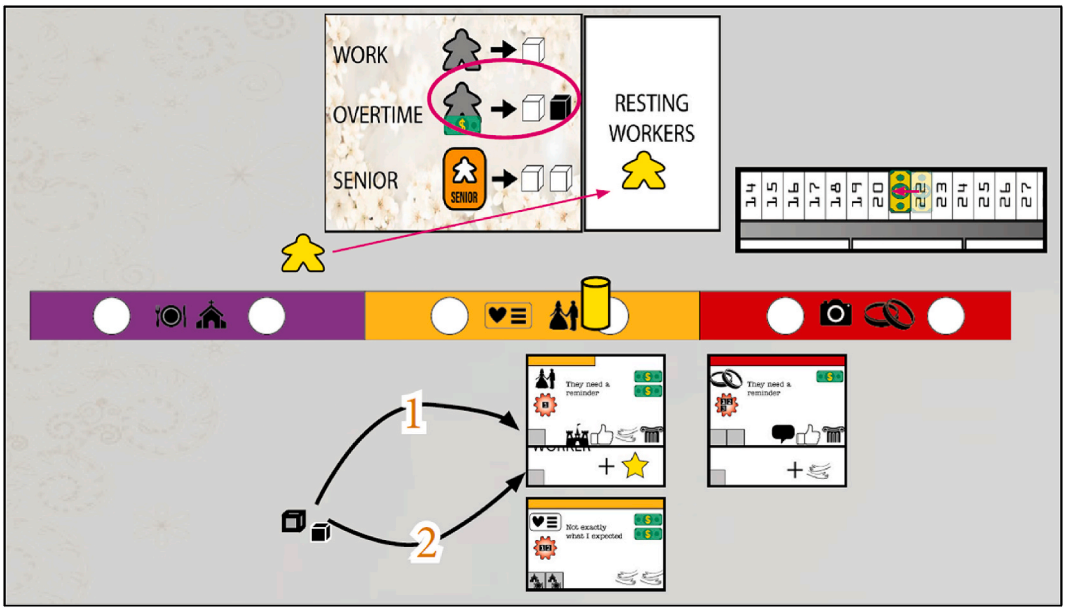
Appendix A

There are 6 different project elements to be achieved through Task cards, divided in 3 groups: location and church (purple), dresses and invitations (yellow), rings and photographer (red). Each card has its own features in terms of: match with couple's style, costs, dependencies, work to do, risks.

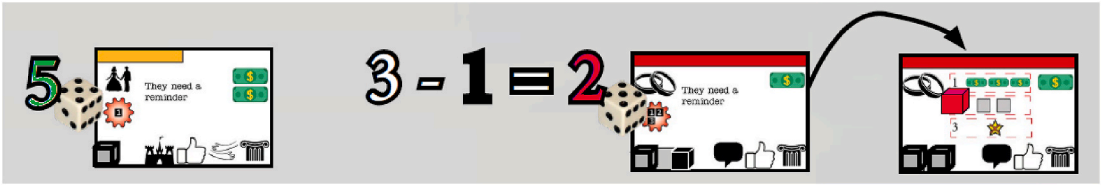
Moreover, there are Utility cards that can give bonuses or power ups during the game.



In order to take any of these cards and put them on their own project plan, players need workers to be assigned. There are 4 types of workers: basic assistant (permanent, assigned at the beginning of match), extra assistants (permanent, assigned during the game as power up), temporary workers (last only one turn, on request), senior assistants (basic assistant that was trained, capable of more effective actions). Once the activity is taken and planned, it must be executed by assistants/workers in order to be considered done.



Furthermore, at the end of the execution of an activity, if expressed on the card, the player must roll the 6-faces dice hoping that none of the numbers on the card will show up (using overtime during work will increase the probability), otherwise there are various types of malus that can happen; players can mitigate such risks by paying a certain amount (or using a senior manager), so that they can roll the 12-faces or 20-faces dice to reduce the risk.



The goal is to manage both assistants and money at the same time in order to plan and execute all the six main elements of marriage before the end of the game (6 turns), trying to get the best fit in terms of style as requested by the couple, the more the elements are in line with the couple's style, the more will be the points for the player.

Appendix B

In the following, we provide a description of the survey's structure submitted to students, including its overall design and a comprehensive list of all survey questions with their corresponding response options. We encourage readers to refer to this appendix for a comprehensive understanding of the data collection process in our study.

Demographic and background information.

1) Indicate your gender:
a) Male
b) Female
c) Other
2) Indicate your age:
   a) 19-21
   b) 22-24
   c) +24
3) Primary education:
   a) High School
   b) Technical Institute
   c) Professional Institute
4) How much are you familiar with Project Management and its meaning? (please indicate on the following scale)

a) never heard
b) unfamiliar
c) known
d) familiar
e) good knowledge

5) Have you ever delved into the discipline of Project Management?
   a) Yes
   b) No
6) Did you attend one of the two PMBoG sessions?
   c) Yes
   d) No

The following section is reserved exclusively for those who have participated in the PMBoG.

7) Did you like the PMBoG playing experience? (give a rating from 1 to 10, where 1 is "didn't like at all" and 10 is "liked very much")
8) Did you have fun playing PMBOG? (give a rating from 1 to 10, where 1 is "didn't have any fun" and 10 is "had so much fun")
9) Do you think to know project management better after the game? (give a rating from 1 to 10, where 1 is "it didn't add anything" and 10 is "I learned a lot more")
10) Do you think that was useful to play this game for your future career? (give a rating from 1 to 10, where 1 is "It was completely useless" and 10 is "It was very useful")
11) Describe your personal opinion about the game by indicating points of strength and points of weakness

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