Beyond the user experience: Evaluating a Digital Serious Game in Project Management

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Abstract

Context: The project management classroom often relies on theoretical teaching methods. However, a gap exists between the demand for skilled project managers and the ability of traditional education to fully prepare students. **Problem:** A major challenge in education, including project management learning, is maintaining student engagement and knowledge retention. Traditional methods often struggle to replicate real-world complexities, resulting in a gap between theoretical knowledge and practical application. This study explores whether a serious game can effectively bridge this gap. **Solution:** Serious games emerge as a promising solution to enhance engagement and knowledge retention in various learning contexts. In this study, we evaluated a digital serious game to improve both the tool and the students' experience. **IS Theory:** The theory of organizational learning proposes that organizations can learn and adapt. Serious align with this theory by providing simulated environments for collaborative learning and practical experience. **Method:** The study utilizes a mixed-methods approach, combining quantitative and qualitative data collection techniques to evaluate a serious game by a group of project management students. **Summarization of Results:** The study found that the serious game was effective in engaging students and enhancing their understanding of project management concepts. Students reported positive experiences with the game, highlighting its ability to simulate real-world scenarios. The game also demonstrated potential for improving knowledge retention and practical skill development. **Contributions and Impact on IS:** Providing empirical evidence for the effectiveness of serious games in project management, the study can inform future research and practice in the field.

CCS Concepts

• Software and its engineering → Applied computing → Education → E-learning

Keywords

Project Management learning, Serious Game, Active Learning, Evaluation Process, DSR.

1 Introduction

In education, one key challenge faced by professors is engaging students and sustaining their interest in the e-learning process. This challenge impacts knowledge retention and, ultimately, students' readiness for the job market.

In the managerial context, the role of a project manager demands a level of complexity that traditional teaching methods and practices often struggle to replicate effectively. The dynamic nature of project management requires not only technical expertise but also adaptability, strategic decision-making, and interpersonal skills, which are difficult to fully develop through conventional educational approaches.

The Project Management Institute (PMI) report [1] highlights a gap between the supply of qualified professionals and the increasing demand for project management skills.

Bridging this gap necessitates innovative instructional strategies that better align with the evolving demands of the market. Initiatives such as the serious games approach in Information System [2] offer a promising solution for enhancing engagement in learning. Serious games serve as a form of experiential learning [3], and have been shown the ability to influence individuals' attitudes [4]. They provide a simplified and contrived situation that contains enough illusion of reality to induce real-world-like responses [5]. Serious games are also a popular way of illustrating complex concepts and improving student motivation [6]. This is addressed to the sociotechnical view of IS [7].

This study aimed to assess the feasibility and usefulness of the game. Additionally, key game elements were evaluated to identify improvements in learning strategies for future classes.

Contributions refers to: i) the experience of evaluating a serious game beyond the user experience, incorporating complementary evidence to achieve its purpose. This includes enhancing the learning process by making it engaging and enjoyable while allowing students to simulate the role of a project manager. ii) The identified improvements can be applied in other serious games used in project management education (for professors, designers, developers).

Considering financial and platform limitations, there is still room for further enhancements to optimize student learning experience. Improvements can be made to ensure an effective and engaging educational environment and learning retention.

Originality of this study stems from the researchers' development of the game and its initial evaluation by its target audience – students of the project management course. It is expected that the key improvement points of the game will result in a new, more robust version that enhances the learning experience.

From the aforementioned motivation, this study seeks to answer the following research question.

***RQ**: How does a digital serious game support student engagement and learning experience in Project Management education?*

This paper will be structured as follows. In Section 2, we will present the background. Section 3 delves into the method. Next, in Section 4, we will illustrate the game evaluating process. Section 5 will demonstrate the results. Subsequently, Section 6 will discuss the threats of validity. Finally, Section 7 will conclude with the key findings.

2 Background

The impressive use of serious games in the industry and academia draws attention to the growing trend.

2.1 Serious games

Serious games are a versatile tool applied in different contexts. The literature shows that serious games can gather entertainment and teaching, providing a lesson for the user, through a non-digital or digital structure. Both game structures can be understood as Information System (IS), once tools and techniques in IS have already been used for game design [2]. Features of design games as IS can be used in training situations [8].

Serious games could be related to simulations to teach military strategies, negotiations and other skills. Dated 1970s serious games with the technology advance became a potential learning strategy in many different areas [6].

The purpose of serious games is to provide meaningful and engaging learning experiences that go beyond the mere transmission of information. Through simulating real-world and challenging situations, serious games allow participants to learn while doing so, developing skills such as problem-solving, decision-making, teamwork, and critical thinking. The importance of serious games in the learning process lies in their ability to motivate and engage participants, making learning more enjoyable and memorable. Additionally, serious games can be customized to meet the specific needs of different learner groups, making the teaching process more effective. Studies have shown that serious games can improve academic performance, increase knowledge retention, and promote the development of transversal skills [9,10,11].

The rising market piece has been notorious. According to a report by IMARC [12], the global serious games reached a value of US$ 5.8 Billion in 2020, US$ 11.1 Billion in 2023. Looking forward, it expects the market to reach US$ 59.4 Billion by 2032, exhibiting a growth rate (CAGR) of 20.1% between 2024 and 2032.

This growing interest in serious games extends to various interdisciplinary areas, such as Project Management.

2.2 Serious games for project management development

In the context of Project Management, the serious games approach offers a simulated and interactive environment that allows students to experience real-world situations, make decisions, and learn from the consequences of their actions.

Initial studies reported the application of serious games in Project Management can be traced back to the 1980s and 1990s [9]. Since then, the field has been a growing body of research consistently demonstrating the benefits for learning complex concepts and developing essential competences, both technical and behavioral [13].

The importance of developing serious games for PM is related to its dynamic nature. By simulating real-word projects, serious games allow students to experience challenges and opportunities typical of the workplace, providing skills such as problem-solving, teamwork, and time management. In addition, serious games can make learning more fun and motivating, which contributes to increased engagement and knowledge retention. The student becomes the protagonist of the learning process, which advocates active learning [14].

Studies point to the benefits of using serious games in PM education. For example, in a study [15], it demonstrated that serious games could improve understanding of complex concepts and develop problem-solving skills. Another study [16] highlights the potential of serious games to promote collaboration and teamwork. Moreover [16], authors provide evidence that serious games can contribute to the effectiveness of learning and training, enabling users to acquire new skills and concepts [17].

In the classroom, skills and concepts are primarily explored theoretically. Strategies such as serious games allow for a closer connection between academia and industry. The goal of better preparing project managers to meet the demand for qualified professionals is related to strengthening this relation. In this context, the organizational learning theory [18] proposes that organizations are learning systems capable of adapting and evolving continuously.

In the PM application, serious games align with this perspective by creating simulated environments that encourage collaborative learning. This is particularly relevant because both concepts emphasize the importance of practical experience, critical reflection, and the construction of knowledge from interaction with the environment.

Furthermore, in the sphere of adding dynamic capabilities to adapt to changes in the organizational context, agile governance theory [19] helps to ground agile principles in the development of competences related to projects and their dynamic nature in the organizational context.

3 Method

In the research we used mixed methods [20] and the Design Science Research approach [21] for the development and evaluation of artifacts and refinement within the Relevance, Design and Rigor cycles.

3.1 Design Science Research cycles

Design Science Research (DSR) [21] is a methodological approach aimed at developing innovative artifacts to solve real-world problems. DSR contains three interconnected cycles: relevance, design, and rigor. Each of these cycles plays a fundamental role in the continuous process of developing and refining the digital serious game in this study.

3.1.1 Relevance Cycle

We seek to identify and justify the need for a new artifact (in this case, a digital serious game). It is vital to demonstrate the relevance of the problem to be solved and how the new artifact will contribute to the field.

In the context of digital serious games for Project Management education, the relevance cycle identified and confirmed the existence of a gap between talent supply and demand, based on literature and PMI projections [1]. Another concern is making the game inclusive even with the historical difference in gender as a project manager in IT projects.

During this cycle we obtained the following outputs for the subsequent stage:

- **Foundation:** Organizational Learning Theory (OLT) [18], Agile Governance Theory (AGT) [19], Design Science Research approach (DSR) [21].
- **Problem**: Teachers have difficulty establishing and maintaining engagement and knowledge retention during the learning process in Project Management. This is a problem that has repercussions on the gap in the qualified workforce for the role of project manager.
- **Goal**: Develop a reasonable solution to reduce the difficulties faced in the project management learning process, a Business Simulation Game (BSG).
- **Requirements**: R1 Behavior (encourage an appreciative and collaborative attitude among students), R2 Cognition (stimulate learning and critical perception of the topics explored in the content), R3 Presence (stimulate students' sense of knowledge, participation, attendance and punctuality).
- **Acceptance criteria**: Feasibility, usefulness and game elements (usability).
- **Application Domain**: Education, professional training.

3.1.2 Design Cycle

After identifying the relevance, the design cycle focuses on the creation and development of the serious game. At this stage, we define the game's architecture, functionalities, user interface and game mechanics. The game design must be coherent with the research objectives and the needs identified in the relevance cycle.

The design cycle involves prototyping, testing and iterative refinement until the game is ready to be evaluated. Figure 1 shows images of the minimum viable product (MVP). The game was developed via Construct 3 (game engine).

3.1.3 Rigor Cycle

This cycle is dedicated to evaluating the artifact (the main purpose of the present study). In this stage, our goal was to collect and analyze the feasibility, usefulness of the game, and game elements (usability). We shared an online form with the students.

3.2 Game concept

The MASTER-PM (Master Project Manager) features a Top-Down visualization style while also incorporating elements of a first-person view for specific interactions. The game is classified as an Interactive Drama (with different story possibilities). The narrative is related to a company structured by projects, in which the player is inserted into the role of a new trainee, and on their very first day. There were situations that depend on the player's decision-making.

3.2.1 The phases of the game

The MPM consists of three phases, each with specific challenges. Each one takes place in a company room, encouraging the player to explore the environments, interact with characters and objects and, in the third phase, the player is faced with questions related to the proposed content.

The challenges throughout the phases are the result of simulated real-world situations and Project Managements competences [22] (technical and behavioral).

At the end of the three phases, the player receives the feedback screen, including the total score obtained and the respective competences were worked on. In addition, the player receives a certificate of participation (in pdf format) to download as another way of recording the experience.

3.2.2 Adaptations for inclusion

Even with the financial and game engine (platform) limitations, adaptations were applied in favor of accessibility and Equality, Diversity and Inclusion (EDI) [23] so that the students could be more inclusive:

- **Design**: Graphic with green and red were avoided, as this situation could be detrimental to students with color blindness.
- **Text**: The game runs in Portuguese, which means that in the dialog, depending on the gender of the player, the text was automatically adapted (e.g., article o, a).
- **Avatars and Characters**: We kept the number of characters balanced between male and female. Despite the limitations on avatar customization, we sought maximum diversity in the color and accessories of the avatars and characters.

In short, these measures were applied to provide better experience for the players.

3.3 Study Design

From the interactive cycles to develop and refining the game, the game was ready to be evaluated by the target audience.

The research protocol was developed in accordance with the ethical guidelines of the ethics committee of the university chosen for convenience where the study was performed. The protocol contained the consent form, confidentiality, procedure and details of the study.

3.4 Participants

From two classes in the Administration program and the Project Management course, 39 students were randomly selected to play the game, out of 68 students. All the students accepted the invitation by signing the consent form and participated in the whole study. The stages of the study are illustrated in Figure 2.

3.5 Data Collection

Considering the focus of this study, which was to evaluate the serious game based on the criteria of feasibility, usefulness, and game elements (usability), the main data collection instruments were the game itself, which presented the students' knowledge score, and an 11-item online form. The form assessed feasibility (3 items), usefulness (1 item), game elements (5 items), player satisfaction (1 item), and perception of the study's purpose (1 item) using a 6-point Likert scale (0 = "not applicable" to 5 = "strongly agreed") to evaluate the game. Additionally, two open-ended questions identified what the students liked most and least about the game.

3.6 Data Analysis

The collected data were analyzed quantitatively using means and frequency of the responses. Results with scores of 4 or 5 were considered positive, while the remaining scores (0 to 3) were considered disagreements by the students.

The open-ended questions were analyzed through the content analysis [24], which allows for the categorization of students' responses, enabling thematic extraction. For example, in a response about what the student liked most about the game, it is possible to also find their suggestions, which indicate more than one response category from the same participant.

The reliability of the data collection instrument was represented by calculating Cronbach's alpha coefficient.

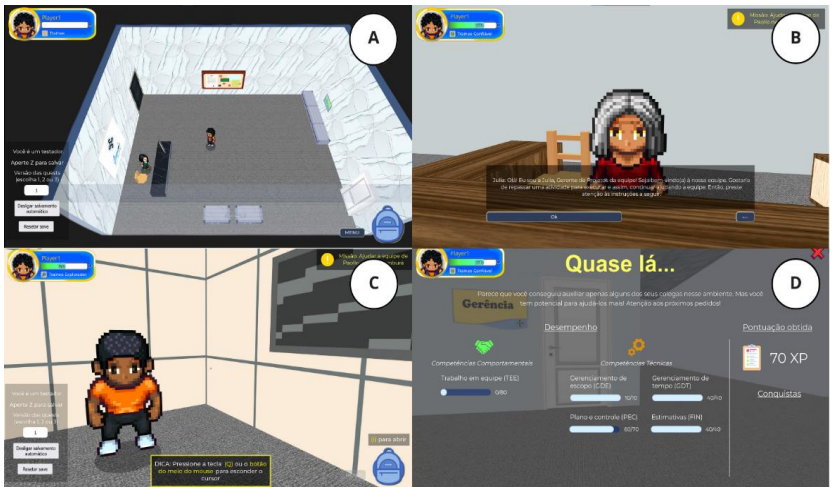

Figure 1: Screenshot of the MASTER-PM (2024). A) The Top-Down visualization style of the hall (first scenario). B) The character and the interactive text (dialogue). C), The interaction with a different character. D) Feedback page showing the results of the respective phase.

4 Game Evaluation Process

The evaluation of the MASTER-PM was structured into four distinct stages: (1) Invitation to the participants, we emailed the participants sending the Research Protocol and the Consent form; (2) The participants completed the Initial form where we collect their demographics, the engagement score (the 17-item Utrecht scale) [25] and knowledge scores (ten questions about Planning, Estimates, and Scheduling content), (3) They played the game, where we collected their performance score, and (4) They completed the Final form, with their evaluation, engagement scores (it was used the same Utrecht scale) and knowledge scores (with ten other questions about the same content). Figure 2 depicts those stages. For both scores, the grade range was between 0 and 10.

This study aimed to evaluate the participants' experience with the game, focusing on the following criteria: feasibility (analyzed through applicability, effectiveness and effort required), usefulness [26], as well as the game's elements (narrative, characters, activities, progression and feedback). In addition, we

utilized supplementary evidence to confirm i) whether the game effectively fulfills its intended purpose, ii) the key strengths that enhance the game's impact, and iii) the specific points that require improvement.

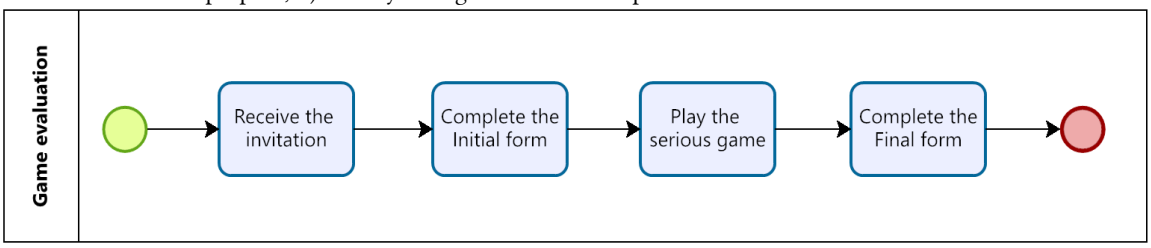

Figure 2: Game evaluation process.

5 Results and Discussion

The feedback collected by the students will be used to improve future versions of the game by prioritizing the elements that need attention in the short term.

A total of 39 students played the game. These participants represented six distinct levels of experience in Project Management. Their diverse background (Table 1) is represented by practical and conceptual experiences.

Table 1: Experience in Project Management

Experience in Project Management	n (%)
I have no practical experience or conceptual knowledge; this course is my first contact with the subject	23 (58.97%)
I have no practical experience but satisfactory conceptual knowledge.	1 (2.56%)
I have no practical experience but possess conceptual knowledge.	3 (7.69%)
I have reasonable practical experience and conceptual knowledge.	10 (25.64%)
I have solid practical experience and conceptual knowledge.	1 (2.56%)
I have excellent practical experience and conceptual knowledge.	1 (2.56%)

The levels of experience in Project Management revealed about 59% of the students had no experience in this field being practical or conceptual. 25.64% had a reasonable practical experience and conceptual knowledge. Only one student declared that had an excellent domain in the field.

Gender distribution identified 24 (61.54%) females and 15 (38.46%) males. The age range included the generations before the Baby Boomers (1946 – 1964) to Generation Z (1997 - 2012). All the students self-declared within Generation Z.

5.1 Game Feasibility

Feasibility was analyzed through three dimensions: applicability, effectiveness, and effort. Applicability allowed verifying whether the instructions in the support materials were enough to play the game. 29 students (74.36%) positively agreed with the statement. Students commented that the instructions were clear and well-detailed, helping them follow the game's steps effectively. Another student emphasized "I believe with all the available information, it is totally possible to achieve the whole process of the game since I got at the first attempt", "it is noticeable that the instructions of the game helped the gameplay."

In contrast, we observed complaints about the key resources related to the applicability criteria: "I found some difficulties to understand the purpose", "I think it was a good way to review it and realize that I did not understand very well".

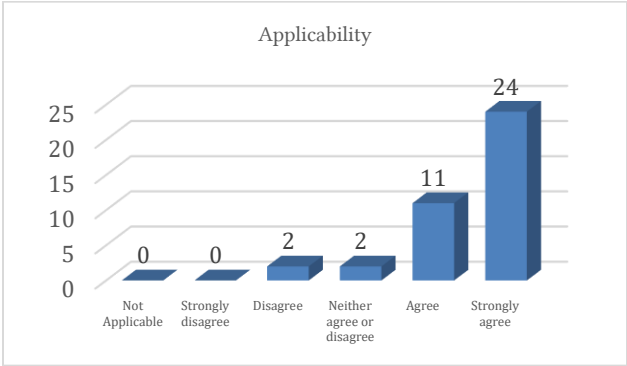

Figure 3: Game applicability distribution.

Effectiveness is related to whether the student was able to effectively complete the activities and interactions with the characters in the game. 23 students (58.90%) positively agreed with the effectiveness of the game.

Students noted that 'the game effectively supports learning challenges by encouraging players to solve problems and retain knowledge.'; "Based on my studies, I was able to complete the missions and interact easily with the characters", "the whole journey of the character was easy to read and to know what he had to do and where."

Nevertheless, some students reported minor issues, such as: "I had a bit of trouble completing all the tasks", "I couldn't quite get to grips with the questions and the ideal way to answer them, and there were too many error messages", and "Getting used to the game, in my case, took a while, so I don't consider it very effective."

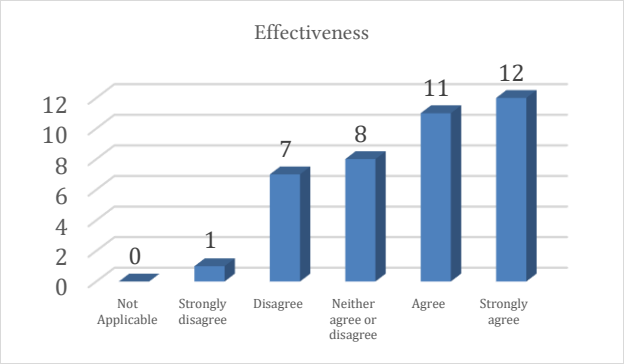

Figure 4: Game effectiveness distribution.

29 students positively expressed a positive recognition of the game's effort. Specifically, 74,36% of respondents indicated that the game was easy to play: "I found some of the stages quite challenging and capable of requiring more effort than expected, given that many project management concepts are more complex", "It does not take much effort on the gameplay. However, it does take a fair amount of effort to solve the challenges. They're not incredibly complex to require a great deal of effort, but it also takes a substantial level of effort to solve them", and "It takes a bit of effort, but I think that's healthy to make the game more fun".

Despite these positive attributes, there were several key points where the game fell short. A few specific claims highlight these shortcomings and can illustrate the aspects that need improvement:

- "It is considered an effort because you have to understand the questions",
- "It takes some effort to solve the challenges", and "In some parts it requires mental effort to complete the missions, but as far as the interface is concerned, it is quite easy."

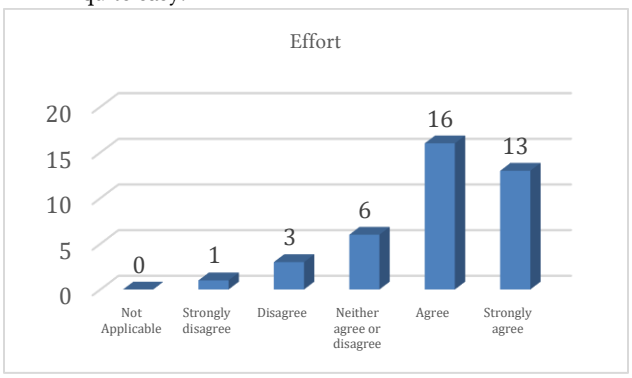

Figure 5: Game effort distribution.

5.2 Game Usefulness

A majority of students (33) praised the game's usefulness. "the game proved useful because it balanced the personal/social challenges with the technical ones", "I managed to put myself in the position of a project practitioner and I that that it the game had ore stages I would have been interested in continuing to play, I remember a notice on the bulletin board about a vacancy in project management, which would be a great next stage and made me want to play more", "the immersion is very cool and I believe that if it had an extended version it would be put to good use".

On the other hand, students argued some topics to improve: "in part, in terms of content, yes, but it was not that productive, I lost a lot of time finishing due to the game crashing my computer, time that I could have absorbed more", and "in parts, since it took me a while to finish the game the first time I played it, because it crashed on my computer, but the proposal is very interesting, a different way of learning, more dynamic."

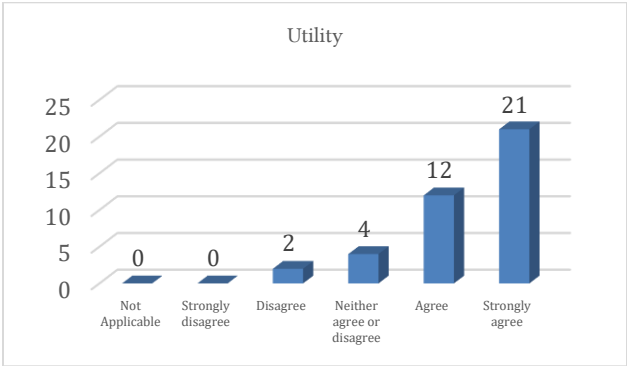

Figure 6: Game usefulness distribution.

The findings regarding Applicability and Usefulness provided the researchers with key elements for improving the game. However, other aspects have helped to detect further improvements by evaluating the elements of the game.

5.3 Elements of the game

As we gathered the students' perception (*N*=39) regarding the essential aspects of the game (Table 3), some highlights emerged:

- We observed 195 responses on the six-point scale. A total of 155 responses (79.49%) positively agreed to the use of the essential parts of the game being satisfactory about its purpose.
- Narrative was well evaluated; it was positively agreed by the 35 students (87.18% approximately).
- 31 students (79.49%) positively agreed to both characters and activities in the game that were satisfactory in fulfilling its purpose.
- One student answered "not applicable" related to the characters.

Based on these highlights, user satisfaction and the perception of the game's purpose supported an overview of how the user's experience with the game was noticed.

5.4 User Satisfaction and Perception of Purpose

User satisfaction is related to their whole experience while they played. 34 students (87.18%) positively self-declared satisfied or highly satisfied with the experience in playing the game. In

contrast, three students (7.69%) indicated that their experience was reasonable. Finally, two students (5.13%) did not have satisfactory experience. One of them complained about the frequency of the "freezing screen" that affected their gameplay. Another student indicated that the changes of the story was the reason they did not feel satisfied.

Moreover, based on the collection of perceptions regarding the purpose of the game, the students reported whether they considered the game had significant potential as a viable solution to mitigate "difficulties faced in engagement during the learning process", specifically concerning the Project Management theme.

In this criterion, the findings were similar to the satisfaction perception:

- 34 students (87.18%) positively agreed to the reasonable solution.
- 3 students (7.69%) indicated that the game was reasonable as a solution to mitigate the difficulties mentioned.
- 2 students (5.13%) did not agree to the game serving as a solution for the class of difficulties.

In addition to the evaluation criteria outlined above, supplementary evidence further supported and strengthened the evaluation process.

5.5 Supplementary evidence

We collected whether the serious game was effective for the learning process and for the students' engagement. Furthermore, from qualitative data we obtained strengths and weaknesses about the game to evidence which improvement key would be prioritized.

5.5.1 Knowledge and Engagement scores

The paired samples t-test was chosen for its ability to compare the group's performance before and after the intervention. As for knowledge (ranging from 0 to 10), on average, the students had a higher score after the game than before the game ($p<0.05$), so there was a statistically significant difference between the knowledge scores. As for engagement, there was no statistically significant difference ($p>0.05$).

Mean and standard deviation (calculated via software SPSS) (Table 2) showed that the group of students slightly increased their knowledge scores (from the ten different questions pre- and post-game about Planning, Estimates, and Scheduling content)) and their engagement scores (using the Utrecht scale) after playing the game. It is a direction to keep improving the game toward higher scores in both variables.

Table 2: Knowledge and engagement scores in the experience

Variable	Pre-game	Post-game
Knowledge	6.39 ± 2.20	7.69 ± 2.10
Engagement	5.61 ± 1.45	5.98 ± 1.40

To also compare student performance in the game (game score), the challenges of the phase played contained the same project management themes as the knowledge test.

The Student Performance in the game (ranging from 0 to 10) was observed 5.51 ± 1.55. It means that the lower knowledge score in the measurement process was found in the game score. Nevertheless, the justification of this result could be evidenced by the complaints about bugs in the game and/or for being a new learning environment for the students, it was challenging for some to adapt.

Based on the data collection, we examined two key qualitative points: i) What aspects of the game were considered the strongest? ii) Which aspects need immediate improvement? These questions guided the analysis to identify both strengths and parts for enhancement.

5.5.2 Strengths and Weaknesses

In addition to this discussion, we considered their qualitative arguments by explaining the reasons for the evaluation.

We identified 52 instances related to what the student most liked in the game. Through the content analysis [24], we established eight categories of themes:

Learning method: 12 students (23.08%) mentioned "the simulation was good for learning", "the entertainment for learning", "practicality of learning", and "the teaching methodology helped to learn".

Characters: 9 students (17.31%) highlighted "the interaction with the characters and objects", and "the dialogue between characters" as key topics they liked most in the game.

Narrative: 9 students mentioned that they liked most the narrative, as "storytelling", "the plot".

Psychological states: 6 students (11.54%) felt "immersed", "being there", "present in the context".

The remaining categories were Aesthetic (5; 9.62%), Activities (4; 7.69%) Games artifacts and Gameplay both reported by three students (5.77% each).

Regarding the essential details for improving the game, we collected 39 instances from the students about what they most disliked, which were organized into seven distinct categories. These categories represent the primary areas for improvement.

Activities: 11 students (28.21%) mentioned that they found difficulties in completing the activities by "the complexity of the content", "the time was short", "the structure of the questions", and "the movement of the avatar through the rooms".

Aesthetic: 7 students (17.95%) complained about "graphics", "interface", "lack of the overview of the game", and "the game format."

Progression: 6 students (15.38%) noticed "difficulties in identifying the next phase of the game", and "the score may not reflect their effort properly."

Gameplay: 5 students (12.82%) indicated that "some parts of the environment were restricted to entry", "the game only works properly in full screen on the computer" and "the game crashed often."

Other categories should be mentioned as Artifacts since for four students (10.26%) the game should have a "time counter during the game"; Characters, three students (7.69%) presented problems "to move the avatars in the scenario". One student revealed that "there is no information about the progress in the game."

Finally, the psychological states category was presented in an interesting way, two students (5.13%) felt such immersed in the game that noticed they disliked:

- "Do not have an interaction with the project manager in the story". Intentionally we included a mission where the player should find the project manager if they are interested in a job opportunity in the mural". This situation simulates the persistence of the player to achieve goals in their career. In this case the player got experience points (XPs) by three attempts to knock on the manager's door.
- "The language course (English) on the wall, I wasted a lot of time trying to register, thinking it was one of the activities to be done (laughs)". Intentionally we shared some events in the mural, but not all of them were part of the activities (they were not clickable), only served to be seen.

5.5.3 Representativeness

In response to researchers' concern for limitations in the interface, considering customization of the avatar, one student positively highlighted their representativeness in the game:

- "Characters: including an avatar in my skin tone, which improves the experience even more, in terms of being more immersed in the scene (real feeling)."

Even there being only one response in this case (representativeness), the feedback confirmed that the details made a difference in the immersion and presence for the play. In the case of platforms that are more limited in terms of skin color, it is necessary to look for additional resources to increase the representativeness of the user (e.g. a variety of hair, eye and clothing colors). Hence, this remains a priority for the next version of the game.

Table 3: Elements of the game distribution

Items	0 (Not Applicable)	1 (Strongly disagree)	2 (Disagree)	3 (Neither agree or disagree)	4 (Agree)	5 (Strongly agree)
NARRATIVE: "I consider the game's narrative to be satisfactory in fulfilling its purpose."	-	-	1 (2.56%)	4 (10.26%)	10 (25.64%)	24 (61.54%)
CHARACTERS: "I consider that the characterization of the game's characters is satisfactory for fulfilling its purpose."	1 (2.56%)	-	2 (5.13%)	5 (12.82%)	11 (28.21%)	20 (51.28%)
ACTIVITIES: "I consider that the activities in the game are satisfactory for fulfilling its purpose."	-	1 (2.56%)	1 (2.56%)	6 (15.38%)	15 (38.46%)	16 (41.03%)
PROGRESSION: "I consider that the progression of the game is satisfactory for fulfilling its purpose."	-	1 (2.56%)	3 (7.69%)	6 (15.38%)	15 (38.46%)	14 (35.90%)
FEEDBACK: "I believe that the feedback provided by the game is satisfactory for fulfilling its purpose."	-	-	5 (12.82%)	4 (10.26%)	16 (41.03%)	14 (35.90%)

5.5.4 Overall experience

They students answered whether they "described their overall experience of playing the game as satisfactory". Figure 7 illustrates most of the students (87%) positively evaluated their satisfaction about their experience (Figure 7).

Cronbach's alpha coefficient for the questionnaire was found to be 0.894, indicating a good internal consistency. This value is well above the recommended threshold of 0.70 [27,28], suggesting that the items within the scale indicated strong evidence of their validity and reliability.

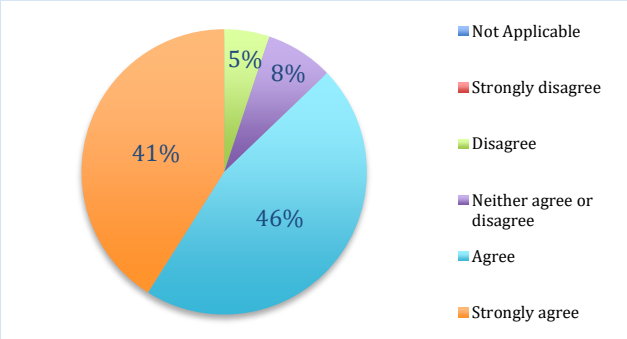

Figure 7: Overall user experience

6 Threats of Validity

Benefits emerged within this investigation, also threats to validity were carefully considered and mitigated regarding the internal, external, and construct validity [29, 30].

Internal validity deals with how research findings match reality [23]. Initially, evaluating the game with a single class could have limited the diversity of the feedback. However, by collecting the participants' level of experience in Project Management, six distinct levels emerged. Then, this finding allowed for the collection of more robust feedback in the first application of the game. Additionally, to prevent participant evasion, visual resources and clear, concise language were used in the instructions, as instructional design strategies in active learning.

External validity refers to the extent to which research findings can be replicated. The choice of a single class may limit the generalizability of the results to other contexts. For the following research, it is suggested to expand the sample to include participants from different institutions, in order to increase the representativeness and generalizability of the results. [24] For instance, after obtaining results from specific case studies, generalization can be established for similar cases in case-based research.

Ultimately, regarding **construct validity**, the data collection instruments may introduce subjective biases in the evaluation of the game. To minimize this threat, we included open-ended questions, allowing participants to express their opinions more freely and in depth, complementing the evidence.

7 Conclusion, Contributions, and Future Research

The study demonstrated the potential of the serious game MASTER-PM for enhancing student engagement and knowledge retention in project management education. By providing a simulated learning environment, serious games can bridge the **gap between theory and practice**, enabling students to apply their knowledge to real-world scenarios. Additionally, they experienced skills development.

The **results** suggested that the serious game is feasible, useful, and presented game elements that satisfactorily fulfill their objective (narrative, characters, activities, progression, and feedback). In an overview perspective, the great majority of participants (87%) presented a higher satisfaction throughout the game experience also they noticed the digital game purpose.

Supplementary evidence indicated that after playing the game, the students showed a slight increase in their knowledge and engagement scores.

Additionally, the analysis of **strengths and weaknesses** provided valuable insights for improving the game's design and development. It was possible to identify areas for improvement, such as game mechanics, user interface, content delivery, and task complexity (Section 5.5.2). Despite the limitations involved in customizing the game, the positive representation of skin color reported by one participant was further evidence that the simulation environment is noticeable, which provides immersion and presence. These insights can inform the development of the next version of the game should be more representative, engaging, effective, and aligned with learning objectives.

While the study provides valuable insights into the potential of serious games in the learning and IS context, it is important to acknowledge its **limitations**. The sample size was relatively small, and the study was conducted in two classes. Future research should explore the generalizability of the findings of different institutions and settings. Additionally, longitudinal studies could be conducted to assess the long-term impact of serious games on students' knowledge.

The findings have **contributions** to professors, designers, and developers. Incorporating serious games into their curriculum even under limitations, professors can enhance student learning and prepare them for the challenges of the workplace as an experimental environment for developing skills. For example, professors should distribute the content in challenges of different complexity at the same phase, as well as the knowledge test.

In addition, game designers and developers can leverage the insights to create more effective serious games for project management education and other areas: i) focus on resources that promote greater representativeness of users (e.g. skin color, eyes, hair and clothing of the characters); ii) seek greater mobility of the avatar in the game, to avoid interruptions and consequently a lack of interest in continuing in the game, iii) Design a balanced time-space structure for the challenges. The **key contribution** of this work lies in the application of innovative technology that provides an immersive environment where students can experience realistic scenarios, make decisions and develop project management skills (technical and behavioral). In addition, the evaluation of the game together with the analysis of knowledge and engagement generated insights for improving the artifact. Consequently, we sought to improve the performance of subsequent students. **The main improvements implemented** included: i) increasing the precision of the avatar's movement and changing the game's view (first and third person), ii) adjusting the dialogues at the end of each challenge, iii) adding a time counter to the last stage of the game. From these improvements, it is to extend the technology for practitioners to reduce the discrepancy pointed out by the Project Management Institute (PMI) report [1] between the demands and the available talent. In summary, to turn the game into a laboratory for developing PM skills.

As **future work**, the game needs to be evaluated in other classes and institutions through a longitudinal evaluation process. Additionally, it could be considered the diverse background of the students as a strategy to evaluate two or more phases of the game. We hope to apply the key points indicated by the participants prioritizing it based on the effect in the gameplay, consequently, the inclusion. Moreover, a mobile version of the game could be developed to easily achieve the new properties of the game, making it more accessible to students.

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