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Article

A systematic review on the use of serious games in project management education

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Abstract

Project management education is well suited for active learning through serious games, and a lot of research has been published on the use of serious games for project management education. Earlier reviews have focused on the content and features of project management serious games. But the objectives for using those serious games have been less reviewed. The aim of this study was to conduct a systematic review to better understand the objectives of using serious games in project management education, with the following research question: Why are project management serious games used in higher education? A systematic review was performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). A systematic search enabled us to identify 175 articles, of which forty-three met the eligibility criteria. An inductive content analysis of those articles showed that project management serious games are used for pedagogical and practical reasons. From a pedagogical perspective, serious games are mainly used to develop specific skills that are difficult to acquire in classic ex-cathedra lectures, such as practical competencies and soft skills. From a practical perspective, serious games are mainly used for proposing a risk-free trial environment. Based on our analysis, we propose a taxonomy of reasons for using PM games in higher education. Our research also reveals that few studies assess whether serious games meet all their objectives, and that more research is needed on how to implement them into a coherent pedagogical scenario.

1. Introduction

Interest in serious games has grown at all levels of education. They are seen as having a positive effect on both motivation and understanding of content. They are also seen as a medium for moving from passive to active pedagogy, and as a means of developing both practical competencies and soft skills.

Project management (PM) is a complex and multidisciplinary field that requires a combination of technical and soft skills. Traditional ex cathedra lectures may not be sufficient

to develop these skills, as they often lack the practical and interactive elements that are necessary for effective learning. Serious games, or digital games and simulations developed for educational purposes, have emerged as a promising alternative for teaching PM as they offer a risk-free trial environment and allow students to develop specific skills that are difficult to acquire through traditional teaching methods.

The subject of PM serious games has been the focus of several systematic reviews, such as those by Rumeser and Emsley [1] and Calderón and Ruiz [2], which analyse the characteristics, features, and content of existing PM serious games. While these reviews have numerous merits, they seem to focus on the serious games themselves, i.e., characteristics, features, and content of the games. However, as argued by Palaganas et al. [3], the use of serious games in training programs is a combination of three dimensions: (1) Purpose, corresponding to reasons why the serious game is used, (2) Modalities, corresponding to the serious game itself and its characteristics and (3) Methods, corresponding to teaching and learning methods used during and around the serious game. Palaganas et al. [3] addresses medical serious games, but we believe that use of those dimensions can be extended to analyse PM serious games. Purposes are related to the reason teachers or organizations choose to include a PM serious game in their training programs. Modalities are related to the PM serious game as an artifact, including content (kind of project simulated), support (board game or web game) or functionalities (trainer dashboard, possible to play alone or in teams). Methods are linked with how teachers implement the PM serious game, how the functionalities are used, and how the serious game is included in PM curriculum. Achieving the objectives of using serious games (purpose) implies the coherent implementation of modalities and methods. (Figure 1).

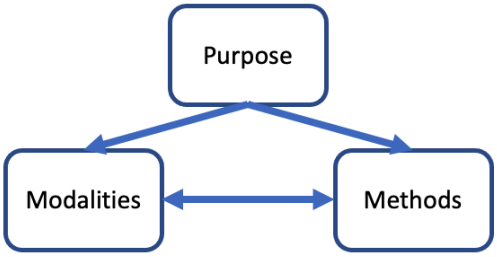

Figure 1. The Purpose, Methods, and Modalities relationships

In terms of the purpose, modalities and methods dimensions described above, previous reviews have focused mostly on modalities. But those reviews focused less on purpose and methods.

To extend the work performed in earlier reviews, we aimed at creating a better overview of the purposes of using PM serious games, with the following research question:

- Why are project management serious games used in higher education?

To answer this question, we performed a systematic review and did an inductive analysis of the content of 43 relevant articles. This led to the identification of two main dimensions of the purpose of using PM serious games. These dimensions were then divided into categories and sub-categories. This enabled us to define an overall taxonomy of reasons for using PM serious games in higher education.

2. Background

2.1 Project management education

With the increasing projectification of western economies (4), project management (PM) education is more relevant than ever. A project can be defined as a temporary endeavour to fulfil a specific objective, and PM is often associated with the practical application of knowledge and techniques (such as scheduling, cost budgeting and risk analysis) to meet this objective. Basic PM education aims at transmitting this knowledge of PM tools and methods. But the necessity of developing the ability to apply these tools and choose appropriate ones for a specific context is also recognized as necessary. In addition, soft skills are recognized as a key element for project success [5, 6]. In the context of PM, soft skills are understood as abilities of a social and subjectivist nature for dealing with people, whereas hard skills refer to objectivist and scientific/engineering abilities [7]. Purely theoretical training in PM is considered not to be sufficient, and the use of other pedagogical modalities are necessary to support the development of practical competencies and soft skills.

2.2 Serious games in higher education

The interest in serious games has increased at all levels of education. And as the COVID-19 crisis has accelerated the digitalization of education, the use of digital resources such as serious games are expected to increase even further in the coming years [8].

Serious games may include any kind of digital or non-digital games that are not intended to be played for amusement [9]. In the context of the expected acceleration of the digitalization of education [8], and to provide a focused review, we decided to focus on digital learning games. We thus accepted the restricted definition of serious games provided by Loh's Sheng's, and Ifenthaler's [10]: "Serious games are digital games and simulation tools that are created for non-entertainment use, but with the primary purpose to improve skills and performance of play-learners through training and instruction". In the remainder of this article, we therefore use the term serious game to refer to both digital games and simulations, as a coherent group of educational resources.

Overall, there seem to be good reasons for using serious games in higher education, and several reviews have been published on the topic during the past decade [11-20]. The use of serious games can provide positive effects such as knowledge acquisition, content understanding, and have affective and motivational outcomes [11-13]. Serious games are employed to educate their users due to their potential to enhance engagement, motivation, and learning outcomes [13]. They offer several advantages such as personalized learning, collaborative problem-solving, and student-centred pedagogy [17], and they can be used to teach a wide range of subjects, from science and mathematics [14. 19, 20] to energy conservation [15, 16] and business [18], including project management.

2.3 Related work on serious games in PM education

With the increased interest both in serious games and in project management education, it is not surprising that many serious games have been developed for PM education and published in several studies (for an overview, see [1, 2]). Most of those PM serious games are of the simulation type, offering students a virtual environment that reproduces the reality of project management [1]. Previous research has shown that the use of serious games in PM education improves students' learning and performance [21].

As mentioned in section 1.2 some systematic reviews have been done about PM serious games. In their systematic review, Rumeser and Emsley [1] cover current PM serious games

features and content: type of project simulated, knowledge areas covered by the serious game, project phases simulated, or game medium. This systematic review provides an overview of existing PM serious games and proposes directions for future development. Another recent review was done by Calderón and Ruiz [2], who studied the use of the ISO21500 standard in software PM education. But these studies focus less on the purposes of using serious games (why use them) and on the pedagogical methods of using them (how to use them).

3. Methods

This review was performed using the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) statement [22, 23] and based on the process described by Wright, Brand, Dunn, and Spindler [24]. We choose to use the PRISMA statement as it is a commonly accepted approach, which provides a standardized reporting framework for systematic reviews and meta-analyses, ensuring that the review process is transparent and reproducible [22]. PRISMA includes a checklist of items that should be reported in a systematic review, such as the search strategy, inclusion and exclusion criteria, and data extraction methods. According to Shea et al [25], following such guidelines ensure a high-quality review that is free from bias. The overall process is presented in Appendix B. As our research approach is of qualitative nature, we also referred to Tranfield et al. [26] for the overall approach and data analysis, and to Guba & Lincoln [27] for the quality assessment.

3.1 Search

Articles for our study were primarily searched in Thomson Reuters Web of Science [v 5.34] Core Collection database, which is one of the most comprehensive databases available covering several indexing bodies (such as SCI, SSCI and ESCI). Our search was extended to databases of renowned publishers in areas of interest: Elsevier (ScienceDirect), Emerald, Sage, Taylor & Francis, and Wiley. Personal knowledge strategy [28] was also used to reach a more comprehensive set of articles. The search was conducted in April 2020 and updated in August 2021.

From our research question, we identified two main topics. Firstly, we were exclusively interested in PM education. Secondly, we wanted to understand the purposes of using serious games in PM education. As we refer to Loh et al's [10] definition of serious games, which includes digital games and simulations, we used both terms "serious games" and "simulation" in the search string.

Hence, we used the following search string: ["project management"] AND ["serious games" OR simulation] AND [education OR teaching]

3.2 Selection Process

3.2.1 Screening: inclusion and exclusion criteria

The first screening was done based on the title and abstract. Two reviewers independently reviewed each article. In case of disagreement between the reviewers, the case was discussed in a meeting with all authors until consensus was reached.

The following inclusion criteria were used:

1. Explicitly considering PM education. PM, as defined in the PMBOK® Guide [29], had to be a central part of the educational objectives of the serious game.
2. The major component of the serious game had to be digital (board games and role-playing games were excluded). This was justified by the definition of serious games as "digital learning games and simulations."

The following exclusion criteria were used:

1. Not referring to usage of the serious game in PM education, that is, the opposite of the first inclusion criteria.
2. Not dealing with higher education at an academic institution (e.g., professional PM training offered by a company). This is in line with the aim and focus of the study.
3. Not including a serious game developed primarily for educational purposes (e.g., for engineering purposes, computer-aided design, computer-aided manufacturing, building information modelling). This is justified by the very definition of a serious game and by the fact that we are explicitly interested in the use of serious games in higher education.
4. Not published in an academic journal, proceedings, or book chapter (e.g., posters). We wanted to ensure that we are dealing with high quality studies (e.g., peer reviewed studies and studies that have matured into a written paper).
5. No use of the serious game (only about the development of the serious game), as we were interested in the use of the game rather than its development process or rationale.
6. Studies not in English (to ensure proper understanding of the texts among the research team).
7. Duplicate study (certain studies appeared twice or sometimes it was obvious that a conference paper had matured into a journal article yet referring to the same data set and results).

3.2.2 Eligibility

Articles eligible for the full-text quality assessment were first independently evaluated by two of the authors. Then all articles were discussed among all the authors.

For ten publications (of which three were non-English), we were unable to find or access the full text, even after having contacted authors. This could be a potential weakness of our study. However, looking at the missing papers only one was published after 2013, meaning the results do not represent the latest research in the field of serious games.

Application of the inclusion and exclusion from the previous step to full text made us further exclude seven duplicates (or similar papers by the same authors), three that were not about digital games, and one that was not explicitly about PM education.

For the remaining articles, we used three common quality criteria. Firstly, to perform a meaningful review, we assessed how *relevant* the article was for the research questions. We examined whether the article included a discussion of the reason for using serious games for teaching PM, discussed various facets of PM training, and included aspects of how serious games were used and implemented in higher education.

Secondly, we looked at the *credibility* of the research. Credibility (corresponding to internal validity) is one of the trustworthiness criteria often used in qualitative research [27]. We examined whether research processes were well documented, whether data collection was based on samples of sufficient size and observation period, and to what extent participating parties (like teachers and students) were included in the study.

Thirdly, we considered *transferability* and how generalizable the findings and conclusions were. Transferability (corresponding to external validity) is another common trustworthiness criteria used in qualitative research [27]. We evaluated how meaningful results were from an educational perspective and what kind of impacts the article could have for PM education and PM serious games.

For the criteria linked to relevance, credibility and transferability, each article was rated by two of the authors on a Likert scale from 1 to 5 (low to high). Based on these ratings, we calculated an average quality indicator for each article. Articles for which the average rating

differed by more than one was discussed in the panel to reach an agreement. Articles with an average quality indicator below 3 or which scored one for any of the criteria relevance, credibility or transferability were excluded from the study.

We then added a criterion related to the number of citations of the article, which may give an idea of the *significance* of an article. No articles were included based on this criterion, but we were careful before excluding highly cited articles and gave priority to the most cited versions when several versions of the same article were available. The overall criteria of the quality assessment are summarized in Table 1.

Table 1. Quality Assessment Criteria

Criteria	Description
Relevance	How relevant are the studies with the research questions? • Includes reason for using PM serious games • Includes various facets of PM training • Includes how Serious games are used and implemented
Credibility	Is research internal validity strong? • Research processes are well documented • Sufficient sample sizes and duration of observation period • Inclusion of stakeholder (teachers, students) in the study
Transferability	How generalizable are the findings and conclusions? • Results interest from an educational perspective • Potential impact for project management education if results or recommendations are implemented • Potential impact for project management serious games if results or recommendations are implemented
Significance	Number of citations = score: • 0-3 = 1 • 4-10 = 2 • 11-39 = 3 • 40-59 = 4 • 60+ = 5

3.3 Data Extraction and Analysis

To get a richer understanding of the selected studies, we performed an inductive content analysis of the articles [30]. This inductive approach enables us to identify thematic beyond what deductive process could do. We used NVivo software and coded passages relevant to our research question regarding the purposes of using serious games. NVivo is a computer-assisted qualitative data analysis software widely used for qualitative analysis and literature reviews (see e.g., [31]). Once having divided the findings into categories, we continued by creating sub-categories. An iterative process of recoding, regrouping, and merging, enables to define a final set of categories and sub-categories in such a way that the categories made sense in relation to our research question and that they were mutually exclusive. The categories where then grouped into two main dimensions.

4. Results

4.1 Study Selection

The search in the databases led to the identification of 161 articles. From the above-mentioned publishers' databases, we identified twelve more articles. Personal knowledge strategy led to the inclusion of two articles that were otherwise known to us, thus reaching 175 articles. After

the first screening, eighty-four articles were selected for quality assessment. The full-text quality assessment resulted in the exclusion of forty-one articles. The forty-three articles included for the qualitative analysis are listed in Appendix A. Figure 3 illustrates the selection process.

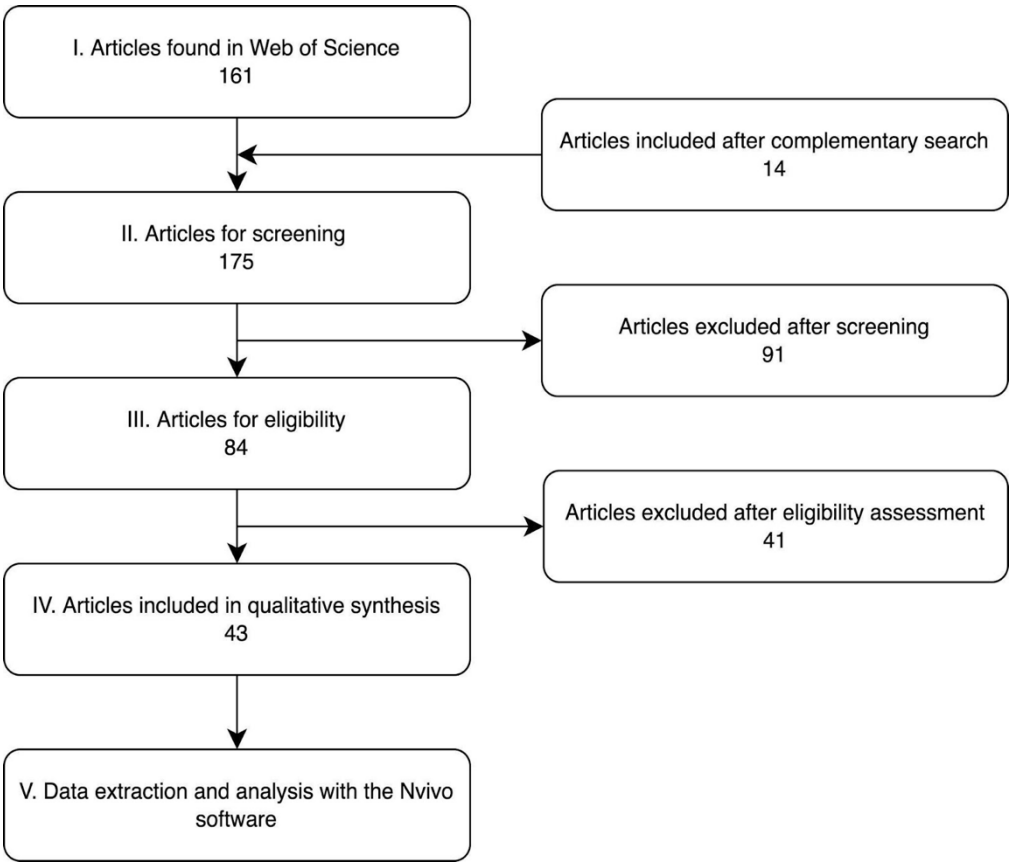

Figure 2. Flowchart of the selection process

4.2 Articles Characteristics

Out of the forty-three articles included in the qualitative analysis, nineteen did not refer to any specific type of project but were concerned with general PM. Eleven made specific references to software engineering PM. The rest (8) referred to various project types, such as engineering, construction, or event projects.

In our search string, we included both simulations and serious games; twenty-three articles referred to the former term, whereas eleven articles explicitly used the term *serious games*. One article used the term *educational game*. Another dealt with both simulations and serious games. Four articles referred to *games* more generally. All those pedagogical resources correspond to Loh et al's [10]) definition of serious games that we used for this article (i.e., digital games or simulations developed for educational purposes).

Twenty different games were mentioned by their specific name. Of those twenty games, some are available on the internet, while others are used by research groups on an exclusive basis.

Among the methods used, two types of studies stood out: eighteen articles used a design science research approach, presenting and arguing for the design features of a PM serious game, and fifteen articles reported on experiments, where either pre-/post-tests or test/control groups were used. Eight articles made use of surveys, either among students, educators, or other expert

groups. Four review articles were included, with one systematic literature review [1] and one which had evaluated a set of PM games [32]. Two articles reported lessons learned from using serious games in PM teaching. See Table 2 for an overview of the characteristics.

Table 2. Article Characteristics.

Items	Number of Articles
Type of Project	
General PM	19
Software engineering PM	11
Various project types (engineering, construction, event, etc.)	8
Terminology	
Simulations	23
Serious games	11
Games (general)	4
Educational game	1
Simulations and serious games	1
Methodology	
Design science research approach	18
Experiments (pre-/post-tests or test/control groups)	15
Surveys	8
Review articles (systematic literature review or evaluation of a set of PM games)	4
Lessons learned from using serious games in PM teaching	2

Based on an inductive analysis, we found two broad aggregate dimensions of reasons for using PM games: the pedagogical and the practical reasons. In the next sections, we will present these two dimensions in more detail with their categories and sub-categories.

4.3 Pedagogical reason for using serious games

Among the pedagogical reasons for using PM games, we found four recurring categories: (1) develop specific knowledge and skills required in real-life projects, (2) implement a new pedagogical approach, (3) improve the learning impact and (4) modify the student-learning relationship.

These pedagogical reasons, with their subcategories are presented in Table 3 and further discussed.

Table 3. Pedagogical reasons for using serious games in PM education, with the corresponding number of articles in each category.

Categories	Definition	Subcategories	# Of articles
Specific knowledge and skills	The serious game is used to link theory and practice, to develop the ability to apply tools and methods, and to develop the ability to collaborate with people	Complexity	13
		Combining theory and practice	12
		Critical thinking	7
		Decision-making	7
		Sociotechnical skills	3
		Simultaneous skills	1
New pedagogical approach	The serious game is used to implement new kinds of pedagogical approaches	Experiential or practice-based learning	22
		Experimental learning	8
		Collective learning	6
		Active learning	6
		Constructivist approach	1
Learning impacts	The serious game is used to achieve better learning impacts	Improved learning	12
		Efficacy	5
		Reflection	3
		Abstraction	2
		Broader learning	2
		Retention	2
Student-learning relationship	The serious game is used to increase students' interest in learning	Motivation	10
		Engagement	8
		Challenge	7
		Fun	3

4.3.1 Developing Specific Knowledge and Skills

Thirteen articles present the use of serious games as a means of developing complex thinking or the ability to tackle the complex problems of project reality. E.g., *"The objective of the game is for students to appreciate and experience the complexity of project management in an intense and yet exciting way."* [33].

Twelve articles refer to practical skills development as a specific reason for using serious games. In those articles, the main goal of using the serious game is to confront students with a practical situation that should help them to gain practical skills and experience. The authors of those articles argue that PM is a practical skill, and that traditional education does not address this. Serious games are presented to fill a gap between theoretical concepts and practical applications. E.g., *"There is a gap between the theoretical concepts that are normally learned in traditional courses and the practical aspects required by the real tasks"* [34, p. 52].

Other reasons for using serious games are soft skills development in parallel with hard skills. As for practical skills, the two main reasons are that (1) PM needs soft skills, and (2) those skills are difficult to acquire in traditional lectures. E.g. *"So, on one hand, the set of methods*

and tools specific to project management is well known and quite limited (WBS, PERT, Gantt, EVM), but, on the other hand, managing projects successfully is less dependent on the knowledge of these tools than on the capacity of applying the right tools, mixed with the project manager's soft skills." [35].

Seven articles refer to critical thinking, which is presented as an essential result of PM education and higher education in general. It is argued to be difficult to develop in traditional classes. Serious games, by offering complex problems, opportunities to examine assumptions and implications, group problem solving, and interconnected decisions, may help to develop critical thinking. E.g., *"Additionally, simulations develop critical and strategic thinking skills."* [36, p. 290].

Three articles refer to socio-technical skills, in particular human issues of PM, and argue that students need to experience those difficulties. Students need to develop both technical and social skills. It is argued that this should be addressed through experiential learning. E.g., *"Project managers must be both technically and socially competent to develop teams that can work dynamically."* [37, p. 1325].

One article presents the serious game to develop simultaneous skills of PM (planning, controlling, organizing, staffing, and directing). E.g. *"[…] uses simulation to reflect the various aspects to be dealt with throughout the management of a project: negotiation, dealing with conflicts, decision-making, and technical concepts related to project management, such as project planning, resource management, budgeting, project execution, project control, group work, etc."* [38, p. 296].

4.3.2 Pedagogical Approaches

Experiential learning, such as practice-based learning and learning by doing, are presented as an effective way of teaching, and learning PM. The serious game is used as the source of experience, to allow experimentation (applying and testing conceptual knowledge) and experience to be repeated.

The use of a serious game is described as providing a better learning environment than traditional lectures for PM education. E.g., *"The source of learning is what the participants do rather than what they are told by the trainer."* [39, p. 243].

PM serious games are presented to move from individual learning towards collaborative learning. This is done by promoting teamwork, group problem solving and decision-making. The serious game is also used to develop interaction between students and create a community. E.g., *"Interpersonal interaction among students creates a community in which educational value can be created by improving learning interest and efficiency."* [33, p. 3878].

In most of the articles, serious games are presented as means to implement practical experiences in the learning process, as the source of experience from which students will construct knowledge.

4.3.3 Learning Impacts

Learning enhancement seems to be a major expectation when using games in education. Serious games are presented as having a higher efficacy level than standard lectures, but this assumption is mainly found in the introduction section, and not supported by studies done by the authors in their articles.

Four articles refer to efficacy. E.g., *"The nature of simulators as online devices yields a higher level of efficacy than traditional lecture."* [40, p. 334]

Three articles refer to reflection, arguing that serious games increase students' reflection. E.g., *"[Serious games] allows the student to think about how he/she relates to the practice … and reflect about their own role."* [41, p. 190]

Two articles argued that use of a serious game may increase students' retention of knowledge. E.g., *"[Serious games] can increase students' conceptual and practical knowledge, students' confidence, task completion and improve retention."* [42, p. 1].

4.3.4 Student-Learning Relationship

In 10 articles, we found that using a PM serious game increases students' motivation and this motivation will increase students' engagement in learning activities. Fun aspects of serious games are mentioned in a few studies. Using a serious game is presented to improve students' relationship with learning. E.g., *"Simulation games can trigger participants' motivation for learning."* [43, p. 185].

In those same ten articles, we also found that serious games are often supposed to be intrinsically motivating and challenging and thought to increase students' engagement in learning. Those assumptions are based on other studies, or the proposition is believed to be self-explanatory. Actual impact on motivation is mainly described in a single sentence in the introduction and not often assessed in the study.

4.4 Practical reasons of using serious games

We identified three recurring categories of practical reasons for using games: (1) convenience of offering a practical experience, (2) flexibility and (3) assessment and data analysis. These results are presented in Table 2 and further discussed.

Table 4 shows those categories, with their sub-categories and corresponding number of articles.

Table 4. Practical reasons for using serious games in PM education.

Categories	Definition	Subcategories	# Of articles
Convenient way to offer a practical experience	The ability of a serious game to provide a realistic PM experience at low cost and at no risk	Risk free environment	12
		Low cost	7
		Dynamism	6
		Time consumption	5
		Fidelity, uncertainty, time pressure	4
Flexibility	The features of a serious game enabling it to be adapted to a variety of learning situations	Controlled learning	4
		Customization	3
		Simple to operate	2
		Accessibility	2
Assessment and data analysis	The feature of a serious game to measure performance	Assessment	3
		Continuous monitoring	3
		History record	1

4.4.1 Convenient Way to Offer a Practical Experience

The possibility to reproduce reality at low cost is presented as the most important reason for using a serious game. Internships are the most authentic means of developing practical training in a real-life context, but problems of cost and time often make them difficult to implement. Serious games are presented as an alternative to those practical experiences.

4.4.2 Flexibility

Three studies pinpointed customization and ability to tailor the game for the class and its learning objectives as an important facet of serious games. This flexibility was mentioned both on the level of the course curriculum and on the level of a specific game instance. Ease of use and simplicity were often mentioned together with customization. But some articles argue that this aspect of gaming may not have received enough attention among scholars. Rodrigues, Souza, and Figueiredo [44] argue that one of the reasons for not adopting serious games is the perceived lack of time among teachers to plan and implement these approaches as part of their courses. Two studies mentioned accessibility as a practical reason for using serious games.

4.4.3 Assessment and Data Analysis

Some studies include analysis and formative evaluation of student performance as a practical reason for using serious games. Aspects that were explicitly mentioned were possibilities to integrate assessment elements in the games, to continuously monitor and control the learning situation, and to keep a record of events and decisions made inside the game. The latter may be useful for debriefing sessions and further analysis of student's managerial behaviour.

5. Discussion

Previous reviews have focused on the modalities of using serious games in PM education, but less on the purposes, i.e., reasons for using serious games. The goal of this review was to study the purposes of the use of serious games in PM education.

We found that pedagogical and practical aspects were the main reasons presented for using serious games. But those reasons were mainly presented as assumptions based on other studies or thought to be self-explanatory. Those statements were mainly found in the introduction, but few studies evaluated whether serious games meet all the objectives for which they are claimed to have been implemented.

We found four categories of pedagogical reasons for using serious games: they (1) develop specific skills required in real-life projects, (2) enable the implementation of new pedagogical approaches, (3) improve learning impact, and (4) care for the student-learning relationship. Results found in these categories were mainly student and learning oriented, and the teacher's perspective was rarely addressed.

We found three categories of practical reasons for using serious games: they offer (1) a convenient way to provide a practical experience, (2) offer flexibility of use, and (3) enable assessment and data analysis. Results found in those categories were mostly teacher oriented. It was surprising that few studies address all these three categories. The only practical reason mentioned in more than ten studies was the risk-free environment. For flexibility, only two articles mentioned online accessibility as a reason for using PM serious games. This is surprising, given the focus on online teaching that we have experienced during the past two decades. With the surge of online teaching witnessed during the COVID-19 pandemic, we believe this aspect of serious games will get more attention in future serious games research and development. We found only a few papers that include a section on assessment and data analysis. But with the development of learning analytics [45-47], we believe that this subject will grow in importance over the next few years.

The identified aggregated dimensions, categories, and sub-categories give rise to a taxonomy of reasons for using PM games in higher education, presented in Table 5.

Table 5. A taxonomy of reasons for using PM games in higher education

Dimensions	Categories	Subcategories
Pedagogical reasons	Specific knowledge and skills	Complexity
		Combining theory and practice
		Critical thinking
		Decision-making
		Sociotechnical skills
		Simultaneous skills
	New pedagogical approach	Experiential or practice-based learning
		Experimental learning
		Collective learning
		Active learning
		Constructivist approach
	Learning impacts	Improved learning
		Efficacy
		Reflection
		Abstraction
		Broader learning
		Retention
	Student-learning relationship	Motivation
		Engagement
		Challenge
		Fun
Practical reasons	Convenient way to offer a practical experience	Risk free environment
		Low cost
		Dynamism
		Time consumption
		Fidelity, uncertainty, time pressure
	Flexibility	Controlled learning
		Customization
		Simple to operate
		Accessibility
	Assessment and data analysis	Assessment
		Continuous monitoring
		History record

We also noticed that most of the articles analysed included only limited information on pedagogical implementation methods, e.g., how serious games were integrated into an overall pedagogical scenario. This contrasts with, for example, the use of serious games in the medical field, where more information is found on the activities around the game itself, such as pe-briefing or debriefing. We believe that this is due to the brief history of PM serious games in comparison with medical serious games. Overall, we feel that the use of serious games in PM education is still in its initial stages.

5.1 Limitations

This systematic review may have several factors that may influence its validity.

As for all reviews, it was limited by search terms and databases included, as well as the time period of articles published. We used the Web of Science database, complemented by databases of renowned publishers, but some relevant articles may not have been identified.

Articles that were not written in English have been excluded. Those articles may however have had potential value for our study.

While the review respected the PRISMA statement, the quality assessment in management studies is not as evidence-based as in medical studies. Inclusion and exclusion criteria were explicitly defined, and each article was evaluated by two authors based on those criteria. But both the definition of those criteria as their application may be subjective and depend on the evaluator. The quality assessment process could also be improved by adding more quantitative criteria.

A further limitation lies in the categorization of sub-categories. Even if it was generally evident, for some items it was trickier. For example, some reasons of using serious games may be linked to both pedagogical and practical objectives.

6. Conclusions and future works

In this research, we wanted to study reasons why serious games are used in project management (PM) education. Based on the analysis of 43 relevant articles, we found two main categories of reasons presented for using serious games in PM education: the pedagogical and the practical reasons. From a pedagogical perspective, serious games are mainly used to develop specific skills that are difficult to acquire in classic ex cathedra lectures, such as practical competencies and soft skills. From a practical perspective, serious games are mainly used for proposing a risk-free trial environment.

6.1 Theoretical contribution and practical implications

Based on results found in the analysis of the content of the sample articles, we propose a taxonomy of reasons for using PM games in higher education. This taxonomy can be used for further analytical purposes by other researchers. Overall, such taxonomies can help researchers to organize and structure information more efficiently and facilitate comparisons across studies. This can be useful for identifying patterns and trends across future studies on the purposes and ways of using serious games in higher education.

The taxonomy expanded the scope of earlier reviews of the use of serious games in PM education. Earlier work has covered current PM serious games features and content [1, 2]. In contrast, the proposed taxonomy provides an overview of the purposes of using serious games in PM education. Previous research indicated that usage of serious games in PM education is driven by pedagogical factors that align with the perceived positive outcomes associated with their use, including increased motivation and engagement [11-13], as well as the provision of a virtual environment that replicates the real-world context of PM [1]. Our review shows that

these benefits were explicitly cited in ten articles for motivation, eight articles for engagement, and twenty-two articles for experiential or practice-based learning. Among these, the latter aspect was mentioned most frequently (12 articles) as a practical rationale for incorporating serious games in education. Our review indicates that the primary justification for employing serious games, from both pedagogical and practical standpoints, is the belief that they can deliver a learning experience that is comparable to real-world practice.

The taxonomy may also prove beneficial for university teachers who wish to reflect on (and potentially expand) their own use of PM games in relation to the variety of rationales included in the taxonomy. The taxonomy may help teachers to define learning objectives and outcomes in connection to the use of PM games, which in turn can improve instructional planning and assessment. It can also help teachers to organize and structure their curriculum and PM games related instruction more effectively. The taxonomy also provides a common language and framework for teachers to communicate learning objectives and outcomes of using serious games, both to students, teachers, and other stakeholders, such as educational program managers.

6.2 Future research

Our review found that most of the reasons for using serious games in PM education are presented as assumptions, based on other studies, or taken as self-evident. But we found few studies that evaluated whether serious games achieved the goals for which they were developed. For this purpose, a taxonomy of reasons for using PM games in higher education, such as proposed in this article, may be helpful. Moreover, we found that most studies adopt a students' perspective. Little is written from a teacher's point of view, which according to some studies is a major obstacle for the dissemination of serious games in higher education [44]. For example, we found almost no information on how to include the serious game in a coherent pedagogical scenario. We propose that future research be conducted to address these knowledge gap.

As shown by this study, PM serious games have the potential to support active pedagogies and to bridge the gap between knowledge and experience. The game technology field is rapidly developing. This may bring up both new reasons and modalities for using games in higher education. But more research is needed on learning implementation. This should provide teachers with guidelines on how to use games and thus make it easier to implement serious games in education.

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Conflicts of interest

None declared conflict of interest.

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Appendix A. Articles included in the review

Ratings are rounded up towards nearest integer.

#	**ARTICLE**	Credibility	Transferability	Relevance	Significance
1	Bollin, A., Hochmüller, E., & Mittermeir, R. T. (2011). Teaching software project management using simulations. *2011 24th IEEE-CS Conference on Software Engineering Education and Training (CSEE&T)*, 81–90.	5	5	5	3
2	Bonazzi, R., Missonier, S., Jaccard, D., Bienz, P., Fritscher, B., & Fernandes, E. (2011, October 7). *Analysis of Serious Games Implementation for Project Management Courses*. https://doi.org/10.1007/978-3-7908-2789-7_53	5	3	5	2
3	Bourdeau S., T. Coulon and M. -C. Petit, "Simulation-Based Training via a "Readymade" Virtual World Platform: Teaching and Learning With Minecraft Education," in IT Professional, vol. 23, no. 2, pp. 33-39, 1 March-April 2021, doi: 10.1109/MITP.2021.3062935.	4	4	3	1
4	Calderón, A., & Ruiz, M. (2016). Coverage of ISO/IEC 12207 Software Lifecycle Process by a Simulation-Based Serious Game. In P. M. Clarke, R. V. O'Connor, T. Rout, & A. Dorling (Eds.), *Software Process Improvement and Capability Determination* (pp. 59–70). Springer International Publishing. https://doi.org/10.1007/978-3-319-38980-6_5	2	3	2	3
5	Calderón, A., Ruiz, M., & O'Connor, R. V. (2018). A serious game to support the ISO 21500 standard education in the context of software project management. *Computer Standards & Interfaces*, *60*, 80–92. https://doi.org/10.1016/j.csi.2018.04.012	4	3	3	2
6	Calderón, A., Ruiz, M., & O'Connor, R. V. (2019). Designing game scenarios for software project management education and assessment. *IET Software*, *13*(2), 144–151. https://doi.org/10.1049/iet-sen.2018.5081	3	3	2	1
7	Cano, Juan L. & María J. Sáenz (2003) Project management simulation laboratory: Experimental learning and knowledge acquisition, Production Planning & Control, 14:2, 166-173, DOI: 10.1080/0953728031000107644	2	5	4	3
8	Cohen, I., Iluz, M., & Shtub, A. (2014). A Simulation-Based Approach in Support of Project Management Training for Systems Engineers. *Systems Engineering*, *17*(1), 26–36. https://doi.org/10.1002/sys.21248	5	4	3	3
9	Davidovitch, L., Parush, A., & Shtub, A. (2006). Simulation-based Learning in Engineering Education: Performance and Transfer in Learning Project Management. *Journal of Engineering Education*, *95*(4), 289–299. https://doi.org/10.1002/j.2168-9830.2006.tb00904.x	3	4	5	5
10	Davidovitch, Lior, Parush, A., Hewett, T., & Shtub, A. (2009). *Training Teams in Managing Projects in a Matrix Structure*. 487–490. https://doi.org/10.1115/ESDA2008-59045	4	5	3	3
11	Davidovitch, Lior, Parush, A., & Shtub, A. (2008). Simulation-based learning: The learning–forgetting–relearning process and impact of learning history. *Computers & Education*, *50*(3), 866–880. https://doi.org/10.1016/j.compedu.2006.09.003	3	4	4	4
12	Davidovitch, Lior, Parush, A., & Shtub, A. (2009). The impact of functional fidelity in simulator-based learning of project management. *International Journal of Engineering Education*, *25*(2), 333–340. https://ir.library.carleton.ca/pub/20176	4	5	3	3
13	Fahmi Hassan, A., Haghighi-Rad, F. and Abtahi, A.-R. (2021), "Enabling construction project managers through a management game", Industrial and Commercial Training, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/ICT-05-2020-0062	4	3	3	n/a
14	Flores, N. H., Paiva, A. C., & Letra, P. (2016). Software engineering management education through game design patterns. *Procedia-Social and Behavioral Sciences*, *228*(21–23), 436–442.	3	4	2	3
15	Galvão, T. A. B., Neto, F. M. M., Bonates, M. F., & Campos, M. T. (2011). A serious game for supporting training in risk management through project-based learning. *International Conference on Virtual and Networked Organizations, Emergent Technologies, and Tools*, 52–61.	3	3	3	1
16	García-Álvarez, M. T., Varela-Candamio, L., & Rubiera Morollón, F. (2016). Simulation in Software Engineering Education: A System Dynamics Proposal. *International Journal*	3	2	2	1

	of Engineering Education, *32*(4), 1611–1617. https://www.ijee.ie/contents/c320416.html				
17	González-Marcos, A., Alba-Elías, F., & Ordieres-Meré, J. (2016). An analytical method for measuring competence in project management: Assessment of project management competences. *British Journal of Educational Technology*, *47*(6), 1324–1339. https://doi.org/10.1111/bjet.12364	3	5	4	3
18	Iluz, M., & Shtub, A. (2013). Simulator Based Training to Improve Tradeoffs Analysis and Decision Making in Lean Development Environment. In V. Prabhu, M. Taisch, & D. Kiritsis (Eds.), *Advances in Production Management Systems. Sustainable Production and Service Supply Chains* (pp. 108–117). Springer. https://doi.org/10.1007/978-3-642-41263-9_14	5	5	3	1
19	Jaccard, D., & Riboni, S. (2010). SimProjet: An innovative simulation platform for experiential learning in project management. *2nd International Conference on Computer Supported Education*.	5	2	4	1
20	Jeong, K.-Y., & Bozkurt, I. (2014). Evaluating a Project Management Simulation Training Exercise. *Simulation & Gaming*, *45*(2), 183–203. https://doi.org/10.1177/1046878113518481	5	4	5	3
21	Lee, W.-L. (2011). Spreadsheet based experiential learning environment for project management. *Proceedings of the 2011 Winter Simulation Conference (WSC)*, 3877–3887. https://doi.org/10.1109/WSC.2011.6148079	5	3	4	3
22	Maratou, V., Chatzidaki, E., & Xenos, M. (2016). Enhance learning on software project management through a role-play game in a virtual world [†]. *Interactive Learning Environments*, *24*(4), 897–915. https://doi.org/10.1080/10494820.2014.937345	3	4	3	3
23	Maria Jesus Saenz & Cano, Juan. (n.d.). Experiential learning through simulation games: An empirical study. *International Journal of Engineering Education*, *25*(2), 296–307. https://www.researchgate.net/profile/Maria-Saenz-11/publication/257614743_Experiential_learning_through_simulation_games_An_empirical_study/links/00b49528666f38cb78000000/Experiential-learning-through-simulation-games-An-empirical-study.pdf	4	5	4	3
24	Mawdesley, M., Long, G., Al-jibouri, S., & Scott, D. (2011). The enhancement of simulation based learning exercises through formalised reflection, focus groups and group presentation. *Computers & Education*, *56*(1), 44–52. https://doi.org/10.1016/j.compedu.2010.05.005	4	5	4	3
25	Mayr, P., Bendl, H., & Mörike, F. (2016). The Double-Effect Approach to Serious Games in Higher Education: Students Designing and Developing Serious Games for Other Students. In A. De Gloria & R. Veltkamp (Eds.), *Games and Learning Alliance* (Vol. 9599, pp. 42–50). Springer International Publishing. https://doi.org/10.1007/978-3-319-40216-1_5	3	2	3	1
26	Misfeldt, M. (2015). Scenario Based Education as a Framework for Understanding Students Engagement and Learning in a Project Management Simulation Game. *Electronic Journal of E-Learning*, *13*(3), 181–191. https://files.eric.ed.gov/fulltext/EJ1060165.pdf	4	3	2	1
27	Nassal, A., & Tichy, M. (2016). Modeling Human Behavior for Software Engineering Simulation Games. *2016 IEEE/ACM 5th International Workshop on Games and Software Engineering (GAS)*, 8–14. https://doi.org/10.1109/GAS.2016.010	4	4	4	1
28	Nembhard, D., Yip, K., & Shtub, A. (2009). Comparing Competitive and Cooperative Strategies for Learning Project Management. *Journal of Engineering Education*, *98*(2), 181–192. https://doi.org/10.1002/j.2168-9830.2009.tb01016.x	4	5	4	3
29	Pagano, R., & Blair, G. (2014). Virtual project management: Evaluation of an e-learning environment. *European Conference on E-Learning*, 378.	3	3	3	1
30	Petri, G., von Wangenheim, C. G., Hauck, J. C. R., & Borgatto, A. F. (2019). Effectiveness of Games in Software Project Management Education: An Experimental Study. *Journal of Universal Computer Science*, *25*(7), 840–864.	4	4	4	1
31	Pfahl, D., Laitenberger, O., Ruhe, G., Dorsch, J., & Krivobokova, T. (2004). Evaluating the learning effectiveness of using simulations in software project management education: Results from a twice replicated experiment. *Information and Software Technology*, *46*(2), 127–147. https://doi.org/10.1016/S0950-5849(03)00115-0	2	3	3	5
32	Raabe, A., Santos, E., Paludo, L., & Benitti, F. (2013). Serious games applied to project management teaching. In *Enterprise Resource Planning: Concepts, Methodologies, Tools, and Applications* (pp. 1427–1451). IGI Global.	5	3	5	1

33	Rodrigues, P., Souza, M., & Figueiredo, E. (2018). Games and Gamification in Software Engineering Education: A Survey with Educators. *2018 IEEE Frontiers in Education Conference (FIE)*, 1–9. https://doi.org/10.1109/FIE.2018.8658524	4	4	4	2
34	Rumeser, D., & Emsley, M. (2018a). Design and evaluation of the project and program crashing games. *Journal of Applied Research in Higher Education*.	4	3	3	1
35	Rumeser, D., & Emsley, M. (2018b). Project Management Serious Games and Simulation: A comparison of three learning methods. *The Journal of Modern Project Management*, *5*(3), Article 3. https://doi.org/10.19255/JMPM01507	4	4	4	2
36	Rumeser, D., & Emsley, M. (2018c). A systematic review of project management serious games: Identifying gaps, trends, and directions for future research. *Journal Modern Project Management*, *06*(01), 48–59. https://doi.org/10.19255/JMPM01605	5	3	5	3
37	Rumeser, D., & Emsley, M. (2018d). Can Serious Games Improve Project Management Decision Making Under Complexity? *Project Management Journal*. https://doi.org/10.1177/8756972818808982	4	4	4	3
38	Rumeser, D., & Emsley, M. (2019). Lessons learned from implementing project management games. *International Journal of Serious Games*, *6*(1), 71–92. https://doi.org/10.17083/ijsg.v6i1.130	4	4	4	2
39	Tews, T., Skulmoski, G., Langston, C., & Patching, A. (2020). Innovation in project management education - let's get serious! *Construction Economics and Building*, 20(3). https://doi.org/10.5130/AJCEB.v20i3.7040	5	4	4	n/a
40	Salminen-Tuomaala, M., & Koskela, T. (2020). How can simulation help with learning project work skills? Experiences from higher education in Finland. *Educational Research*, *62*(1), 77–94. https://doi.org/10.1080/00131881.2020.1711791	5	3	3	1
41	Shtub, A. (2010). Project management simulation with PTB Project Team Builder. *Proceedings of the 2010 Winter Simulation Conference*, 242–253. https://doi.org/10.1109/WSC.2010.5679160	3	2	4	3
42	Svirakova, E. (n.d.). SYSTEM DYNAMICS IN EDUCATION: CASE STUDY OF A MUSIC FESTIVAL. *Proceedings of EFFICIENCY AND RESPONSIBILITY IN EDUCATION 2015*.	3	3	3	1
43	Zwikael, O., & Gonen, A. (2007). Project execution game (PEG): Training towards managing unexpected events. *Journal of European Industrial Training*, *31*(6), 495–512. https://doi.org/10.1108/03090590710772668	5	3	5	3

Appendix B. PRISMA Flow diagram for systematic review

The flow chart visualizing the approach adopted for our review, according to the PRISMA statement (adapted from [23]).