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Empirical Research Paper

Game-based learning and students' motivation in project management education

Elina Jääskä *, Jere Lehtinen, Jaakko Kujala, Osmo Kauppila

University of Oulu, Industrial Engineering and Management, P.O. Box 4610, FIN-90014, University of Oulu, Finland

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ABSTRACT

Research on game-based learning (GBL) methods shows that they may increase students' motivation and learning in the context of higher education. However, there is still unclarity regarding whether and how GBL methods can be utilized in project management education. Our quasi-experimental study analyzes project management students' experiences of a GBL method applied in six European higher education institutes during late 2021 and early 2022. Data about students' experiences were collected using a post-game survey in which students were asked to evaluate how the applied GBL method affected their motivation and learning. The data were analyzed using both qualitative and quantitative methods. Our findings include students' positive and negative perceptions related to the applied GBL method, which influenced students' motivation to study and learn project management phenomena. Our findings indicate that game-based learning solutions can be used to motivate students and to prepare learners to deal with uncertainty, as in real-life projects.

1. Introduction

The projectification of society, which means that an increasing amount of work is organized and managed through single projects or series of projects in organizations, companies, and personal life, is on the rise in Western economies (Gemünden, 2013; Kuura, 2020; Schoper and Ingason, 2019). Therefore, there is an increasing demand for highly skilled project personnel in project-based organizations. However, a recent report highlighted a talent gap in the global economy of project-oriented sectors (PMI, 2017). There is and will be a shortage of project practitioners with essential competencies, such as technical and leadership skills completed with strategic and business management skills (PMI, 2017). Project management educators thus face the challenge of training highly skilled personnel with practice-oriented and motivating educational methods for the future success of project-based sectors and their respective organizations.

Finding an educational method that can simulate and contextualize complex project management phenomena realistically may not be easy for project management educators. Game-based learning (GBL) methods, including educational games and simulations, have been acknowledged as a promising solution in higher education (Crocco et al., 2016). For example, educational games may provide learners and instructors with a virtual model of real-world experience in which management skills can be practiced in a safe environment. GBL methods utilize a game to teach knowledge and skills (Kolb and Kolb, 2005), and digital GBL integrates an education-focused digital game or application in teaching to engage students and promote learning (Prensky, 2003; Van Eck, 2006).

GBL as a method in project management education has been regarded as potential and beneficial for enhancing students' learning (Calderón et al., 2018; Law, 2019; Rumeser and Emsley, 2019). Previous research on project management education has established that innovative, inspiring, and interactive educational methods put practitioners' reflection, lived experience, and contextual learning at the focus (Cicmil et al., 2006; Svejvig and Andersen, 2015; Winter et al., 2006; Westera, 2019). For example, GBL methods can enable the development of technical and leadership skills related to practical project experience (Anastasiadis et al., 2018; Ramazani and Jergeas, 2015) and enable experiential reflective learning in responsible project management education (Cicmil and Gaggiotti, 2018). GBL environments can allow "learning by doing," which is essential when studying complex project management phenomena.

In addition to offering an environment for learning by doing, GBL methods can enhance and maintain students' motivation to learn (Plass et al., 2015), which, according to pedagogical studies, is one of the main factors that keeps students learning (Paas et al., 2005). Motivation refers

* Corresponding author.
E-mail addresses: elina.jaaska@oulu.fi (E. Jääskä), jere.lehtinen@oulu.fi (J. Lehtinen), jaakko.kujala@oulu.fi (J. Kujala), osmo.kauppila@oulu.fi (O. Kauppila).

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to the wants or needs that direct human behavior toward a goal. The link between GBL methods, students' motivation, and learning outcomes exists, but there is limited understanding of how GBL methods influence project management students' motivation in a higher education context. As discussed above, previous research on project management education has recognized the potential of GBL methods, but there is a need for a more detailed understanding of how GBL methods contribute to students' motivation to learn. To this end, we formulated the following research question: *How do GBL methods influence students' motivation in learning project management phenomena in the higher education context?*

We adopted Kellers' ARCS motivational model (Keller, 1987) as our theoretical framework. It distinguishes four components associated with motivation: attention, relevance, confidence, and satisfaction.

Our empirical research follows a one-group posttest-only quasi-experimental design (Kirk, 2009). We developed a digital educational game for project management and piloted it in six European universities in autumn 2021 and spring 2022. The research data were collected post-game through student feedback surveys, including both Likert-scale questionnaires and open-ended questions related to students' motivation to learn. Empirical data were analyzed using mixed methods, including descriptive quantitative statistics and qualitative content analysis.

This study contributes to previous research on project management education by offering a new understanding of how to design and implement GBL methods in project management education. Our findings highlight factors regarding how GBL methods can gain and sustain students' motivation to learn project management phenomena. Additionally, our findings offer an understanding of demotivating factors that need to be mitigated concurrently for the successful design and implementation of GBL methods. The rest of this paper is organized as follows. First, we briefly discuss the concepts and constructs related to student motivation and review what is known about GBL methods' influence on student motivation. Next, we introduce our experimental research design before analyzing and presenting the empirical findings. Thereafter, we discuss the findings and outline the theoretical contributions and educational implications of this study. We conclude with the research limitations and future research ideas.

2. Theoretical background

2.1. Game-based learning and motivation

Game-based learning as a pedagogical method utilizes a game to teach knowledge and skills in an activating and experiential game environment (Kolb and Kolb, 2005; Shaffer et al., 2005; Wiggins, 2016; Jaccard et al., 2022). The motivational effect of GBL has been studied in several disciplines, such as computer, education, and psychological sciences. Research has discovered that GBL methods can both increase and decrease students' motivation.

To design learning environments that foster learning, students should be interested, motivated, and engaged (Garris et al., 2002; Järvelä and Renninger, 2014) in an active learning environment (Freeman et al., 2014). Erhel and Jamet (2013) determined that GBL environments can promote meaningful learning and motivation, assuming that learners' cognitive processing of the educational content is ensured. Digital GBL solutions can enable reflective, experiential, and intriguing learning environments (Bygstad et al., 2022), making them suitable for project management education. According to project management teachers, GBL methods may provide students with a memorable learning experience by affecting their emotions (Jääskä and Aaltonen, 2022).

Game features such as game structure, involvement, and appeal may motivate students and promote achieving desired learning outcomes (Garris et al., 2002; Huang et al., 2013; Jääskä et al., 2021; Breien and Wasson, 2021; Naul and Liu, 2020; Plass et al., 2015). Existing research has identified a positive impact of GBL on students' activation, motivation, and emotional behavior (Barbosa and de Ávila Rodrigues, 2020; de Freitas, 2018; Law, 2019; Vu and Feinstein, 2017), feelings of interest and immersion (Hamari et al., 2016; Schwabe and Göth, 2005), and student engagement (Hartt et al., 2020). Overall, research on GBL methods implies that students' motivation is positively influenced when affirmative affective states such as delight and excitement are generated (Barbosa and de Ávila Rodrigues, 2020).

In addition to these positive effects, GBL situations may also cause negative emotions and frustration for learners. Observed challenges can manifest as time-consuming and demanding exercises with a game or difficulties with environments (Boghian et al., 2019), technical unreliability, unbalance, or instability (Jääskä and Aaltonen, 2022; Jong, 2016; Marklund and Taylor, 2016), and complexity of games (Lomas et al., 2017). Moreover, students may feel uncomfortable with competition and results comparison in GBL situations (Scepanovic et al., 2015). Negative experiences are usually demotivating, but a suitable amount of challenge in the form of positive stress may increase motivation and learning achievements (Shute et al., 2015). In conclusion, GBL methods can increase students' motivation to learn in many ways, but there are also potential pitfalls that need to be avoided.

2.2. Students' motivation and learning

Motivational theories try to comprehend what energizes individuals toward activities (Pintrich, 2003). They wish to explain what makes individuals "move" in the meaning of being inspired and engaged, or alternatively passive and alienated (Ryan and Deci, 2000). Willingness to learn due to individual motivations like challenge, curiosity, control and fantasy and interpersonal motivations like cooperation, competition, and recognition, have been discussed in motivational research (Deci and Ryan, 2014; Malone and Lepper, 1987).

According to Ryan and Deci (2000), self-determination theory of motivation considers human beings as actors, who are active, goal-oriented and strive to learn. Satisfied psychological needs of competence, autonomy and relatedness enhance self-regulation and well-being which are all significant in education domain. Motivation can be discussed in terms of intrinsic and extrinsic motivation. Intrinsic motivation means personal desires and individual interests, which manifest as tendency to seek out novelty and challenges and willingness to perform activities, because it is interesting and satisfying to do them. Driver for extrinsic motivation is attaining some separable outcome like rewards when performing required activities (Ryan and Deci, 2000). In education context, both of these motivational forces should be understood and delt with for enhanced student motivation (Hidi and Harackiewicz, 2000). GBL methods may increase intrinsic motivation as novel and compelling learning activity (Martín-Hernández et al., 2021). Proceedings, scores, and competition of educational games can be associated with external reward, increasing extrinsic motivation.

Motivation engages students, which positively influences on achieving learning outcomes (Fredricks et al., 2004; Krapp, 1999). Student's motivation in educational situations can be triggered for example by new learning experiences, challenge or variety (Palmer, 2009). Positive emotions and pleasant experiences activate students cognitively, increase their motivation and help them acquire competencies (Linnenbrink, 2007). Also other feelings like confusion affect student motivation, yielding critical thinking and deep learning (D'Mello and Graesser, 2012). In conclusion, student motivation is a multifaceted concept and a critical precondition for learning.

2.3. The ARCS model of motivation

As discussed in 2.1 and 2.2, motivation is a central mechanism explaining how GBL methods can help students achieve learning outcomes. We adopted Keller's ARCS model (Keller, 1999) as the motivating theory for considering how educational methods in general influence motivational variables and requirements because the model is

appropriate and tested in the educational context. The operationalization and contextualization of the ARCS model in our research are explained in 3.3.

ARCS stands for attention, relevance, confidence, and satisfaction, breaking motivation down into four motivational components. The ARCS model helps in understanding and incorporating motivational components into the creation of learning experiences and materials. The model can be used as guidance to analyze the motivational factors of learners, and it can be applied to plan course design strategies to stimulate and maintain students' motivation to learn (Keller, 2000). Keller's ARCS model implies that to motivate students, their attention needs to be captured and sustained, relevance to learning content should be stated, and students' feelings of success must be obtained and rewarded (Li and Keller, 2018).

The ARCS model has been applied to motivational instructional design and to reporting the motivation variable with quantitative and qualitative methods in various educational settings (Li and Keller, 2018). Keller (2008) has presented the theory of motivation, volition, and performance (MVP), where learners' motivational processing leads to learning processing. Learners' curiosity to explore the learning task (attention), to understand its value (relevance), and to rely on achieving performance goals (confidence) are the phases of motivational processing. At the end of this process, learners evaluate their expectations and efforts with performance consequences (satisfaction).

Keller (1999, 2000) defines the motivational components of the ARCS model as follows. Students' *attention* can be captured with new or unexpected events that instill variation into instruction. New and stimulating teaching methods not only help to gain attention but also help sustain it. A suitable number of challenges or problems stimulate students mentally and arouse curiosity. *Relevance*, as a component of students' motivation, means that students perceive personal relevance in instruction. Relevance means believing that the instruction is related to the learners' prior learning experiences and personal goals, such as academic or future job requirements. Relevance means ensuring that students perceive value in instruction and learning. This requires convincing the student that what they are learning is relevant for developing their knowledge or skills in the scope of the course. *Confidence* is connected to feelings of success in developing skills. Low confidence is often caused by unclear expectations regarding objectives or acceptable achievements. Success in connection with personal effort or ability improves confidence, and failure decreases it. *Satisfaction* refers to students' positive feelings of accomplishments and positive learning experiences, where both intrinsic motivation and extrinsic reward are combined. Tangible evidence of success, such as points or grades, may help sustain motivation. Fairness and a sense of equity must be ensured if these kinds of extrinsic rewards are used.

3. Research method

3.1. Research design

The research process of this study is summarized in Fig. 1, and the following subsections elaborate on the process phases.

Our study adopts a quasi-experimental design following a one-group (i.e., no control or comparison groups) posttest-only (i.e., effect of the GBL method measured post-game) design (Kirk, 2009). We employed a mixed-method approach, including both qualitative and quantitative methods of data collection and analysis (Creswell, 1999; Tashakkori and Creswell, 2007). The data were collected post-game with student feedback surveys that included Likert-scale questions derived from the ARCS model and open-ended questions related to students' motivation to learn. Data analysis was performed using the ARCS model as a framework.

The Likert-scale questions were analyzed using descriptive statistics, but we considered that a deeper understanding of students' observations and opinions of GBL in project management through qualitative data was necessary to cross-validate the quantitative results. Consequently, a qualitative content analysis of the open-ended questions was performed.

3.2. Quasi-experiment: Project Business Game as the GBL method

We used a non-commercial, university-built computer game environment called Project Business Game (PBG). We carried out 10 quasi-experiments in 10 different project management courses in six European universities (Table 1). Each quasi-experiment was a one-group test in which all students received the treatment (i.e., played the game), and there were no comparison groups. We measured the treatment effect with a posttest-only design, meaning that the effect of our GBL method on students' motivation was measured after they played the game.

PBG is a digital educational game environment used in web browsers that aims for an active and experiential learning experience in project management education. The game environment is highly tailorable according to the planned duration, learning topics, or goals. Due to its configurability, the game environment can be easily adapted to simulate different types of project management phenomena or processes, depending on the expected learning outcomes of the course, module, or class. Fig. 2 illustrates the user interface of PBG and its key functionalities.

The basic idea of the game is that a player (a student) acts as a project manager and makes informed decisions about project management issues to deliver the project successfully, e.g., on schedule, budget, and quality. The game is turn-based, and turns simulate project schedules. In practice, the player reserves needed contractors, orders materials, allocates resources to project tasks or sub-tasks, and then proceeds to the next turn by pressing the current turn indicator button. Depending on the game configuration, turns can be days, weeks, or months. The project includes a sequential task network in which task dependencies define the order of completion. The game narrative and context help students adjust to the situation.

As in real-life projects, there is uncertainty that causes unexpected events or risks during gameplay. For example, new customer requests, problems with subcontracts or material deliveries, or bad weather conditions may cause delays or generate extra costs that affect the project. Game events require informed actions and decisions from the player. For instance, a player may decide to accept or reject new customer requests that again further influence the project—e.g.,

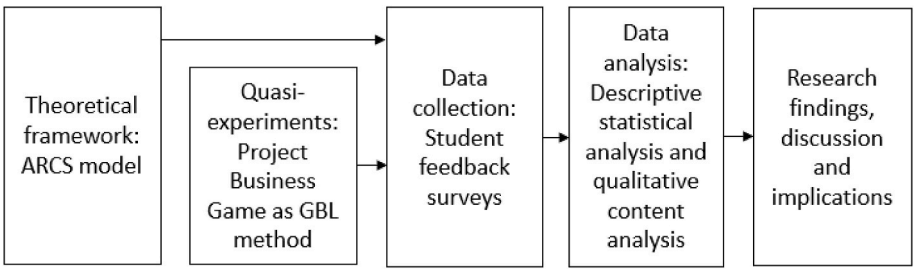

Fig. 1. Research process.

Table 1
Details of the quasi-experiments.

Learning solution name	Expected learning outcomes	University and country	Date	Course level	N of students	Survey response rate
1. Building a chemical plant (ChemX)	• Identify the main cost elements in an industrial investment project • Understand the importance of product life-cycle costs and operational expenditure (OPEX) when determining the profitability of an investment • Understand different phases and tasks in an industrial investment project • Understand the business implications of decisions made during the project • Identify and manage typical risks in an industrial investment project	University of Oulu, Finland	Nov 2021	Master	49	24%
2. Building a townhouse	• Utilize activity network calculation in the management of the project schedule • Estimate the project progress and application of earned value analysis in the estimation of total cost and time at completion • Identify and assess risks and their effects as well as plan risk management responses • Understand the implications of uncertainty and risks for project schedules and procurement management • Calculate the project budget and understand the importance of contingency planning and management	University of Oulu, Finland	Nov 2021	Bachelor	398	13%
3. Concurrent engineering	• Explain the basic principles of concurrent engineering • Solve a basic concurrent engineering problem • Examine a concurrent engineering problem using the design structure matrix • Devise a solution for managing the risks associated with fast tracking (and concurrent engineering)	University of Adger, Norway	Oct 2021	Master	30	47%
4. Production line design and implementation	• Consider how uncertainty influences the project and take this into account in managing the project • Follow the progress of the project and factors influencing project progress • Steer the implementation of the project as needed • Critically evaluate one's own performance in managing the project	Tampere University, Finland	Dec 2021	Bachelor	360	16%
5. Production line investment	• Evaluate how the decisions made during the project influence the total value of the investment • Understand how the engagement of internal stakeholders and/or early integration of key subcontractors influence project success • Identify and manage typical risks in small investment projects • Analyze project success from the perspective of different stakeholders	Technical University of Darmstadt, Germany	Oct 2021	Master	134	30%
6. Production line investment	(The same as above)	Uppsala University, Sweden	Oct 2021	Bachelor	100	40%
7. Project portfolio management	• Assess a portfolio and its projects critically and create a plan for portfolio management • Allocate resources efficiently (optimize) to maximize portfolio value • Comprehend the complexity and dynamism of decision-making in managing project portfolios • Recognize the need for changes in project priorities and resource allocation	Technical University of Darmstadt, Germany	Dec 2021	Master	121	43%
8. Project portfolio management	(The same as above)	University of Oulu, Finland	Feb 2022	Master	26	42%
9. Project progress control	• Comprehend the complexity and dynamism of decision-making in project management • Analyze how project complexity and uncertainty influence project cost, schedule, and quality • Apply earned value method to compare project progress against baseline budget and schedule • Recognize the need for changes in project plan and resource allocation during project implementation	Aalto University, Finland	Mar 2022	Master	36	72%
10. Project risk management	• Recognize the role of systematic and continuous PRM process for project management • Identify and analyze risks and uncertainty in projects • Apply risk and uncertainty management principles and tools in projects • Comprehend how different decisions/choices influence project risk level	University of Oulu, Finland	Dec 2021	Master	55	25%

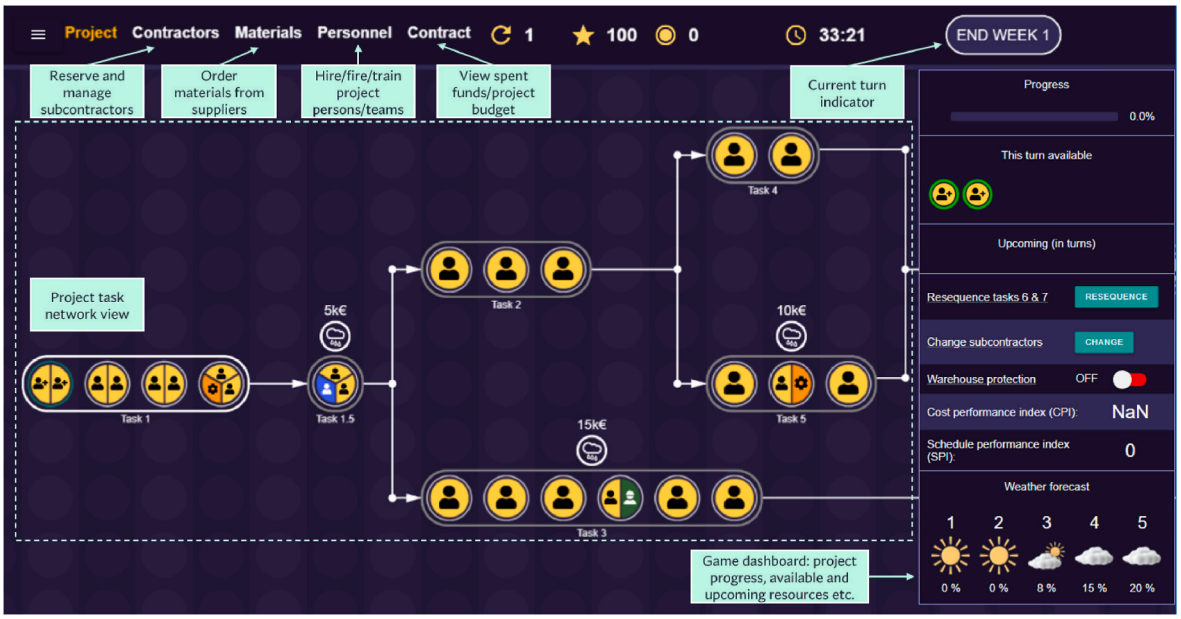

Fig. 2. Example of the user interface of Project Business Game.

accepting a customer request can create additional customer value—but concurrently, the project's scope expands, making it difficult to stay on schedule. Players are required to plan gaming strategies before and during the game, to solve problems, to select between options as they arise, and to take or mitigate risks.

We configured eight different games using the PBG game environment. Each game is part of a *learning solution* with its own learning goals, outcomes, and materials, as described in Table 1. Besides the game itself, a learning solution includes a package of instructions and supporting documents for both teachers and students. A learning solution includes pre-materials that help with preparations for the game session (e.g., scientific articles, game instructions, and case/game descriptions, including learning outcomes and game objectives), assignments (e.g., pre-game exercises related to the project management topic), and the game itself, tailored for teaching the specific project management topic and post-material (e.g., post-game analysis/assignment including feedback and reflection). Learning solution materials and game links were delivered to instructors via e-mail.

The learning solutions were implemented in 10 different project management courses in six universities in Finland, Germany, Norway, and Sweden during autumn term 2021 and spring term 2022. Table 1 contains details of the quasi-experiments, including learning solutions, expected learning outcomes, and context.

The expected learning outcomes of each learning solution can be associated with project management knowledge areas and key competences of project managers (PMI, 2021). As an example, the *Project risk management* learning solution can be used to teach students how to identify and analyze risks before and during a project and thus how to manage uncertainty in projects. Players can practice their skills, such as critical thinking and decision making, with the game, which prepares them for real project management work.

3.3. Data collection: Student feedback surveys

We collected data through post-game feedback surveys. Each survey was voluntary and anonymous and consisted of three sections: a background section, Likert-scale questionnaire section, and open-ended question section. We also disclosed that the data will only be used for research purposes. All sections needed to be fully completed to submit the survey, so there were no incomplete survey responses.

In the first section, we collected background data from each student (gender, birth year, educational background, work experience in years related to project management, previous experience with computer games, and previous experience with educational games) to develop a contextual understanding of the student samples in each experiment. In the second section, we designed a symmetric 5-point Likert-scale questionnaire for each learning solution to gather data after the PBG gameplay sessions about students' subjective experiences of and motivation to learn using the piloted GBL. Surveys using Likert-scale questionnaire can be used to quantify subjective, qualitative attributes such as attitude, perceptions, and opinions (Joshi et al., 2015), which is appropriate for our research purposes of measuring students' perceptions of their motivation.

We operationalized motivation in this study by applying Kellers ARCS model (Keller, 2000), because of its suitability to instructional design. We also relied on other research papers that had utilized Keller's model in surveys to study students' motivation to learn in other contexts, e.g. (Kebritchi et al., 2010), and (Huang et al., 2013). We analyzed and utilized similarities and best practices of these papers for contextualizing Keller's model to our research purposes. We also relied on our earlier experiences of other PBG pilots and related student feedback surveys in other contexts.

In the second section, students were asked to respond to 16 statements measuring their motivation using a 5-point Likert scale, where 1 denotes strongly disagree, 2 disagree, 3 neither agree nor disagree, 4 agree, and 5 strongly agree. Following the ARCS model, the questionnaire included questions related to their attention (questions A1–A4), relevance (questions R1–R4), confidence (questions C1–C4), and satisfaction (questions S1–S4). An example of this part of the student feedback survey with the ARCS model constructs is provided in Appendix A.

In the third section of the questionnaire, we included an open-ended question to gather qualitative data on the research phenomenon. The purpose was to delve beyond the Likert-scale statistics and comprehend students' experiences and motivation more profoundly.

3.4. Data analysis: Descriptive statistical analysis and qualitative content analysis

The data analysis was twofold. First, we used descriptive statistics to report the mean and standard deviation values for each Likert-scale question (Boone and Boone, 2012). To gauge the variation in the responses between students caused by the background variables and

between-samples from the 10 quasi-experiments, we performed between-groups comparisons for the background variables and each of the 16 Likert scale questions. Due to the ordinality of the Likert scale and skewed distributions of the responses, the Kruskal–Wallis (K–W) test was used, as suggested by Lantz (2013). Logistic regression was used to analyze the relationship between the year of birth and the Likert scale questions. We used Minitab 19 software for these analyses. Subsequently, we created a pooled sample due to the homogeneity of the ten samples (see Section 4.1 for further reasoning), tabulated the data, and calculated the mean and standard deviation for each Likert scale question (Boone and Boone, 2012).

Second, the qualitative analysis followed a qualitative content analysis approach adopted from Miles et al. (2014). We analyzed students' open-ended inputs with Nvivo to identify themes, issues, and topics that influenced students' motivation when participating in the quasi-experiments. We stayed open to both positive and negative feedback to understand which issues were considered beneficial or helpful and enhanced motivation and which issues were considered stressful or disturbing and decreased motivation. We then compared the similarities and differences of the open-ended findings and connected them with the ARCS model components to provide further support for the statistical findings.

4. Research findings

4.1. Student sample analysis

The analysis of the students' background data indicated that the quasi-experiments included very similar student samples (see Appendix B for details). Most of the students in all experiment groups were bachelor's students, and they had less than two years or no experience of project management work. Their experience of using educational games previously was also similar between sample groups.

To further study the student profiles and ensure the trustworthiness of our findings, we performed statistical tests (K–W and logistic regression) on the background variables introduced in Section 3.3 and Appendix B (six variables) and the Likert scale survey questions (16 questions). A total of 19 statistically significant ($p < 0.05$) effects were found out of the 96 relationships. However, the effect sizes were negligible in all these correlations. For example, even though the difference between the mean answers of females and males on question S2, *"I felt gaming stressful,"* was statistically significant ($p < 0.003$), both groups still disagreed on this statement. The disagreement on the Likert scale was, on average, only 0.4 units stronger for males. Overall, none of the 96 correlations included contrasting opinions. Therefore, we concluded that the background variables had little to no effect on the findings and conclusions from the survey.

In addition, we performed statistical K–W tests and interval plot tests between the quasi-experiments and Likert-scale survey questions to determine whether the different experiments yielded similar findings. The null hypothesis was that Likert-scale question medians were equal between the quasi-experiments. In 14 out of 16 questions, we rejected the null hypothesis, as there was at least one statistically different quasi-experiment. However, the differences were not systematically from any particular learning solution but seemed random (i.e., changed from question to question without any pattern or clear logic), meaning that there were no clear outlier quasi-experiments. Additionally, the differences (effect sizes) were small in general and, most importantly, did not include contrasting answers, except for two questions. First, quasi-experiments *Building a chemical plant (ChemX)* and *Concurrent engineering* agreed with statement S2 *I felt gaming stressful* (median 4 and 3.5, respectively), whereas the other quasi-experiments disagreed or were neutral on this statement. Second, the quasi-experiments *Concurrent engineering* and *Production line investment* (5 in Table 1) agreed with statement *A4 Learning the game rules and mechanics felt frustrating* (median 3.5 and 4, respectively), whereas the other quasi-experiments disagreed or were neutral on this statement. These were the only differences with slightly contrasting answers, and the answering tendency was otherwise similar among the quasi-experiments on all other questions. Thus, we are confident in concluding that there were no systematic differences between the different quasi-experiments, and we believe that the 10 quasi-experiments included enough homogeneous samples to justify the pooled sample approach in our main analysis.

4.2. Summary of quantitative findings

Because the student sample analysis in Section 4.1 indicated that the student samples in the 10 quasi-experiments were rather similar, creating a pooled sample of 319 survey responses was justified. The descriptive statistics of the pooled sample are shown in Table 2, including frequency per Likert scale category, mean, and standard deviation values.

The statements listed in Table 2 were used to evaluate how the use of GBL influenced students' motivation, measured as attention (questions A1–A4), relevance (questions R1–R4), confidence (questions C1–C4), and satisfaction (questions S1–S4). In the following Subsections 4.3–4.6, we will elaborate the quantitative findings related to each ARCS component by concurrently connecting and explaining the qualitative findings with illustrative quotes that support the findings.

4.3. Influence of PBG on students' attention

Looking at the influence of our PBG on students' attention, it seems that students regarded gaming as fun, exciting, and intriguing enough to capture their attention (A1 and A3). The mean value of survey statement A1 "I think learning from gaming was fun and exciting" is the highest of all survey statements, as 84% of students agreed or strongly agreed with this statement. Statement A3 about game content and flow also captured students' attention, since most of the students agreed (54%) or strongly agreed (18%) with the argument.

Many students also mentioned in their open-ended answers that they liked the game and had fun while playing. As one student stated, *"It [the game] was nice! Very cool idea!"* Some of the students had felt the PBG experience enjoyable and stimulating even if they did not have earlier experiences with playing educational games. The game was regarded as intuitive to play, and it offered an insightful experience to learners. The novelty of the PBG method was also appreciated. The following quote from one student illustrates this: *"After understanding the way it works, it is good. It is nice that you develop new ways to learn."* This feedback resonates with survey questions A1 and S1 as well.

Half of the students did not consider the game too easy to play (50% in A2), which would potentially have made students feel bored or distracted their concentration and attention from the game and learning objectives. As one student said, *"Thanks for [the] game. I think that [the] game has a good balance of complexity and the environment looks engaging."* While 17% of the students felt that there was not enough challenge, only 5% felt so strongly. Thus, it seemed that a suitable number of challenges and problems stimulated students to maintain their attention.

Learning the game rules and mechanics requires extra effort from students in addition to all other learning requirements, which might feel burdening (A4). Nearly half of the students did not consider learning how to play the game frustrating (45%), while 29% experienced negative feelings. Students' open-ended answers indicate that some students felt insecure about how to play the game and what the rules were. A lack of sufficient time to learn the game mechanics and environment prior to the game session was also mentioned.

A great deal of the open-ended answers were about game instructions, which were regarded as missing or incomplete. Typically, each quasi-experiment (learning solution) included a practice game that was played or presented by the instructor, but obviously that was not always enough, especially, one can surmise, for those who had little to no experience with games in general. A demo video presenting the game

Table 2
Pooled sample: descriptive statistics of students' perceptions of GBL experience (n = 319).

	Survey statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Standard Deviation
A1	I think learning from gaming was fun and exciting	2%	5%	9%	**39%**	**45%**	4.2	1.0
A2	There was not enough challenge and complexity in the game	**12%**	**38%**	28%	17%	5%	2.6	1.0
A3	The game content and flow captured my attention	3%	7%	18%	**54%**	**18%**	3.8	0.9
A4	Learning the game rules and mechanics felt frustrating	**12%**	**33%**	26%	21%	8%	2.8	1.2
R1	I understand what kind of real-life situation the game simulated	3%	3%	12%	**58%**	**23%**	3.9	0.9
R2	I felt like learning	3%	7%	12%	**60%**	**18%**	3.8	0.9
R3	It is apparent to me how to use the learnings from this gameplay	3%	8%	26%	**54%**	**10%**	3.6	0.9
R4	The narrative and game environment were disconnected from reality	6%	38%	38%	**16%**	**2%**	2.7	0.9
C1	The game increased my interest in learning project management	2%	8%	26%	**49%**	**16%**	3.7	0.9
C2	I could apply the theory that was taught in this course in the game	4%	6%	23%	**53%**	**13%**	3.6	0.9
C3	I think I learned from my success and failure in the game	3%	3%	12%	**53%**	**29%**	4.0	0.9
C4	The game motivated me to progress and get better	2%	3%	17%	**54%**	**24%**	3.9	0.8
S1	I enjoyed participating in this game-based learning session	2%	4%	10%	**52%**	**32%**	4.0	0.9
S2	I felt gaming stressful	18%	35%	25%	**16%**	**7%**	2.6	1.1
S3	I prefer other learning methods over game-based methods	7%	35%	**38%**	14%	7%	2.8	1.0
S4	I wouldn't like to be graded according to my game result	8%	18%	28%	**24%**	**24%**	3.4	1.2

mechanics, user interface, and environment was available in some of the quasi-experiments (e.g., Building a townhouse, Project portfolio management, and Project progress control). Many students expressed frustration and negative feelings because they had not been familiar with the game mechanics and therefore made mistakes or errors in the game that could not be undone later on. The following quotes illustrate this:

> "It would have helped to have a demo video of the game, because I didn't get how to play the game only by instruction and trying out."

> "I think the most important part of learning via games is to have a deep understanding of the rules and the user interface prior to starting the game."

> "[There is *a need to …] have adequate and precise instructions on how to play the game beforehand."*

Interestingly, negative affections due to lack of competence in playing the game did not correlate with answers to survey questions measuring their confidence or satisfaction. For example, statements C1 "The game increased my interest in learning project management," C4 "The game motivated me to progress and get better," and S1 "I enjoyed participating in this game-based learning session" were evaluated using the whole scale, varying from strongly disagree to strongly agree. Some students just pointed out that there could have been better instructions available but were positive in their questionnaire answers of confidence and satisfaction, whereas others felt the lack of guidelines bothersome, which reflected negatively on their game experience.

4.4. Influence of PBG on students' perception of relevance

Relevance refers to students' perceptions that the instruction is related to learners' personal goals of developing their knowledge and skills for current and future use. We asked students to evaluate how they understood the game's ability to simulate real-life phenomena (R1). The statement was formulated to comprehend whether students were able to observe the game's connection to real project phenomena they were supposed to learn with the game. Most of the students (81%) agreed with this statement; furthermore, only 18% agreed with statement R4, arguing that the narrative and game environment were disconnected from reality. As one student described, *"The game was a good tool to simulate real life."* However, some students mentioned that the game was not entirely realistic, which may have hindered its relevance: *"Some occurrences were a bit random in the game …"* and *"Some of the events were difficult to comprehend."*

Statement R2 "I felt like learning" was intentionally formulated as short and open to capture an overall sense of learning with the game. 78% of the students thought that the game experience helped them to learn—an extremely positive response. Students' positive answers (64% agree/strongly agree) to statement R3 "It is apparent to me how to use the learnings from this gameplay" resonate with answers to R2, which may explain why students felt like learning.

Students' open-ended answers revealed that they seemed to understand and appreciate the connection of the game to real projects and think that their skills to understand and apply their learnings were improved. The PBG quasi-experiments provided students with an environment in which topics covered in lectures or learning materials could be applied and tested with a pragmatic and problem-based exercise. Students said that they believed they were able to learn while gaming because the game simulated project events that might occur in the real world. Practicing skills such as decision making and risk management with the game were seen as important. The following quotes are examples from students' open-ended answers that illustrate the above:

> "The game was an excellent environment to demonstrate the complexity and dynamism of decision-making in projects; there were so many considerations to be made at each round, and decisions affected other decisions …"

> "I learned … How to find out risk. How to manage things that practically do not fail. So it was a good learning experience."

> "The game was a good tool to simulate real life."

4.5. The influence of PBG on students' confidence

Students' confidence as a motivational component is connected to their feelings of success in developing their skills. Most of the students (65%) agreed or strongly agreed with statement C1 "The game increased my interest in learning project management." The open-ended answers highlighted how students considered that the game was engaging, added value, and supplemented the course lectures. For example, one student described this as follows: *"This [PBG] is an excellent manner to create interest in Project management."* Another student corroborated this view: "*I'd say that the game really addressed very important aspects of project management."* Those few students who disagreed with this statement had, e.g., experienced problems regarding the game instructions or functionalities that likely decreased their confidence, as introduced in Subsections 4.3 and 4.4 above.

Students also expressed that they were able to apply the lessons from lectures in the gameplay and that the game had addressed important project management theories (C2). For instance, one student noted that *"… overall this is definitely a good start to engage project management and its principles."*

connection between player decisions and game events. Students

Table 3
Synthesis of the research findings.

Construct	Definition	Students positive perceptions	Students negative perceptions
Attention	Students' interest is gained and maintained with variation and challenge	• Suitable amount of challenge and complexity • Excitement, a new and nice way to learn	• Not sure how to play the game • Lack of gameplay instructions
Relevance	Students understand the value of instruction and can connect it to their prior learning and personal goals	• Learning project management by practice with a game • Understanding how to utilize lessons from the game in real life	• Unrealistic or awkward events in the game
Confidence	Students develop their skills with successful learning experiences.	• Learning from success and failure in the game • Ability to apply lessons from theory in gameplay • Increased interest in learning project management	• Unexpected events in the game, which could not be utilized, anticipated, or prepared for • Insecurity regarding game rules and mechanics
Satisfaction	Students feel satisfaction as they increase their competence and are rewarded.	• Feelings of enjoyment and fun	• Feelings of stress and dislike • Grading based on game results not seen as good or fair • Game crashes or error situations • Dislike for the GBL method

indicated in their comments that they had felt the game user interface or functions were incomplete or misleading and that it complicated applying the central lessons from the course. For example, a student reflected as follows: *"Expedition's [a feature in the game] functionality wasn't clear. The need for it only came up after the delay already occurred and it was hard to estimate when to use it."*

Success and failure in gameplay inspired students to try the game again for better results. Students evaluated that success and failure in the game helped them to learn project management phenomena (C3 – 82% agree/strongly agree). Moreover, students were confident that the game encouraged them to progress and get better (C4 – 78% agree/strongly agree). For instance, one student described that *"You wanted to get better and get the best score and try different approaches …"* Reasons for negative experiences related to statements C3 and C4 were not easy to identify from students' open-ended answers, except that missing instructions or incompleteness in some of the game functionalities were mentioned again: *"It is nice that the game is not bloated with unnecessary features, but some more animations and sound would make it feel more complete."* As another student expressed, "*I felt like there were too many random events to increase the challenge, to the point that halfway through you lost interest in trying to get the best possible outcome."*

4.6. Influence of PBG on students' satisfaction

We evaluated students' intrinsic enjoyment and the role of extrinsic rewards in connection with PBG with statements S1–S4. Most of the students (84% agree/strongly agree) answered that they had enjoyed participating in the GBL session (S1) and mentioned this in their open-ended answers explicitly. For example, as one student wrote, *"However, the game was very good and it was fun to play it. More projects like this in the future!"* Statement S2 sought to partly measure the opposite of S1, and it indicated that 23% (agree/strongly agree) were not satisfied with the game, as they had felt stressful. The open-ended answers yielded an understanding of the factors that explained why students felt stressful or were in general unsatisfied. One major reason was that there were some error situations in the different quasi-experiments due to technical problems with computer equipment or bugs in the respective game that had gone unnoticed thus far. As one student wrote, *"[The game was] Good but the game was broke. When I tried to go into the charts, [the] game crashed."* Another student described the following: *"The game froze in the same point continuously. Couldn't get past the point where you had to report to the bank manager after first try."* However, students who mentioned serious technical problems in their open-ended answers were otherwise positive in their other feedback.

While most of the students felt that they liked the game, others expressed honestly that they just did not like this particular game, even if they usually liked games in general. As one student elaborated, *"I like games, but didn't like this one. It was stressful and felt [like a] really big project to start."* They expressed in their open-ended answers that the game was not good, they did not like the game as a learning method, and familiarizing themselves with the assignment and playing felt stressful. These students' answers to statements A1 "I think learning from gaming was fun and exciting," R1 "I understand what kind of real-life situation the game simulated," and R2 "I felt like learning," were accordingly strongly negative. Based on the survey answers, these students also felt gaming stressful and that learning the rules and mechanics of the game was frustrating.

Statement S3 "I prefer other learning methods over game-based methods" was asked to understand at a more generic level whether students favored other learning methods over GBL methods. Students both disagreed and agreed with this statement, and 38% of the responses were in the "neutral" category. Students who stated that some other educational method would have been better evaluated GBL methods as appropriate and enjoyable regardless.

Statement S4 sought to understand how tangible evidence of success, such as scores or grades, affects extrinsic motivation. The findings related to statement S4 *"I wouldn't like to be graded according to my game results"* revealed that 48% of students were not content with grading based on success in the game. This is a relevant concern because grading might not be fair because of game features (e.g., stochastic events or luck) or technical and human errors that negatively influence the game outcome. Computer performance or internet connection instability may also influence game results negatively. Students expressed in their open-ended answers that other game-related assignments (e.g., preparing a project plan for the game) together with game results would be a more appropriate way to assess students' performance. That is, if extrinsic motivation is used, it should be fair and equal to all students. Statistical analysis of survey results clearly indicates that students would not like to connect assignments or course assessments with the game results. The following quotes are examples from students' open-ended answers that illustrate the above:

> "To me it seemed that there might've been some bugs or features that felt a little unfair for the player."
>
> "I wouldn't like to be graded according to my game result, because [the] second time I really tried and got [the] same result when 'just trying.'"
>
> "Course assessment should be based on other game-related course assignment like Excel-file and report to realize the actual effort and learning."

We synthesized the main observations from the student feedback

surveys in Table 3, which summarizes how our PBG as a learning method influenced students' motivation to learn project management. Both key positive and negative perceptions are presented.

5. Discussion

Overall, our empirical findings suggest that the use of PBG as a GBL method influenced students' motivation to learn project management. We observed both positive and negative insights from the survey questionnaire, which can be considered when GBL methods are planned for use in project management higher education. Overall, our study complements the previous understanding of the role of GBL methods in enhancing students' motivation (Barbosa and de Ávila Rodrigues, 2020; de Freitas, 2018) but also yields a new understanding of some of the factors that may decrease students' motivation. More importantly, this study offers a new understanding of the potential remedies, i.e., concrete practices, that can be used to mitigate the identified factors that decrease students' motivation.

5.1. GBL methods sustain students' attention

Our quasi-experiments showed that the use of GBL methods in project management education can capture and maintain students' *attention* if they are complex enough and provide challenge and excitement. These findings resonate with previous research on the role of challenge and complexity in GBL methods in capturing students' attention (Huang et al., 2013; Martín-Hernández et al., 2021) and in the project management education context (Barbosa and de Ávila Rodrigues, 2020; Law, 2019). The students experienced the PBG as captivating and responded that the game was not too easy to play, which would have made the gameplay boring or a routine-like activity. Unanticipated challenges and the complexity of the game, together with time pressure for playing, are the means that can be considered to create positive stress for students, helping to hold their attention in the learning process. However, as the findings indicated, a lack of proper induction may make the gameplay too complex, contributing negatively to students' attention. For example, some students raised concerns about missing or incomplete game instructions, and these students felt that they did not know how to play the game and what the rules were. An unintentional consequence of the previous issue might have been that students tried the game several times because in the first try, they focused on gaining understanding of the game mechanics, and in the subsequent rounds, they could focus more on the game and learning.

GBL methods should contain not only the game itself but also relevant and required documents, videos, or other supplementary materials. This forms a coherent learning solution that adjusts the overall complexity and challenge of the game to suit the context at hand. Finding a balance in complexity may require teachers to try various educational games with different student groups. Configurable games like the studied PBG will enable adjusting the level of complexity according to students' earlier knowledge or expected learning outcomes of the course. Additionally, multiple opportunities for playing the game with varying difficulty adjustments can help hold students' attention. The findings above support the notion that challenge and complexity in educational gaming and related assignments can cause positive stress and facilitate capturing students' attention (Hamari et al., 2016; Shute et al., 2015). However, previous studies have also observed that it is difficult to find a balance in game complexity and challenge and that too much challenge can be counterproductive from the perspective of maintaining students' attention (Lomas et al., 2017). While previous research has identified the game complexity and challenge dilemma, there is little understanding of the remedies, i.e., concrete means and practices to find a balance, especially in the context of project management education. Consequently, our study contributes to previous research by showing how adjustable and configurable GBL methods, sequential game settings with variable complexity levels, and appropriate supplementary materials are concrete practices to find a balance in game complexity and challenge that support not only capturing but also maintaining students' attention throughout the learning session.

5.2. GBL methods enable students to understand the real-life implications

According to our findings, students understood what kinds of real-life phenomena the game simulated and expressed feelings of learning, which is an indicator of students' comprehension of the *relevance* of the GBL method. That is, PBG enabled students to practice real-life project management skills with pragmatic and realistic assignments. Students' feedback revealed that they could associate the game events and related dynamism and complexity with project management competence requirements that exist in real-life project work. Our findings suggest that, in the project management education context, it is relevant to design and develop GBL methods such that they simulate project processes and events sufficiently realistically. This is, according to our analysis, essential for students' comprehension of the relevance of the GBL method.

However, some students raised concerns related to game events that did not appear relevant or realistic or that happened too often or suddenly. Unrealistic events or awkward functionalities in the game can detach the game from relevant, real-life project phenomena. Therefore, special attention should be paid, for example, to contextualization and game narrative when designing GBL solutions. We, for instance, developed some of the learning solutions (e.g., Building a chemical plant (ChemX) in Table 1) together with industry partners that helped us to develop realistic game narratives and contexts that include actual tasks and events from similar real-life projects. This way, educational games can avoid the pitfalls related to unrealism that otherwise impede students' understanding of the real-life implications of the game. Additionally, collaborating with industry partners enabled the development of educational games that function as a test environment or "laboratory" to learn project management skills in practice in a safe environment without severe negative consequences. In the GBL environment, students can make mistakes and learn project management skills even 'the hard way' before entering real-life project work, where there is much less room for errors.

Furthermore, GBL methods as a test environment offered possibilities for trial and error, yielding both successful and unsuccessful outcomes that boosted students' *confidence* and interest in learning project management phenomena and skills. As stated in the previous paragraph, GBL methods enable a contextual learning environment to develop project management skills, the importance of which is emphasized by Svejvig and Andersen (2015) and Winter et al. (2006). Typically, in GBL setups, students first listen to a lecture, watch a video, or study other materials related to the study subject. Then, to internalize theoretical lessons, they will need an environment to try their lessons in practice (i.e., knowledge-to-action learning), which was done in our experiments. Most of the students indicated that they were able to apply theoretical lessons in practice in the game. However, some students argued that overly surprising events in the game caused unsuccessful outcomes, decreasing their confidence and interest. Despite some of the negative perceptions caused by unexpected game events, the findings also showed that these game events are appropriate for teaching project uncertainty and risk management as long as the GBL solution is designed in such a way that it offers enough means to prepare for dealing with or tolerating uncertainty. Real-life projects contain uncertainty, such as risks, change requests, and surprises, which the game events simulate. A minority of the students may have regarded such game events as "random" or unfair, but these unexpected events also illustrate and give concrete examples of what might happen in real-life projects. Therefore, we assume that educational project management games may prepare future project managers to tolerate uncertainty and face both success and failure.

The above findings elaborate on the previous understanding of the role of GBL methods in enabling practice-based learning in higher education for project management (Anastasiadis et al., 2018; Jääskä et al., 2021; Rumeser and Emsley, 2019; Jaccard et al., 2022) by highlighting that GBL methods are not just practical games but should include carefully planned simulative elements. This enables a realistic test environment where students can put theoretical project management lessons into practice to gain confidence through trial and error.

5.3. GBL methods are also about fun and enjoyment in project management education

GBL methods can provide *satisfaction* in project management learning through positive affections. In our quasi-experiments, we observed that students experienced positive feelings of enjoyment, accomplishments, and fun. Some students said, that they liked the game and would like to see similar methods to be used in the future as well. On the contrary, learning the game and gameplay itself had felt stressful for some other students. Feelings of stress and dislike can be caused by personal preferences regarding other learning methods, which was also measured with one of the survey questions. Some students may not want to try novel methods, but prefer more conventional teaching like lectures or written assignments. Complicated user interface, difficult game mechanics and game crashes or bugs may disturb students' satisfaction, but will not completely prevent satisfaction. Therefore, a thorough educational game evaluation and selection is crucial: the game should be reliable, error-free and designed according to expected learning outcomes. These findings are in line with previous research on project management education that has identified technical unreliability, unbalance or instability of GBL environments a challenge for both learners and instructors, which may compromise the use of GBL as an educational method (Jääskä and Aaltonen, 2022; Marklund and Taylor, 2016). Unclear game rules and confusion regarding game mechanics affect attention, confidence, and finally satisfaction, and should be accounted for in designing game instructions and induction materials.

Tangible rewarding affect satisfaction of learning experience (Keller, 2000). Tangible evidence of success like points or grades may help sustaining motivation, but our study reveals, that students would not like to be graded (i.e., summative assessment) based on game results. The reason for being careful with the connection of game results to assignment or course assessment is, that students think it can be unfair, because project management games, like PBG, typically include stochastic events. Therefore, students may associate game results with luck, because of different game experiences and difficulty of game sessions score-wise. However, this comes back to our earlier point above related to designing GBL solutions in a way that they offer enough means to prepare for dealing with uncertainty including stochastic events. Also, it is possible to design GBL methods, where events, whether anticipated or not, are completely the same for all students (i.e deterministic), for example happen similarly at similar points in time. This way summative assessment based on the game results would be fairer to students. Nevertheless, students were concerned that the game may not give correct or fair results because of bad luck or errors in game software. Results could also be misinterpreted resulting in incorrect grading. However, GBL methods may be well-suited for formative assessment, e.g., to monitor students' learning and provide feedback based on students' activities in the game, and help them identify weaknesses, strengths and areas that require further work.

We suggest that fairness and sense of equity should be ensured when considering the use of stochastic events and extrinsic rewards in the design of GBL methods. The above findings related to students' perceptions of unfair summative assessment based on GBL methods resonate with previous findings by Scepanovic et al. (2015) and Jääskä and Aaltonen (2022) who identified, that teachers have very similar concerns regarding the use of grading with GBL methods. It is more important to provide feedback on learning progress than learner's game performance (Westera, 2019).

6. Conclusions

This paper reports a quasi-experimental study of students' motivation to study project management phenomena in higher education, yielding a new understanding of the role of GBL methods in project management education.

6.1. Educational implications

The findings of this study may help teachers and administrators of educational institutes decide on and plan the use of GBL methods in instructing project management phenomena and skills. The findings will help identify key enablers and impediments for implementing GBL methods successfully. We have synthesized key lessons in the list below that offer guidance for designing and implementing digital GBL methods in project management education.

- **Feelings of excitement and fun are crucial**: GBL methods need to include a fascinating narrative and interesting project context that help sustain students' interest.
- **Suitably challenging games for learning by trial and error**: Educational games should not be too easy or too complex to stimulate students' learning. Configurable game environments and the use of difficulty levels in games can be used to create variability for sequential game sessions.
- **GBL methods are not only about games**: Integrating relevant instructions, materials, and tools with educational games into comprehensive learning solutions could help implement GBL successfully.
- **Not all students are familiar with games**: Appropriate game instructions or practice games should be available to ensure that all students learn the game mechanics and rules before the actual game.
- **Induction is important**: Time needs to be reserved for learning game requirements, rules, and practicalities so that, when the actual game is on, students can concentrate on learning from actual game events.
- **Games must be realistic and not just fun**: Game activities' connection to learning objectives and real-word situations should be ensured with a carefully designed game narrative, context, and project events, preferably together with industry practitioners.
- **Games should prepare learners to tolerate uncertainty**: Game should contain features to practice skills such as decision making and problem solving amid uncertainty and change because project managers will face both success and failure in real-life projects.
- **One size does not fit all**: Games need to be tailored and contextualized according to expected learning outcomes with appropriate events. Virtual experience of a real-world project or part of it is essential for teaching complex and dynamic project management phenomena and skills.
- **Pay attention to technical stability**: The technical functionality and reliability of the digital educational game should be evaluated thoroughly before using it, because incompleteness, bugs, and crashes of the game cause frustration and negative feelings and can easily spoil the learning experience.

- **Assessment with caution**: Summative assessment can be connected to game results, but the teacher must ensure that grading is fair. Stochastic events should not play a major role in game scores, which can be avoided by using a deterministic game design, which tries to exclude purely stochastic events. Overall, a game should not have too large a weight in course or module grading. Instead, formative assessment is advised.

6.2. Limitations and suggestions for further research

While the findings of this study are limited to a single GBL method, we experimented with the method in several universities and courses with different game configurations. While there are always issues with generalizability, we believe that the findings are relevant to other educational contexts because the findings were very similar across experiments (hence, the pooled sample). We especially consider that the educational implications presented in Section 6.1 could be used as guidelines for applying GBL methods in other contexts as well.

The impact of GBL methods on students' academic performance and achieving learning outcomes were not in the scope of this study. However, the influence on learning outcomes is an important and intriguing avenue for further research. Thus, we suggest future research to study educational project management games not only from motivational and pedagogical perspectives, but also from learning performance perspectives. For example, experiments with sample and control groups could be used to measure GBL methods effect on achieving expected learning outcomes.

The present study has some limitations regarding data collection and analysis. The student questionnaire for data collection was developed based on the ARCS model to explore the factors that positively and negatively contributed to students' motivation when playing the educational game. Operationalizing motivation is not easy due to its multifaceted and highly subjective nature. Therefore, we chose a motivational model that has been demonstrated to be appropriate for educational design in education research. To avoid biased answers, we designed survey questions containing both positive and negative statements. We kept the number of questions relatively small to motivate the respondents to answer well and truly. We recognized that the words used in self-administered surveys are significant and can be easily misunderstood; therefore, we tried to choose unambiguous and simple words in our questions.

In this study, we applied a quasi-experimental research design in which the effect of a GBL method was measured post-game. We did not have a comparison or control group, but we performed the research with homogenous student samples to analyze and report the influence of the GBL method on learners' motivation. Our purpose was to understand and explore the factors that contribute to students' motivation when playing educational games. Thus, a one-group posttest-only design was a justified approach to study the feasibility of GBL methods in motivating project management students. To further quantify the influence, we advise future research to design experiments with a comparative design to analyze how different learning methods help achieve students' motivation and the same learning outcomes.

Our experiments with PBG in various universities were not random trials but were designed for learning solutions targeted at accomplishing pre-defined learning objectives, which are documented in this article. While the game variants could be considered different treatments, they used a harmonized game platform with similar game mechanics and characteristics for comparability purposes. In addition, the quasi-experiments and different learning solutions included very similar student samples (i.e., no significant differences between learning solutions or in relation to students' background variables), thus justifying creating a pooled sample in analysis. Students' self-selection in the learning solutions and sessions is not an issue because we are only interested in self-selected project management students.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. GBL experiences survey for students

Survey statement	Construct
1. I think learning from gaming was fun and exciting	Attention
2. I think I learned from my success and failure in the game	Confidence
3. I prefer other learning methods over game-based methods	Satisfaction
4. I understand what kind of real-life situation the game simulated	Relevance
5. There was not enough challenge and complexity in the game	Attention
6. I felt like learning	Relevance
7. It is apparent to me how to use the learnings from this gameplay	Relevance
8. I felt gaming stressful	Satisfaction
9. The game increased my interest in learning project management	Confidence
10. The game motivated me to progress and get better	Confidence
11. I enjoyed participating in this game-based learning session	Satisfaction
12. The narrative and game environment were disconnected from reality	Relevance
13. I could apply the theory that was taught in this course in the gameplay	Confidence
14. I wouldn't like to be graded according to my game result	Satisfaction
15. The game content and flow captured my attention	Attention
16. Learning the game rules and mechanics felt frustrating	Attention

Appendix B. Student profiles in quasi-experiments

	Completed education				Project management work experience				Earlier experience of computer games				Earlier experience of educational games			
Learning solution name	Matriculation	Bachelor	Master	Other	No exp.	<2 years	2–5 years	>10 years	No exp.	Some exp.	Lot of exp.	Enthusiastic	No exp.	Some exp.	Lot of exp.	Enthusiastic
1. Building a chemical plant (ChemX)		75%	25%		50%	42%	8%		8%	59%	33%		75%	17%	8%	
2. Building a townhouse	33%	35%	20%	12%	73%	10%	8%	10%	24%	45%	24%	8%	59%	39%	2%	
3. Concurrent engineering		79%	21%		79%	7%	14%		29%	7%	43%	21%	57%	36%	7%	
4. Production line design and implementation	46%	44%		9%	86%	5%	7%	2%	2%	44%	35%	19%	37%	59%	3%	
5. Production line investment		82%	18%		60%	30%	7%	3%	15%	50%	28%	7%	52%	48%		
6. Production line investment		88%	10%	2%	60%	25%	12%	3%	27%	35%	28%	10%	60%	35%	3%	3%
7. Project portfolio management		81%	19%		64%	27%	6%	4%	33%	35%	19%	13%	48%	52%		
8. Project portfolio management		73%	27%		55%	36%	9%		18%	46%	36%		55%	36%	9%	
9. Project progress control		77%	23%		69%	27%	4%		12%	38%	42%	8%	15%	77%	8%	
10. Project risk management		71%	14%	14%	64%	29%		7%	29%	36%	21%	14%	29%	71%		

(Table does not include gender and birth-year due to confidentiality.).

References

Anastasiadis, T., Lampropoulos, G., Siakas, K., 2018. Digital game-based learning and serious games in education. IJASRE 4, 139–144. https://doi.org/10.31695/IJASRE.2018.33016.

Barbosa, M.W., de Ávila Rodrigues, C., 2020. Project portfolio management teaching: contributions of a gamified approach. Int. J. Manag. Educ. 18, 100388 https://doi.org/10.1016/j.ijme.2020.100388.

Boghian, I., Cojocariu, V.-M., Popescu, C.V., Mâță, L., 2019. Game-based learning. Using board games in adult education. J. Educat. Sci. Psychol. 9, 51–57.

Boone, H.N., Boone, D.A., 2012. Analyzing likert data. J. Ext. 50, 1–5.

Breien, F.S., Wasson, B., 2021. Narrative categorization in digital game-based learning: engagement, motivation & learning. Br. J. Educ. Technol. 52, 91–111. https://doi.org/10.1111/bjet.13004.

Bygstad, B., Øvrelid, E., Ludvigsen, S., Dæhlen, M., 2022. From dual digitalization to digital learning space: exploring the digital transformation of higher education. Comput. Educ. 182, 104463 https://doi.org/10.1016/j.compedu.2022.104463.

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. In: Computer Standards & Interfaces, Standards in Software Process Improvement and Capability Determination, 60, pp. 80–92. https://doi.org/10.1016/j.csi.2018.04.012.

Cicmil, S., Gaggiotti, H., 2018. Responsible forms of project management education: theoretical plurality and reflective pedagogies. Int. J. Project Manage. Festschrift for Profes. J. Rodney Turner 36, 208–218. https://doi.org/10.1016/j.ijproman.2017.07.005.

Cicmil, S., Williams, T., Thomas, J., Hodgson, D., 2006. Rethinking project management: researching the actuality of projects. Int. J. Proj. Manage., Rethink. Proj. Manag. 24, 675–686. https://doi.org/10.1016/j.ijproman.2006.08.006.

Creswell, J.W., 1999. Chapter 18 - mixed-method research: introduction and application. In: Cizek, G.J. (Ed.), Handbook of Educational Policy, Educational Psychology. Academic Press, San Diego, pp. 455–472. https://doi.org/10.1016/B978-012174698-8/50045-X.

Crocco, F., Offenholley, K., Hernandez, C., 2016. A proof-of-concept study of game-based learning in higher education. Simulat. Gaming 47, 403–422. https://doi.org/10.1177/1046878116632484.

de Freitas, S., 2018. Are games effective learning tools? A review of educational games. J. Educ. Technol. Soc. 21, 74–84.

Deci, E.L., Ryan, R.M., 2014. Intrinsic Motivation and Self-Determination in Human Behavior. Perspectives in Social Psychology. Springer Science + Business Media, New York.

D'Mello, S., Graesser, A., 2012. Dynamics of affective states during complex learning. Learn. InStruct. 22, 145–157. https://doi.org/10.1016/j.learninstruc.2011.10.001.

Erhel, S., Jamet, E., 2013. Digital game-based learning: impact of instructions and feedback on motivation and learning effectiveness. Comput. Educ. 67, 156–167. https://doi.org/10.1016/j.compedu.2013.02.019.

Fredricks, J.A., Blumenfeld, P.C., Paris, A.H., 2004. School engagement: potential of the concept, state of the evidence. Rev. Educ. Res. 74, 59–109. https://doi.org/10.3102/00346543074001059.

Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H., Wenderoth, M.P., 2014. Active learning increases student performance in science, engineering, and mathematics. Proc. Natl. Acad. Sci. USA 111, 8410–8415. https://doi.org/10.1073/pnas.1319030111.

Garris, R., Ahlers, R., Driskell, J.E., 2002. Games, motivation, and learning: a research and practice model. Simulat. Gaming 33, 441–467. https://doi.org/10.1177/1046878102238607.

Gemünden, H.G., 2013. Projectification of society. Proj. Manag. J. 44, 2–4.

Hamari, J., Shernoff, D.J., Rowe, E., Coller, B., Asbell-Clarke, J., Edwards, T., 2016. Challenging games help students learn: an empirical study on engagement, flow and immersion in game-based learning. Comput. Hum. Behav. 54, 170–179. https://doi.org/10.1016/j.chb.2015.07.045.

Hartt, M., Hosseini, H., Mostafapour, M., 2020. Game on: exploring the effectiveness of game-based learning. Plann. Pract. Res. 35, 589–604. https://doi.org/10.1080/02697459.2020.1778859.

Hidi, S., Harackiewicz, J.M., 2000. Motivating the academically unmotivated: a critical issue for the 21st century. Rev. Educ. Res. 70, 151–179. https://doi.org/10.3102/00346543070002151.

Huang, W.D., Johnson, T.E., Han, S.-H.C., 2013. Impact of online instructional game features on college students' perceived motivational support and cognitive investment: a structural equation modeling study. Internet High Educ. 17, 58–68. https://doi.org/10.1016/j.iheduc.2012.11.004.

Jaccard, D., Bonnier, K.E., Hellström, M., 2022. How might serious games trigger a transformation in project management education? Lessons learned from 10 Years of experimentations. Proj. Lead. Soc. 3, 100047 https://doi.org/10.1016/j.plas.2022.100047.

Jong, M.S.Y., 2016. Teachers' concerns about adopting constructivist online game-based learning in formal curriculum teaching: the VISOLE experience. Br. J. Educ. Technol. 47, 601–617. https://doi.org/10.1111/bjet.12247.

Joshi, A., Kale, S., Chandel, S., Pal, D., 2015. Likert scale: explored and explained. BJAST 7, 396–403. https://doi.org/10.9734/BJAST/2015/14975.

Jääskä, E., Aaltonen, K., 2022. Teachers' experiences of using game-based learning methods in project management higher education. Proj. Lead. Soc. 3, 100041 https://doi.org/10.1016/j.plas.2022.100041.

Jääskä, E., Aaltonen, K., Kujala, J., 2021. Game-based learning in project sustainability management education. Sustainability 13, 8204. https://doi.org/10.3390/su13158204.

Järvelä, S., Renninger, K.A., 2014. Designing for learning: interest, motivation, and engagement. In: Sawyer, R.K. (Ed.), The Cambridge Handbook of the Learning Sciences, Cambridge Handbooks in Psychology. Cambridge University Press, Cambridge, pp. 668–685. https://doi.org/10.1017/CBO9781139519526.040.

Kebritchi, M., Hirumi, A., Bai, H., 2010. The effects of modern mathematics computer games on mathematics achievement and class motivation. Comput. Educ. 55, 427–443. https://doi.org/10.1016/j.compedu.2010.02.007.

Keller, J.M., 2000. How to Integrate Learner Motivation Planning into Lesson Planning: the ARCS Model Approach. VII Semanario, Santiago. Cuba 1–13.

Keller, J.M., 1999. Using the ARCS motivational process in computer-based instruction and distance education. N. Dir. Teach. Learn. 37–47. https://doi.org/10.1002/tl.7804, 1999.

Keller, J.M., 1987. Development and use of the ARCS model of instructional design. J. Instr. Dev. 10, 2–10. https://doi.org/10.1007/BF02905780.

Keller, J.M., 2008. An integrative theory of motivation, volition, and performance. Techn, Instruction, Cognition, and Learn. 6 (2), 79–104.

Kirk, R.E., 2009. Experimental design. In: The SAGE Handbook of Quantitative Methods in Psychology. SAGE Publications Ltd, 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom, pp. 23–45. https://doi.org/10.4135/9780857020994.n2.

Kolb, A.Y., Kolb, D.A., 2005. Learning styles and learning spaces: enhancing experiential learning in higher education. AMLE 4, 193–212. https://doi.org/10.5465/amle.2005.17268566.

Krapp, A., 1999. Interest, motivation and learning: an educational-psychological perspective. Eur. J. Psychol. Educ. 14, 23–40. https://doi.org/10.1007/BF03173109.

Kuura, A., 2020. 25 years of projectification research. PM World J. 9.

Lantz, B., 2013. The impact of sample non-normality on ANOVA and alternative methods. Br. J. Math. Stat. Psychol. 66, 224–244. https://doi.org/10.1111/j.2044-8317.2012.02047.x.

Law, K.M., 2019. Teaching project management using project-action learning (PAL) games: a case involving engineering management students in Hong Kong. Int. J. Eng. Bus. Manag. 11, 184797901982857 https://doi.org/10.1177/1847979019828570.
Li, K., Keller, J.M., 2018. Use of the ARCS model in education: a literature review. Comput. Educ. 122, 54–62. https://doi.org/10.1016/j.compedu.2018.03.019.
Linnenbrink, E.A., 2007. Chapter 7 - the role of affect in student learning: a multi-dimensional approach to considering the interaction of affect, motivation, and engagement. In: Schutz, P.A., Pekrun, R. (Eds.), Emotion in Education, Educational Psychology. Academic Press, Burlington, pp. 107–124. https://doi.org/10.1016/B978-012372545-5/50008-3.
Lomas, J.D., Koedinger, K., Patel, N., Shodhan, S., Poonwala, N., Forlizzi, J.L., 2017. Is difficulty overrated? The effects of choice, novelty and suspense on intrinsic motivation in educational games. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, CHI '17. Association for Computing Machinery, New York, NY, USA, pp. 1028–1039. https://doi.org/10.1145/3025453.3025638.
Malone, T.W., Lepper, M.R., 1987. Making learning fun: a taxonomy of intrinsic motivations for learning. In: Aptitude, Learning, and Instruction. Routledge.
Marklund, B.B., Taylor, A.-S.A., 2016. Educational Games in Practice: the Challenges Involved in Conducting a Game-Based Curriculum, 14, p. 14.
Martín-Hernández, P., Gil-Lacruz, M., Gil-Lacruz, A.I., Azkue-Beteta, J.L., Lira, E.M., Cantarero, L., 2021. Fostering university students' engagement in teamwork and innovation behaviors through game-based learning (GBL). Sustainability 13, 13573. https://doi.org/10.3390/su132413573.
Miles, M.B., Huberman, A.M., Saldaña, J., 2014. Qualitative Data Analysis: a Methods Sourcebook, third ed. SAGE Publications, Inc., Thousand Oaks, California.
Naul, E., Liu, M., 2020. Why story matters: a review of narrative in serious games. J. Educ. Comput. Res. 58, 687–707. https://doi.org/10.1177/0735633119859904.
Paas, F., Tuovinen, J.E., van Merriënboer, J.J.G., Aubteen Darabi, A., 2005. A motivational perspective on the relation between mental effort and performance: optimizing learner involvement in instruction. ETR&D 53, 25–34. https://doi.org/10.1007/BF02504795.
Palmer, D.H., 2009. Student interest generated during an inquiry skills lesson. J. Res. Sci. Teach. 46, 147–165. https://doi.org/10.1002/tea.20263.
Pintrich, P.R., 2003. A motivational science perspective on the role of student motivation in learning and teaching contexts. J. Educ. Psychol. 95, 667–686. https://doi.org/10.1037/0022-0663.95.4.667.
Plass, J.L., Homer, B.D., Kinzer, C.K., 2015. Foundations of game-based learning. Educ. Psychol. 50, 258–283. https://doi.org/10.1080/00461520.2015.1122533.
PMI, 2021. Project Management Body of Knowledge, seventh ed.
PMI, 2017. Job Growth and Talent Gap: 2017–2027.
Prensky, M., 2003. Digital game-based learning. Comput. Entertain. 1, 21. https://doi.org/10.1145/950566.950596.
Ramazani, J., Jergeas, G., 2015. Project managers and the journey from good to great: the benefits of investment in project management training and education. Int. J. Proj. Manag. 33, 41–52. https://doi.org/10.1016/j.ijproman.2014.03.012.
Rumeser, D., Emsley, M., 2019. Can serious games improve project management decision making under complexity? Proj. Manag. J. 50, 23–39. https://doi.org/10.1177/8756972818808982.
Ryan, R.M., Deci, E.L., 2000. Self-determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being, 67. American Psychologist.
Scepanovic, S., Zaric, N., Matijevic, T., 2015. Gamification in Higher Education Learning–State of the Art Challenges and Opportunities. The Sixth International Conference on e-Learning.
Schoper, Y., Ingason, H.T., 2019. Projectification and the impact on societies. Int. J. Manag. Proj. Bus. 12, 517–521. https://doi.org/10.1108/IJMPB-09-2019-288.
Schwabe, G., Göth, C., 2005. Mobile learning with a mobile game: design and motivational effects. J. Comput. Assist. Learn. 21, 204–216. https://doi.org/10.1111/j.1365-2729.2005.00128.x.
Shaffer, D.W., Squire, K.R., Halverson, R., Gee, J.P., 2005. Video games and the future of learning. Phi Delta Kappan 87, 105–111. https://doi.org/10.1177/003172170508700205.
Shute, V.J., D'Mello, S., Baker, R., Cho, K., Bosch, N., Ocumpaugh, J., Ventura, M., Almeda, V., 2015. Modeling how incoming knowledge, persistence, affective states, and in-game progress influence student learning from an educational game. Comput. Educ. 86, 224–235. https://doi.org/10.1016/j.compedu.2015.08.001.
Svejvig, P., Andersen, P., 2015. Rethinking project management: a structured literature review with a critical look at the brave new world. Int. J. Proj. Manag. 33, 278–290. https://doi.org/10.1016/j.ijproman.2014.06.004.
Tashakkori, A., Creswell, J.W., 2007. Editorial: the new era of mixed methods. J. Mix. Methods Res. 1, 3–7. https://doi.org/10.1177/2345678906293042.
Van Eck, R., 2006. Digital game based learning: it's not just the digital natives who are restless. EDUCAUSE 41.
Vu, P., Feinstein, S., 2017. An exploratory multiple case study about using game-based learning in STEM classrooms. Int. J. Res. Educ. Sci. 582. https://doi.org/10.21890/ijres.328087, 582.
Westera, W., 2019. Why and how serious games can become far more effective: accommodating productive learning experiences, learner motivation and the monitoring of learning gains. J. Educ. Technol. Soc. 22 (1), 59–69.
Wiggins, B., 2016. An overview and study on the use of games, simulations, and gamification in higher education. Int. J. Game Base. Learn. 6, 18–29. https://doi.org/10.4018/IJGBL.2016010102.
Winter, M., Smith, C., Morris, P., Cicmil, S., 2006. Directions for future research in project management: the main findings of a UK government-funded research network. Int. J. Proj. Manag. 24, 638–649. https://doi.org/10.1016/j.ijproman.2006.08.009.