Journal of Universal Computer Science, vol. 24, no. 10 (2018), 1424-1451
submitted: 27/3/18, accepted: 6/9/18, appeared: 28/10/18

Games for Teaching Software Project Management: An Analysis of the Benefits of Digital and Non-Digital Games

Giani Petri
(Federal University of Santa Maria, Santa Maria/RS, Brazil
Federal University of Santa Catarina, Florianópolis/SC, Brazil
gpetri@inf.ufsm.br)

Alejandro Calderón
(University of Cádiz, Puerto Real (Cádiz), Spain
alejandro.calderon@uca.es)

Christiane Gresse von Wangenheim
(Federal University of Santa Catarina, Florianópolis/SC, Brazil
c.wangenheim@ufsc.br)

Adriano F. Borgatto
(Federal University of Santa Catarina, Florianópolis/SC, Brazil
adriano.borgatto@ufsc.br)

Mercedes Ruiz
(University of Cádiz, Puerto Real (Cádiz), Spain
mercedes.ruiz@uca.es)

Abstract: Driven by the need to provide more hands-on opportunities to computing students, educational digital and non-digital games have been used as an instructional strategy for teaching Software Project Management (SPM). However, a question that arises is to which regard the expected benefits of these games are real. Thus, the objective of this study is to analyse the benefits of digital and non-digital games used for SPM education in order to evaluate their quality in terms of player experience and perceived learning adopting the MEEGA+ evaluation model. The analysis is based on data collected from 27 case studies, evaluating 11 different SPM games, involving a population of 562 students. Results provide evidence that both digital and non-digital games contribute positively to the students' perceived learning, as well as to social interaction, being considered relevant to students' learning, and promoting fun. A slightly higher usability degree was observed with respect to digital games due the easiness to learn how to play the games. On the other hand, a slightly more positive evaluation of the achievement of the learning objectives of non-digital games has been observed. The results of this study may guide instructors in the selection of games as an instructional strategy for SPM education and/or game creators with respect to aspects to be considered in the development of new educational games in order to maximize their benefits and continuous improvement.

Keywords: Educational game, Software project management, Evaluation, Digital games, Non-digital games, MEEGA+
Categories: D.2.9, L.0.0, L.5.1

1 Introduction

Project Management (PM) is the discipline of initiating, planning, executing, monitoring & controlling, and closing the work of a team to achieve specific project goals and success requirements [PMI, 13]. In the context of software projects, Software Project Management (SPM) is applied in order to ensure that software products and services are delivered efficiently, effectively, and to the benefit of stakeholders [Bourque, 14]. Thus, SPM is an important (and critical) knowledge area for the software industry on the road to success of software projects.

The teaching of SPM has been supported by organizations such as the Association for Computing Machinery (ACM) and IEEE-Computer Society in their joint task force curricula for undergraduate computing courses [ACM, 13]. They recommend that the learning about the concepts, methods, and principles of SPM should be rather practical than theoretical. However, typically, SPM is taught through traditional lectures, in which students are only exposed to the theoretical concepts, lacking practical training in real-life scenarios [Geist, 07; Ojiako, 11; Hussein, 15].

On the other hand, other instructional strategies, such as educational games, may assist in demonstrating the application of theory and can help students to practice them in a risk-free environment [Geist, 07; Ojiako, 11; Backlund, 13; Connolly, 12]. Educational games, besides promoting entertainment, are specifically designed to teach people about a certain subject, expand and revise concepts, reinforce development, or assist them in drilling or learning a skill or seeking a change of attitude as they play [Dempsey, 96; Abt, 02; Prensky, 07]. Driven by the need to provide more hands-on opportunities for computing students, some educational games have been developed for teaching SPM, including digital games such as SimSE [Navarro, 07], ProDec [Calderón, 13], as well as non-digital games, *e.g.*, SCRUMIA [Gresse von Wangenheim, 13a], Detective Game [Gresse von Wangenheim, 14], among others.

In this context, games used for SPM education are expected to result in a wide range of benefits, like increasing learning effectiveness, students' interest, and motivation [Garris, 02; Barnes, 08; Gresse von Wangenheim, 09; Boyle, 11; Olgun, 17]. Educational games are expected to provide a fun and safe environment, in which students can try alternatives and observe the consequences, learning from their own mistakes [Pfahl, 01; Prensky, 07]. They are supposed to be an effective and efficient instructional strategy for SPM education [Backlund, 13; Calderón, 15; Olgun, 17]. However, these claims seem to be questionable [Hays, 05; Gresse von Wangenheim, 09; Caulfield, 11; Connolly, 12; Olgun, 17]. In practice, games for SPM education seem to lack the empirical evidence of their expected learning impact and/or the engagement they promise [Hays, 05; Akili, 06; Gresse von Wangenheim, 09; Caulfield, 11; Ibrahim, 11; Connolly, 12; Backlund, 13; Boyle, 16]. Evaluations of such games are often performed in an ad-hoc manner in terms of research design, measurement, data collection & analysis [Caulfield, 11; Connolly, 12; Calderón, 15; Petri, 16a; All, 16; Kosa, 16; Petri, 17].

In order to obtain a more comprehensive understanding of the benefits of games, we conducted a series of case studies evaluating digital and non-digital games used for SPM education. The case studies were conducted adopting the MEEGA+ games' evaluation model [Petri, 18], an evolution of the MEEGA model, a widely used evaluation model in practice [Calderón, 15; Petri, 17]. It is a well-defined model developed for the evaluation of educational games with respect to player experience and perceived learning. The model measures the perception of students after they played a game by applying a standardized questionnaire answered by the students adopting a one-shot post-test research design [Petri, 16b; Petri, 18]. Our analysis is based on a data set from 27 case studies conducted using the MEEGA+ model, evaluating 11 educational games for SPM education in different computing education institutions, involving a total population of 562 students.

2 Research Method

In order to analyse the benefits of digital and non-digital games used for SPM education, we perform a series of case studies [Wohlin, 12; Yin, 17] structured as illustrated in Figure 1.

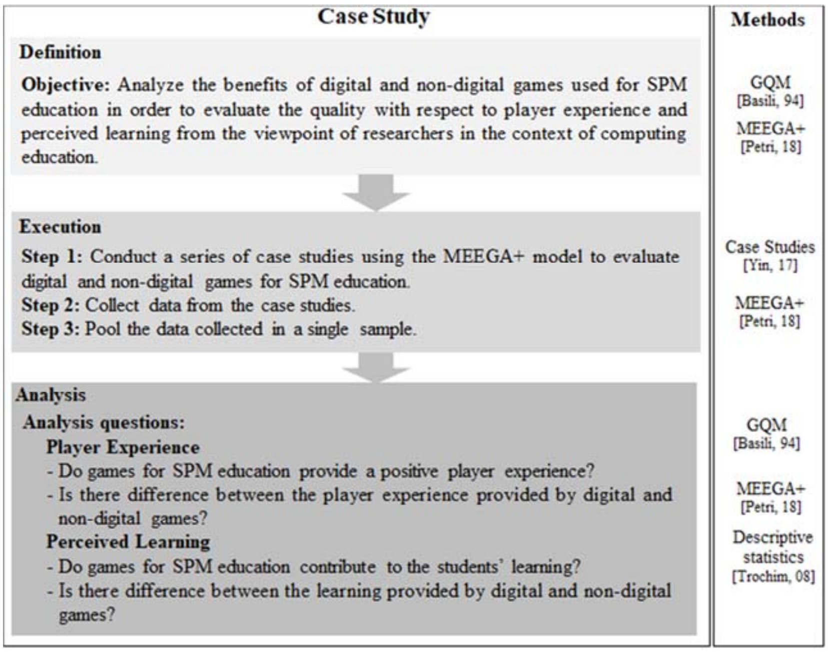

Figure 1: Research method

In the first phase, the evaluation study is defined (Section 3). Following the GQM (Goal/Question/Metric) approach [Basili, 94], the study objective is decomposed into quality aspects and questions to be analysed based on the data collected in the games' evaluation. In accordance with the defined objective of this study, the MEEGA+ evaluation model for educational games [Petri, 16b; Petri, 18] has been adopted decomposing the objective in quality factors and a set of dimensions. The MEEGA+ model has been developed as an evolution of the initial version of the MEEGA model

[Savi 11], based on the results of the literature reviews [Petri, 16a; Petri, 17] and the large-scale analysis of the initial version of the MEEGA model [Petri, 17b], increasing its validity and reliability. The decomposition of the quality factors of the MEEGA+ model is presented in Figure 2.

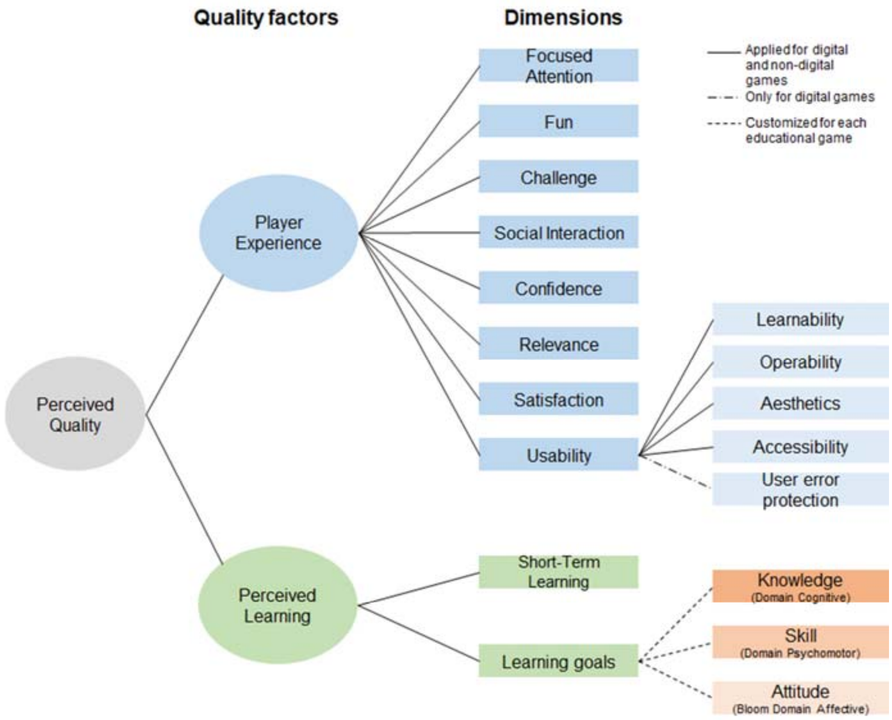

Figure 2: Decomposition of the quality of educational games in the MEEGA+ Model [Petri, 18]

Following the MEEGA+ model, a standardized questionnaire is used in order to operationalize the data collection. The case studies are standardized in terms of measures (quality factors/dimension), data collection instrument (MEEGA+ questionnaire), and response format 5-point Likert scale ranging from -2 (strongly disagree) to 2 (strongly agree).

The execution phase (Section 3) was organized in three steps. First, we conducted 27 case studies evaluating 11 games for SPM education. The games used in the case studies were selected in according to their adequacy and relevance to the teaching of SPM concepts. The case studies were conducted with a one-shot post-test only design, in which the case study begins with the application of the treatment (educational game) and after the game session the MEEGA+ questionnaire is answered by the students in order to collect their perceptions (step 2). Then, in step 3, we grouped the data collected in the conducted case studies (Table 1) into a single sample in order to conduct the data analysis.

In the analysis phase (Section 4), we performed a comprehensive analysis using the data collected cumulatively in order to summarize empirical evidence on the benefits of digital and non-digital games in terms of player experience and perceived learning. Following the MEEGA+ model, we analysed the data in order to answer each of the defined analysis questions using descriptive statistics. The results were interpreted and discussed achieving the research objective.

3 Definition and Execution of the Study

The objective of this study is "to analyse the benefits of digital and non-digital games used for SPM education in order to evaluate the quality with respect to player experience and perceived learning from the viewpoint of researchers in the context of computing education. Thus, in this study the results are interpreted from the researchers' perspective, being the researchers the authors, with backgrounds in computing/SPM, including PMP certified professionals.
From this objective, we derive the following analysis questions, grouped by the evaluated quality factors:

Player Experience
AQ1: Do games for SPM education provide a positive player experience?
AQ2: Is there a difference between the player experience provided by digital and non-digital games used for SPM education?
Perceived Learning
AQ3: Do games for SPM education contribute to the students' learning?
AQ4: Is there a difference between the learning provided by digital and non-digital games used for SPM education?

In order to answer these analysis questions, we conducted 27 case studies evaluating 4 digital and 7 non-digital games in SPM courses using the MEEGA+ evaluation model. As a result of the execution phase, we obtained data from 562 students in 6 different educational contexts/institutions as summarized in Table 1.

In summary, 11 different educational games for teaching SPM (4 digital and 7 non-digital games) were applied in the case studies conducted. The non-digital games were typically used to review and reinforce basic SPM concepts (*e.g.*, PM Master), to simulate the planning, execution, and control of a software project (*e.g.*, Detective Game, SCRUMIA, PMDome, Risk Management Game), or to reinforce and develop human resource management concepts and soft skills (*e.g.*, Dealing with Difficult People and Ball Point Game). Similarly, the digital games were used to review and reinforce the PM knowledge using mobile devices (*e.g.*, PMQuiz, QuizGame), to simulate the SPM concepts and practices in a simulation-based serious game (*e.g.*, ProDec), or to reinforce and exemplify Scrum concepts in a 3D environment (*e.g.*, SCRUM'ed). An overview of each of the applied games and its objectives are presented in the next section.

Game	Game session time	Context	Course/Semester	Institution/ Country	Sample size (M - Men, W - Women, NI – Not Informed)
Digital Games					
PMQuiz [Petri, 16c]	30 minutes	Undergraduate course in computing program	Software project management/2016-2	Federal University of Santa Maria/Brazil	11 (9M, 2W)
			Project planning and management/2016-2	Federal University of Santa Catarina/Brazil	29 (26M, 3W)
			Project management/2016-2		20 (19M, 1W)
			Project planning and management/2017-1		17 (16M, 1W)
			Project management/2017-1		24 (18M, 6W)
QuizGame [Tonussi, 17]	30 minutes	Undergraduate course in computing program	Project planning and management/2017-1	Federal University of Santa Catarina/Brazil	21 (20M, 1W)
SCRUM'ed [Schneider, 15]	30 minutes	Undergraduate course in computing program	Software engineering/2016-2	Lutheran University of Brazil/Brazil	18 (18M)
ProDec [Calderón, 13]	45 minutes	Undergraduate course in computing program	Software project management/2017-2	University of Cádiz/Spain	20 (20M)
		Master course in computing program	Software project management/2017-1		4 (3M, 1W)
				Sub-total digital games	**164** (149M, 15W)
Non-Digital Games					
Detective Game – what killed the project? [Gresse von Wangenheim, 14]	90 minutes	Undergraduate course in computing program	Project planning and management/2016-2	Federal University of Santa Catarina/Brazil	26 (23M, 3W)
			Project planning and management/2017-1		17 (16M, 1W)
PMDome [PMDome, 17]	120 minutes	Graduate course in computing program	Project management fundamentals/2016-2	Federal Institute Farroupilha/Brazil	20 (17M, 3W)
		Computing Technical Course Integrated to High School	Workshop games/2016-2	Federal Institute of Santa Catarina/Brazil	27 (18M, 9W)
Risk Management	90 minutes	Undergraduate course in	Project planning and management/2016-2	Federal University of	31 (28M, 3W)

Game		computing program	Project management/2016-2	Santa Catarina/Brazil	23 (22M, 1W)
			Project planning and management/2017-1		21 (20M, 1W)
			Project management/2017-1		21 (16M, 5W)
		Computing Technical Course Integrated to High School	Games Workshop/2017-1	Federal Institute of Santa Catarina/Brazil	36 (16M, 18W, 2NI)
		Computing Technical Course Integrated to High School	Games Workshop/2017-1		31 (18M, 12W, 1NI)
PM Master [Gresse von Wangenheim, 12]	90 minutes	Undergraduate course in computing program	Project planning and management/2016-2	Federal University of Santa Catarina/Brazil	24 (23M, 1W)
			Project management/2016-2		21 (20M, 1W)
			Project planning and management/2017-1		17 (16M, 1W)
			Project management/2017-1		18 (13M, 5W)
SCRUMIA [Gresse von Wangenheim, 13a]	90 minutes	Undergraduate course in computing program	Project planning and management/2016-2	Federal University of Santa Catarina/Brazil	26 (24M, 2W)
			Project planning and management/2017-1		19 (19M)
Ball Point Game [Gloger, 17]	30 minutes	Undergraduate course in computing program	Games Workshop/2017-2	University of Cádiz/Spain	10 (9M, 1W)
Dealing with difficult people [Gresse von Wangenheim, 13b]	30 minutes	Undergraduate course in computing program	Games Workshop/2017-2	University of Cádiz/Spain	10 (9M, 1W)
				Sub-total non-digital games	**398** (327M, 68W, 3NI)
				Total	**562** (476M, 83W, 3NI)

Table 1: Summary of the conducted case studies

3.1 Overview of the Evaluated Games

3.1.1 Digital Games

PMQuiz [Petri, 16c] is a quiz game to review SPM knowledge. Players answer each question within a time limit using their smartphone (Figure 3). The player, who scores most points by answering more questions correctly in the shortest time is the winner.

The learning objective of this game is to review SPM concepts such as scope, time, and cost. The game is available at <http://www.gqs.ufsc.br/kahoot-pm-quiz/>.

Figure 3: Applications of the game PMQuiz

QuizGame [Tonussi, 17] is an educational question and answer game integrated into the Moodle platform (Figure 4). The learning objective of the game is to review and reinforce SPM concepts. The students answer questions using their personal mobile devices. The player who answers more questions correctly in the shortest time is the winner.

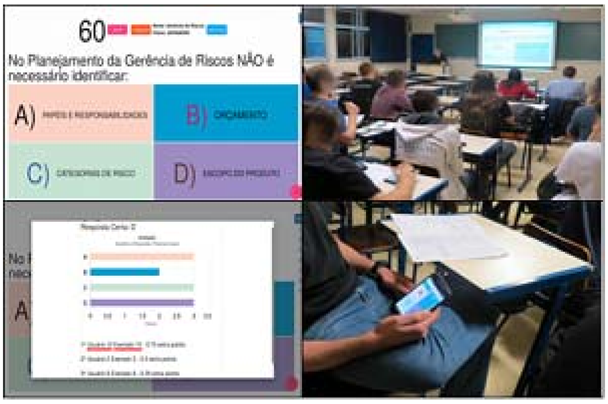

Figure 4: Applications of the QuizGame

ProDec [Calderón, 13] is a simulation-based game to teach, assess and motivate learners with respect to SPM concepts and practices, as well as supporting the comprehension and knowledge acquisition of SPM lifecycle processes and activities (Figure 5). Its aim is that learners are able to successfully manage a software project. Player win when s/he is able to complete the project within the time and cost constraints. ProDec allows learners to create their own project plans from scratch, execute the simulation of their own project scenarios, practice their decision-making skills by controlling and monitoring the progress of the project execution, and close the project analysing the results of their performance during gameplay to get lessons learned.

Figure 5: Applications of the game ProDec

SCRUM'ed [Schneider, 15] is a 3D role-playing game with a narrative based on Scrum concepts (roles, ceremonies, and artefacts). The learning objective is to reinforce and exemplify Scrum concepts. Players assume the role of a Scrum Master and need to help "knights" in planning and executing the project for their client, the King (Figure 6). Players are taken on a journey through a Daily Scrum, helping the team to define and update the Sprint Backlog and the Taskboard based on the Product Backlog, running a Sprint Review Meeting, with the goal to keep the project on schedule. The game is available at <http://www.gqs.ufsc.br/scrumed-a-3d-role-playing-game-to-learn-scrum/>.

Figure 6: Applications of the game SCRUM'ed

3.1.2 Non-Digital Games

Detective Game – what killed the project? [Gresse von Wangenheim, 14] is a deductive tabletop game with the objective to monitor and control a software project using earned value management (Figure 7). The game takes place in the context of a hypothetical software company that finished a software project that failed and now the company is contracting the players as consultants in order to identify what went wrong. Players receive a set of project documents to analyse and revise its monitoring and control by completing calculations of schedule and cost variances as well as performance indexes. The learning objective of the game is to reinforce concepts and to teach the competency to apply knowledge on earned value management. The game materials are available at <http://www.gqs.ufsc.br/detective-game-what-killed-the-project/>.

Figure 7: Applications of the game Detective

PMDome [PMDome, 17] is a simulation game with the learning objective to motive the importance of planning in a project (Figure 8). The game simulates PM planning and execution phases asking students to plan time and resources and then executing the project, constructing a Geodesic Dome, using pens, and sheets of paper.

Figure 8: Applications of the game PMDome

SCRUMIA [Gresse von Wangenheim, 13a] is a group simulation exercise with the purpose of planning and executing sprints of a hypothetical project by applying

SCRUM as part of a SPM course (Figure 9). Its learning objective is to reinforce the concepts and to teach the competency to apply agile project management using SCRUM. The game materials and rules are available at <http://www.gqs.ufsc.br/applying-scrum-welcome-to-scrumia/>.

Figure 9: Applications of the game SCRUMIA

Risk Management Game is a board game that aims to motivate the importance of risk planning in PM (Figure 10). In the game, players must arrive at the delivery of a hypothetical project (end of the board), planning and passing through project phases with the allocated resources. Starting the game, players need to perform a risk analysis, identifying how unexpected risks may affect the project's resources. The player who reaches the end of the game first with financial resources left is the winner.

Figure 10: Applications of the Risk Management Game

PM Master [Gresse von Wangenheim, 12] is a board game with questions about different PM knowledge areas, such as scope, time, human resources, and quality management (Figure 11). The player who first correctly answers a question from each of the knowledge area wins the game. It aims to review and reinforce basic PM concepts in accordance with the PMBOK (4th edition), focusing specifically on SPM. The game is available at <http://www.gqs.ufsc.br/pm-master/>.

Figure 11: Applications of the game PM Master

Ball Point Game [Gloger, 17] aims to illustrate the dynamics of a team working iteratively focusing on continuous improvement (Figure 12). In the game, teams must pass balls by all participants until they return to the starting point to score points. The balls cannot be passed to the neighbours on the right and left, they cannot touch the ground and the balls must pass through the air to the other player. At the end of the game, the team that scored the most points is the winner.

Figure 12: Applications of the Ball Point Game

Dealing with difficult people [Gresse von Wangenheim, 13b] is a simulation that aims to illustrate difficulties related to team management in software projects (Figure

13). In small groups, the game simulates a kick-off meeting of a software project. One of the students assumes the role of the project manager, who conducts the meeting and at the end must have received the agreement of all other group members. Each member of the group assumes a difficult personality (*e.g.*, no person, know-it-all, grenade), while the project manager must react accordingly in order to manage these difficult personalities. The game materials are available at <http://www.gqs.ufsc.br/leadership-exercise-dealing-with-difficult-people-2/>.

Figure 13: Applications of the game Dealing with difficult people

Among the 562 participants in the game evaluations, 476 participants were men (~85%), 83 participants were women (~15%) (three students did not provide this information). Most of the participants were between 18 and 28 years (75%), 17% are under 18 years, and 8% were over 29 years. 19% of the participants play digital games every day, 30% weekly, 17% monthly, 29% rarely and 5% never played digital games. On the other hand, participants rarely play non-digital games (7% play non-digital games daily, 10% weekly, 25% monthly, 56% rarely, and 2% never played a non-digital game).

4 Analysis

Data collected in the selected case studies (Table 1) were pooled in a single sample, using them cumulatively in order to analyse the benefits of digital and non-digital games used for teaching SPM (and not to evaluate a specific game). The grouping of data was possible due to the similarity of the case studies conducted and standardization of the data collection [Kish, 94], as the studies conducted are similar in terms of definition (with the objective to evaluate an educational game for SPM education in terms of player experience and perceived learning), research design (case study), and context (SPM education).

We analyse the data collected using descriptive statistics in terms of frequency distribution and central tendency (median) [Trochim, 08] in order to answer each of the analysis questions as defined in the research method, grouped by each quality factor (player experience (Section 4.1) and perceived learning (Section 4.2)). The analysis questions AQ1 and AQ3 are assessed in terms of the frequency distribution of the data collected, considering the scale ranging from -2 (strongly disagree) to 2 (strongly agree). The analysis questions AQ2 and AQ4 are analysed comparing the central tendency (median) per platform (digital and non-digital game) for each measurement instrument item, also considering the scale ranging from -2 (strongly disagree) to 2 (strongly agree).

4.1 Player Experience

AQ1: Do games for SPM education provide a positive player experience?

According to the MEEGA+ model, the player experience was evaluated in terms of usability, confidence, challenge, satisfaction, social interaction, fun, focused attention, and relevance. Based on the data collected, we observed that the educational games used as an instructional strategy for teaching SPM, in general, provide a positive experience for computing students (Figure 14), especially, in terms of relevance, social interaction, and fun. This demonstrates that the games are a positive and engaging instructional strategy for learning SPM, promoting feelings of pleasure, happiness, and distracting in a pleasant environment of learning, encouraging the cooperation and the sharing of ideas among the students.

In general, the students also confirmed that the games provide a good usability, indicating that the fonts' size and style used in the games are easy to read. The students also confirmed that the colours are meaningful, the text, font, and colours are well blended and consistent. And, that the games are easy to play with clear rules. A slightly higher usability was observed by the digital games due to the easiness to learn how to play these games. Especially, the game PMQuiz [Petri, 16c] was evaluated with a higher usability degree, indicating that the colours and fonts used in this game are meaningful and consistent and that students found this game very easy to start to play.

Yet, although most participants indicated that the games are easy to play, 14% of the students still think that most people would not learn to play the games quickly, especially considering non-digital games. An example is the Risk Management Game, which has a large number of rules and requires that player make decisions at the beginning of the game, for example, with respect to risk analysis. Thus, as these decisions need to be made early in the game, players may make decisions without a clear understanding of all the game' rules, and so, they may be prejudiced in order to win the game.

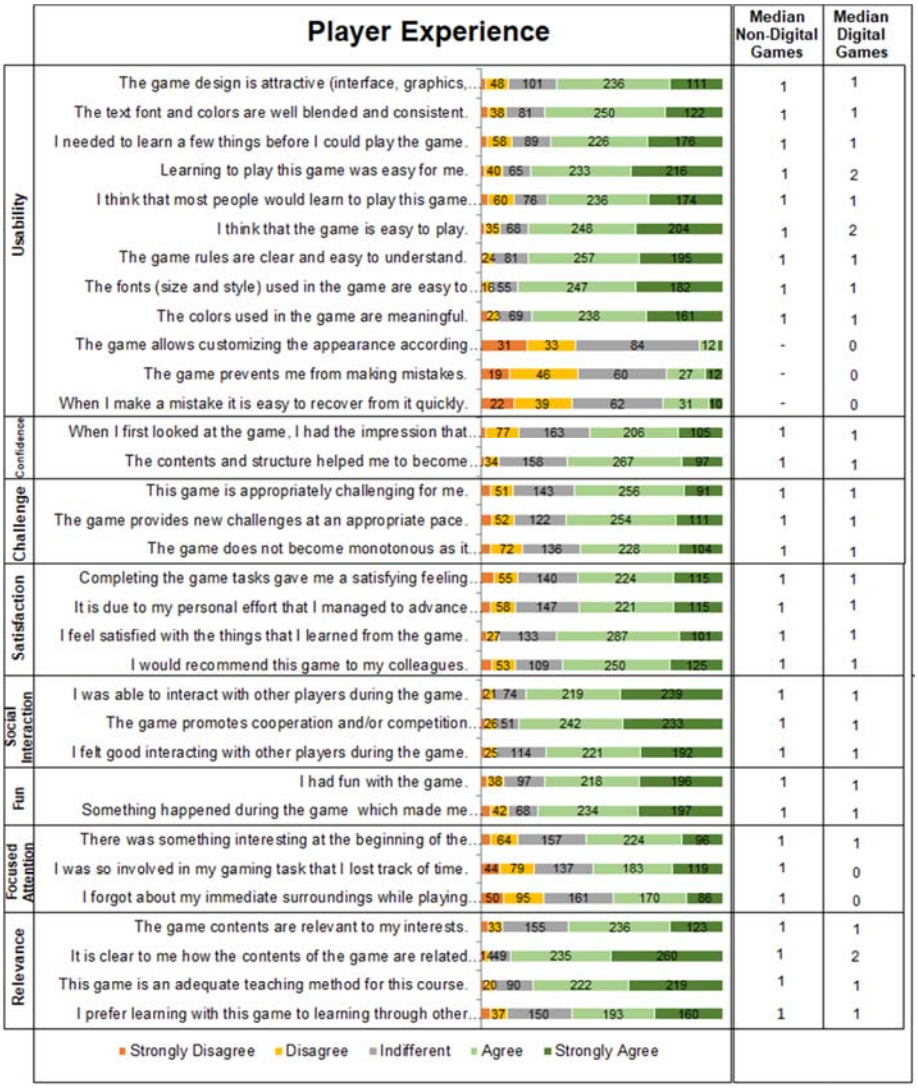

Figure 14: Frequency diagram of player experience (total of 562 responses)

The majority of students confirmed that the games provide a good usability, only 12% of the participants considered the games' design as not attractive. This may be related to the profile of the participants that the majority of students playing digital games frequently, and thus, can be accustomed to attractive interfaces and 3D graphics common in entertainment games. Another issue that may have led to a negative evaluation of usability may be the fact that most of the evaluated digital games do not allow the customization of appearance according to the player's preferences. Furthermore, contrary to usability heuristics, typically, the digital games do not prevent the players from making mistakes and/or do not help players to recover from errors.

The students confirmed that the organization of games' contents helped them to be confident that they would learn to play the games. On the other hand, some students also indicated that when looking at the game for the first time, they had the impression that it would not be easy to play.

Most of the students indicated that the games are challenging, offering new challenges to the players at an adequate pace and, in general, games do not become repetitive and/or monotonous. The students also confirmed that they are satisfied with the contents that they have learned by playing the games and would recommend the games to their colleagues. Most of the students also confirmed that they were able to advance in the game because of their personal effort, which is an essential element of an educational game that should only allow students to win if they have achieved their learning objectives [Prensky, 07].

Social interaction has been the highest positively rated factor of the games. Most of the students strongly agreed that the games provided moments of cooperation and competition among the players, also confirming that they had fun interacting with others during the game. In a similar way, the fun promoted by the games was another highest positively rated factor by the students, confirming that the participants enjoyed playing the games and that some games' situation made them smile. This feature of games is important because it promotes an enjoyable learning environment resulting in engagement and immersion, contributing to the students' learning [Abt, 02; Prensky, 07; Hamari, 16].

Analysing the students' focused attention provided by the games, although rated positive, 26% of the participants did not forget about their immediate surroundings while playing the games. 22% of the students indicated that they did not lose track of time. These results indicate that the games could still be improved to better capture the attention, considering that the concentration, absorption and the temporal dissociation of the students are indicated as important aspects that may contribute to the students' deeper learning [Prensky, 07; Hamari, 16].

The relevance of the games to the students' interest was evaluated in a very positive way, indicating that the contents covered in the games are related to the course. In addition, the majority of the students indicated that they consider games to be a suitable active instructional strategy for the course and that they prefer to learn by playing. This result shows that the students have experienced a positive and relevant learning experience with the content involved in the games.

AQ2: Is there a difference between the player experience provided by digital and non-digital games used for SPM education?

Analysing the differences between the player experience provided by digital and non-digital games, we observe that both platforms have been rated positively (Figure 14). This demonstrates that the majority of students experienced the games as a positive and engaging learning strategy using both digital and non-digital games.

Regarding the dimensions of confidence, challenge, satisfaction, social interaction and fun, the results of both, digital and non-digital games, show similar positive results. Both platforms provided a positive experience for the students, mainly, in terms of cooperation and/or competition among the players, promoting fun. This result indicates that indifferent to the platform, games are considered an instructional strategy suitable and relevant to the students' interest, promoting an engaging and pleasant environment for learning SPM.

Yet, although recognizing a good usability of both platforms, digital games have been rated to be easier to play than non-digital games. This result can be explained by characteristics of non-digital games, which need an instructor to explain the rules and mechanics of the game, which may make the game appear to be more difficult, until understanding all the rules and starting to play. However, one exception was the Ball Point Game. This game has few clear and easy rules, which has helped students to start playing it quickly.

On the other hand, in digital games, games' rules are typically explained in a self-explanatory way, during the game play, making this step easier for the students. However, analysing the characteristics of accessibility and user error protection in digital games, most games do not allow customization in terms of appearance and do not prevent players from making mistakes. This result indicates that these characteristics need to be improved in digital games, in order to promote the inclusion of all students in the activity allowing the customization the games respecting students' special preferences and respecting usability heuristics.

In terms of focused attention promoted by the games, although recognizing the positive evaluation of both platforms, non-digital games have been rated more positively than digital ones. This result can be explained by the shared environment promoted by the non-digital games, making that the students being connected with others in activities of cooperation or competition and, thus, stimulating the focused attention [Wiebe, 14].

Regarding the relevance of the games to the students' interest, both, digital and non-digital games, also have been rated positively. However, a slightly more positive evaluation on how the contents of the game are related to the course was perceived with respect to digital games. This result can be explained by the learning objectives of the evaluated games, as the digital games aim to review and/or apply concepts on SPM while, on the other hand, some non-digital games (*e.g.*, PMDome, Risk Management) just aim to motivate the students with respect to the importance of the management.

4.2 Perceived Learning

AQ3: Do games for SPM education contribute to the students' learning?

In general, the majority of students recognized that the games contributed positively to their learning (Figure 15). They also indicated that the games used for teaching SPM were efficient for their learning in comparison to other activities carried out in the course. However, some low ratings have been given. For example, with respect to the Risk Management Game, which aims at motivating the students on the importance of risk planning and, thus, to develop students' attitude and not knowledge. In this respect, the low ratings may be indicating that some students may prefer other activities of the course for their learning.

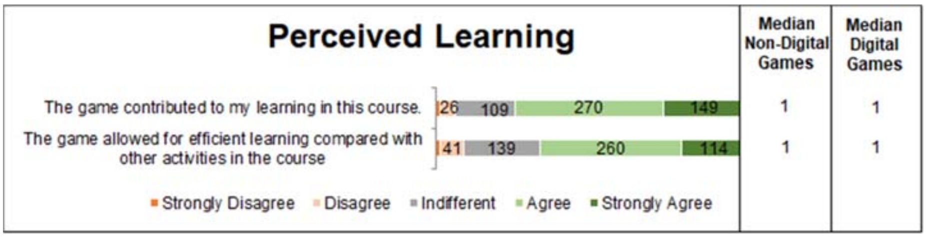

Figure 15: Frequency diagram of the Perceived Learning considering the 562 responses

AQ4: Is there a difference between the learning provided by digital and non-digital games used for SPM education?

Analysing the differences between the students' perceived learning provided by digital and non-digital games, no significant difference with respect to learning has been observed, as both platforms have been rated positive (Figure 15). This indicates that digital and non-digital games are an effective instructional strategy for the teaching SPM, even when compared to other activities in the course.

The learning objectives of each game were also evaluated by the students (Table 2). The measurement instrument items to measure the students' perception of achievement of the learning objectives are customized in accordance with the learning objectives of each evaluated game. The measurement instrument items to evaluate the learning objectives adopt the same scale as used by the other items (ranging from -2 (strongly disagree) to 2 (strongly agree)) and their results are presented by the median.

In general, all the educational games applied for teaching SPM were evaluated positively, indicating a perception by the students that the games achieved their learning objectives. However, although no significant difference has been identified with respect to the achievement of the learning objectives when comparing digital and non-digital games, a slightly more positive evaluation of non-digital games has been observed, especially by the games Dealing with Difficult People, Ball Point Game, and PMDome. The learning objectives of these games are to motivate the students with respect to the importance of planning in SPM and to develop soft skills such as teamwork, communication, and team management. These games may have been evaluated more positively by the students by developing, in a playful way, important skills for computing students.

Game	Learning Objectives	Median
Non-Digital Games		
PMDome	The game contributed to recognize the importance of management (of material, team, time, risks, etc.).	2
Risk Management Game	The game contributed to recognize the importance of risk management.	1
PM Master	The game contributed to reinforce and establish the concepts about the groups of processes of project management (initiation, planning, etc.).	1
	The game contributed to reinforce and establish the concepts about the knowledge areas of project management (scope, time, cost, etc.).	1
Detective Game	The game contributed to understand the technique of earned value management.	1
	The game contributed to apply in practice the technique of earned value management.	1
	The game contributed to understand the processes of monitoring and control.	1
SCRUMIA	The game contributed to recall the concepts from sprint planning.	1
	The game contributed to recall the concepts from monitoring a sprint.	1
	The game contributed to recall the concepts from a sprint review meeting.	1
	The game contributed to remember what the taskboard is.	1
	The game contributed to differentiate the roles, meetings, and artefacts involved in a sprint planning.	1
	The game contributed to differentiate the roles, meetings, and artefacts involved in a monitoring of a sprint.	1
	The game contributed to differentiate the roles, meetings, and artefacts involved in a sprint review meeting.	1
	The game contributed to differentiate the organization structure of the taskboard.	1
	The game contributed to practice the sprint planning.	1
	The game contributed to practice the monitoring of a sprint.	1
	The game contributed to practice the Sprint review meeting.	1
	The game contributed to practice the organization of a taskboard.	1
Ball Point Game	The game contributed to recognize the importance of teamwork to achieve the goals.	2
	The game contributed to recognize the importance of the re (organization) in a work team.	2
	The game contributed to recognize the importance of communication in a work team.	2
	The game contributed to recognize the importance of evaluation of the work for its continuous improvement.	2
Dealing with difficult people	The game contributed to recognize the difficulties posed by the different personalities that may exist in a work team.	2
	The game contributed to recognize how the personality of a team member influences the teamwork productivity.	2
	The game contributed to recognize the importance of knowing how to manage the different personalities of the members in a work team.	1
	The game contributed to recognize the importance of communication within a team when it comes to generating ideas.	2
Digital Games		
PMQuiz	The game contributed for review the knowledge of scope planning	1
QuizGame	The game contributed to recall concepts about risk management taught so far.	1
	The game contributed to clarify the information needed to answer the questions about risk management.	1
	The game contributed to understand the proposed questions about risk management.	1
	The game contributed to distinguish my knowledge applied in the responses on risk management.	1
SCRUM'ed (Schneider,	The game contributed to understand the roles involved in Scrum (Scrum master, development team, and product owner).	1

2015)	The game contributed to understand the ceremonies involved in Scrum (sprint planning, daily scrum, and sprint review).	1
	The game contributed to understanding the artefacts involved in Scrum (product backlog, sprint backlog, burndown chart, taskboard).	1
ProDec	The game contributed to recall the concepts to develop a project plan.	1
	The game contributed to understand the concepts to develop a project plan.	1
	The game contributed to apply the concepts to develop a project plan.	1
	The game contributed to recall the concepts to perform the size estimation of a software project using the technique of function points.	1
	The game contributed to understand the concepts to perform the size estimation of a software project using the technique of function points.	1
	The game contributed to apply the concepts to perform the size estimation of a software project using the technique of function points.	1
	The game contributed to recall the relevance to select a good project team.	1
	The game contributed to understand the relevance to select a good project team.	1
	The game contributed to recall the concepts of PERT diagrams to plan the project tasks.	1
	The game contributed to understand the concepts of PERT diagrams to plan the project tasks.	1
	The game contributed to apply the concepts of PERT diagrams to plan the project tasks.	1
	The game contributed to recall the concepts to perform a quantitative analysis of the project risks.	1
	The game contributed to understand the concepts to perform a quantitative analysis of the project risks.	1
	The game contributed to apply the concepts to perform a quantitative analysis of the project risks.	1
	The game contributed to recall the concepts of the earned value analysis for controlling and monitoring a project.	1
	The game contributed to understand the concepts of the earned value analysis for controlling and monitoring a project.	0
	The game contributed to apply the concepts of the earned value analysis for controlling and monitoring a project.	0
	The game contributed to recall the influence of the personality of the team members in the productivity of the project team (synergy).	1
	The game contributed to understand the influence of the personality of the team members in the productivity of the project team (synergy).	1
	The game contributed to recall the influence of the skill of the team members in the productivity of the project team (experience).	1
	The game contributed to understand the influence of the skill of the team members in the productivity of the project team (experience).	1
	The game contributed to recall the influence of the motivation of the team members in the productivity of the project team (motivation).	1
	The game contributed to understand the influence of the motivation of the team members in the productivity of the project team (motivation).	1
	The game contributed to apply the concepts related to the factors that influence in the productivity of the Project Team (motivation, synergy, experience) in order to select a good Project Team.	1

Table 2: Evaluation of the learning objectives

5 Discussion

The results obtained from the comprehensive analysis of the evaluation of 11 different SPM games provide evidence that games can yield a positive contribution to the learning of SPM based on the students' perception and provide a positive experience to the players.

Regarding the experience promoted by the games, we observed that in contrast to passive learning strategies (*e.g.* traditional lectures), which are instructor-centred and, often let students to get distracted from the learning tasks [Cui, 13], games can promote an engaged experience to the players, stimulating their motivation and active participation in the learning tasks, providing an environment of cooperation and social interaction.

Most of the evaluated games presented a positive evaluation with respect its usability, been indicated by the students as to easy to play, with an attractive design, and that their rules are clear and easy to understand. This result can be observed slightly more positive in digital games. One possible explanation for this result, as observed by the instructors, may be the fact that in digital games the rules are, typically, explained in a self-explanatory way, during the game play, making this step easier for the students, not requiring the intervention of an instructor to explain the games' rules. However, a main weakness of the evaluated digital games is the accessibility, due to the fact that the evaluated games do not allow the customization of its appearance in accordance with the players' needs. This result indicates that the accessibility needs to be improved in digital games, in order to promote the inclusion of all students respecting their special preferences.

Our results also indicated that both, digital and non-digital games, promoted a feeling of confidence, relevance, and satisfaction to the students, indicating that they were learning while playing. These results directly contribute to the students' motivation, creating conditions that will stimulate students desire to be interested and involved in the learning tasks [Keller, 87].

Regarding the challenges provided by the games, although most of the students also indicated that the games are challenging, 17% of the participants indicated that the games' activities were monotonous. Based on the instructors' perceptions, an example for this result may be the PMDome game, in which in the first game task the students have to create 65 paper tubes to create a Geodesic Dome, being considered a repetitive task by the participants.

Social interaction and fun were the most positively evaluated factors of both digital and non-digital games, indicating that the games contribute to the cooperation and competition among the players, also confirming that the students had fun with others during the game. This behaviour could be observed by the instructors during the applications of the games, especially when playing non-digital games (*e.g.* PM Master, SCRUMIA, and Risk Management Game), which happened in a very engaging way, providing a sense of shared environment. Instructors also reported that in several cases the interaction during the game session motivated a continuation of a closer interaction between the students outside the class. This emphasises how strongly the elements of cooperation and competition in games captures the involvement of the students, contributing to their motivation in perform the game tasks, representing learning tasks. These observations confirm similar previous results that also indicate that competition and motivation contribute to the students' learning [Cagiltay, 15].

In general, analysing the main similarities when comparing the experience provided by digital and non-digital games, we observed that both platforms present similar positive results in terms of confidence, satisfaction, challenge, social interaction, fun, and relevance. These similarities show that students, although playing more often digital games, have felt a positive and relevant experience playing digital and non-digital games. This may be an indication that both digital and non-digital educational games may be an active instructional strategy that contributes positively to the students' experience in teaching SPM. In addition, our results also indicate that these aspects may provide positive results when considered by game creators in the development of new educational games.

On the other hand, we can observe that the usability and focused attention are the main differences between digital and non-digital games. While the usability has been rated as more positive in digital games, mainly in terms of ease of learning to play and attractive design, non-digital games seem to promote a slightly more positive focused attention on students, creating an environment of immersion and concentration of the students in the learning tasks.

Regarding the perception of learning provided by the games, the students expressed that the both digital and non-digital games contributed positively to their learning. And, in terms of the learning objectives of the evaluated games, which typically aimed to review and/or reinforce SPM concepts as presented in the games PM Master, PMQuiz, and QuizGame, or to simulate the SPM concepts and practices as presented in the games ProDec and SCRUMIA, students indicated that, in general, the learning objectives of the evaluated games were positively achieved by games of both platforms, with a slightly more positive evaluation of non-digital games.

In summary, the results of our study are an indication that games used as a complementary instructional strategy for teaching SPM can contribute to the students' learning from their perception, besides being an instructional strategy that provides a pleasant and engaging experience to the students. In addition, our study provides evidence that when aspects such as challenge, usability, confidence, satisfaction, social interaction, fun, and relevance are considered in the selection of educational games for SPM education, they can promote an engaging experience and contribute positively to students' perceptions of learning.

Our results indicating the benefits of digital and non-digital games for teaching SPM, can also be related to others computing knowledge areas, confirming the results of similar researches indicating the effectiveness and/or contributions of games in areas such as Software Engineering [Caulfield, 11; Kosa, 16; Petri, 17c] and Programming [Battistella, 17; Santos, 18].

5.1 Threats to validity

Due to the characteristics of this research, this work is subject to various threats to validity. We, therefore, identified potential threats and applied mitigation strategies in order to minimize their impact on our research.

Some threats are related to the research design [Wohlin, 12]. Considering the context of this study, the evaluation of a game should be performed quickly and a non-intrusive way, not interrupting the normal flow of the class. Therefore, we decided to conduct a series of case studies that allow an in-depth study of an individual, group or event [Wohlin, 12; Yin, 17]. Experiments, on the other hand, would cause a major disruption in class, and require the definition of control groups that may be impaired by using alternative teaching methods considered inferior. And in order to obtain significant statistical results from such an experiment, a considerable sample is required [Sitzmann, 10]. However, this may not be feasible due to the small number of students commonly enrolled in computing courses [Bowman, 18].

Another risk refers to the reliability and validity of the data collected in the case studies. To minimize this risk, all case studies were conducted adopting the MEEGA+ games' evaluation model, a systematically developed model widely evaluated in terms of validity and reliability [Petri, 16b; Petri, 18].

Another threat refers to the evaluation of learning. Adopting a non-experimental research design (case studies), only a post-test was applied in order to evaluate the students' perceived learning. A pre-test, typically used in experiments, was not applied and, therefore, it was not possible to accurately identify how much each student learned about the SPM contents covered in the games. Regarding the self-assessment, although no consensus is reached, several studies provide evidence that self-assessment can provide reliable and valid information [Ross, 06; Andrade, 09; Thomas, 11; Brown, 15; Sharma, 16], especially when using reliable and valid measurement instruments [Brown, 15]. Therefore, in order to minimize this limitation, a compromise may be the use of the standardized and statistically validated measurement instruments provided by the MEEGA+ model increasing the validity and reliability of the data being collected [Wohlin, 12].

Another risk refers to students providing a better evaluation of a game in order to receive a better grade in the course. However, all case studies were conducted by one of the authors, who does not participate of the students' assessment in the respective course, thus minimizing this risk.

In terms of external validity, the generalization of the results may be threatened due to the research method adopted, a small sample size and/or lack of diversity of the data. However, using data collected from 27 case studies evaluating 11 different games for SPM education with a population of 562 students, we consider this a satisfactory sample size allowing the generation of significant results [Sitzmann, 10]. Although the focus of this article is the SPM education, all evaluated games aim at learning objectives to develop a competence in the computing education context. Furthermore, the data has been obtained from game applications in 6 different institutions/contexts. Yet, as the data collection was restricted to the evaluations of games using the MEEGA+ model, the majority of the data has been collected from Brazilian institutions, where it is used more prominently, with only five case studies from an institution in Spain. In terms of the research method adopted, all evaluations were conducted under the supervision of one of the authors, in order to follow the defined research method in similar conditions in the conduction of the case studies. In addition, all game sessions and evaluations were conducted using the native language (Brazilian Portuguese or Spanish), under supervision of one of the authors (native speaker), also adopting the Brazilian Portuguese or Spanish version of the MEEGA+ measurement instrument. Although the study involved students from different institutions, all students are in similar context (enrolled in a SPM course in higher computing education) and most of them (75% of the students) are in the same age group (18 to 28 years).

In terms of reliability, a threat refers to the extent to which the data and the analysis are dependent on the specific researchers. In order to mitigate this threat, we followed a systematic methodology, defining clearly the study objective, the process of data collection, and data analysis.

6 Conclusions

In order to obtain a more comprehensive understanding of the benefits of games used for SPM education, we conducted a series of case studies evaluating digital and non-digital games. The results from our analysis of 27 case studies of 11 different SPM games involving 562 students, provide evidence that digital and non-digital games can yield a positive effect on learning of SPM based on the students' perceptions, providing a pleasant and engaging experience to computing students, especially, in terms of relevance, social interaction, and fun. Thus, results of our study provide evidence that games can be a positive and engaging instructional strategy for SPM education, which promote feelings of pleasure, happiness, and distraction in an engaging learning environment, encouraging cooperation and sharing of ideas among the students.

Comparing digital and non-digital games used for SPM education, a slightly higher usability degree was observed in digital games due to the easiness to learn how to play, as the self-explanatory way of digital games may be easier to understand. Our data also indicate that both platforms contribute positively to the students' learning, yet, the achievement of the learning objectives of non-digital games has been slightly more positive. This demonstrates that non-digital games can also be an effective alternative instructional strategy for teaching SPM, especially with limited resources available for the game development, as on the other hand the development of digital games, typically, requires a larger effort with higher costs.

Therefore, the results of our study provide systematic evidence of the positive benefits of games for teaching SPM. To further extend this research, we plan to explore the evaluation of educational games with other games in different contexts, analysing the contributions of educational games also to other computing knowledge areas. In addition, we are currently conducting an experimental study that aims to analyse the effectiveness of games for an SPM course, in comparison with other SPM course that not adopts games.

Acknowledgements

We would like to thank all the students and instructors that accepted participate in the applications of the games.

This work was conducted during a visiting scholar period at University of Cádiz, sponsored by the CAPES (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*) foundation of the Ministry of Education, Brazil (grant n. 88881.131485/2016-01) and the CNPq (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*), an entity of the Brazilian government focused on scientific and technological development (grant no. 302149/2016-3). This work was also funded by the Spanish National Research Agency (AEI) with ERDF funds under project BadgePeople (TIN2016-76956-C3-3-R) and the Andalusian Plan for Research, Development and Innovation (grant TIC-195).

References

[ACM, 13] ACM/IEEE-CS.: Computer Science Curricula 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science, 2013. Available on: <https://www.acm.org/education/CS2013-final-report.pdf> Access: 06 Feb. 2018.

[Abt, 02] Abt, C.C.: Serious Games. Lanhan, MD: University Press of America, 2002.

[Akili, 06] Akili, G. K.: A New Approach in Education. In D. Gibson, C. Aldrich, M. Prensky (Eds.), Games and Simulations in Online Learning: Research and Development Frameworks, pp. 1-20, Information Science Publishing, 2006.

[All, 16] All, A., Castellar, E. P. N., Looy, J. V.: Assessing the effectiveness of digital game-based learning: Best practices, Computers & Education, 92–93, 90-103, 2016.

[Andrade, 09] Andrade, H., Valtcheva, A.: Promoting learning and achievement through self-assessment. Theory into Practice, 48, 12-19, 2009.

[Backlund, 13] Backlund, P., Hendrix, M.: Educational games - Are they worth the effort? A literature survey of the effectiveness of serious games, Proc. of the 5th Int. Conf. on Games and Virtual Worlds for Serious Applications, Poole, GB, 2013.

[Barnes, 08] Barnes, T., Powell, E., Chaffin, A., Lipford, H.: Game2Learn: improving the motivation of CS1 students. Proc. of the 3rd International Conference on Game Development in Computer Science Education, pp. 1-5. New York, USA, 2008.

[Basili, 94] Basili, V. R., Caldiera, G., Rombach, H. D.: Goal, Question Metric Paradigm. In J. J. Marciniak, Encyclopedia of Software Engineering, pp. 528-532, Wiley-Interscience, New York, NY, USA, 1994.

[Battistella, 16] Battistella, P., Wangenheim, C. G.: Games for Teaching Computing in Higher Education – A Systematic Review. IEEE Technology and Engineering Education (ITEE) Journal, 9(1), 8-30, 2016.

[Battistella, 17] Battistella, P. E., Gresse von Wangenheim, C., von Wangenheim, A., Martina, J. E.: Design and Large-scale Evaluation of Educational Games for Teaching Sorting Algorithms. Informatics in Education, 17(2), 141-164, 2017.

[Bourque, 14] Bourque, P., Fairley, R. E.: Swebok v3.0 Guide to the software engineering body of knowledge. IEEE Computer Society, 2014.

[Bowman, 18] Bowman, D. D. (2018). Declining Talent in Computer Related Careers. Journal of Academic Administration in Higher Education, 14(1), 1-4.

[Boyle, 11] Boyle, E. A., Connolly, T. M., Hainey, T.: The role of psychology in understanding the impact of computer games. Entertainment Computing, 2, 69–74, 2011.

[Boyle, 16] Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C., Pereira, J.: An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. Computers & Education, 94, 178-192, 2016.

[Brown, 15] Brown, G., Andrade, H., Chen, F.: Accuracy in student self-assessment: Directions and cautions for research. Assessment in Education Principles Policy and Practice, 22(4), 1-26, 2015.

[Calderón, 13] Calderón, A., Ruiz, M.: ProDec: a serious game for software project management training. Proc. of the 8th International Conference on Software Engineering Advances, pp. 565-570. Venice, Italy, 2013.

[Calderón, 15] Calderón A., Ruiz M.: A systematic literature review on serious games evaluation: An application to software project management, Computers & Education, 87, 396-422, 2015.

[Cagiltay, 15] Cagiltay, N. E., Ozcelik, E., Ozcelik, N. S.: The effect of competition on learning in games, Computers & Education, 87, 35-41, 2015.

[Caulfield, 11] Caulfield, C., Xia, J., Veal, D., Maj, S. P.: A systematic survey of games used for software engineering education, Modern Applied Science, 5(6), 28-43, 2011.

[Connolly, 12] Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., Boyle, J. M.: A systematic literature review of empirical evidence on computer games and serious games, Computers & Education, 59(2), 661-686, 2012.

[Cui, 13] Cui, Y.: An Empirical Study of Learning Outcomes Based on Active Versus Passive Teaching Styles, Journal of Education and Management Engineering, 3(1), 39-43, 2013.

[Dempsey, 96] Dempsey, J., Rasmussen, K., Lucassen, B.: The instructional gaming literature: Implications and 99 sources. Technical Report 96-1. College of Education, University of South Alabama, AL, 1996.

[Garris, 02] Garris, R., Ahlers, R., Driskell, J. E.: Games, motivation, and learning: A research and practice model. Simulation Gaming, 33(4), 441-467, 2002.

[Gibson, 13] Gibson, B., Bell, T.: Evaluation of games for teaching computer science, Proc. of the 8th Workshop in Primary and Secondary Computing Education, pp. 51-60, New York, NY, USA, 2013.

[Geist, 07] Geist, D. B., Myers, M. E.: Pedagogy and project management: Should you practice what you preach. Journal of Computing Sciences in Colleges, 23(2), 202–208, 2007.

[Gloger, 17] Gloger, B.: Ball Point Game. Available at: <https://borisgloger.com/wp-cotent/uploads/2016/08/Ball_Point_Game.pdf> Access: 27 November 2017.

[Gresse von Wangenheim, 09] Gresse von Wangenheim, C., Shull, F.: To Game or Not to Game? Software, IEEE, 26(2), 92-94, 2009.

[Gresse von Wangenheim, 12] Gresse von Wangenheim, C.: PM Master. Available at: <http://www.gqs.ufsc.br/pm-master/> Access: 06 February 2018.

[Gresse von Wangenheim, 13a] Gresse von Wangenheim, C., Savi, R., Borgatto, A. F.: SCRUMIA - An educational game for teaching SCRUM in computing courses. Journal of Systems and Software, 86(10), 2675-2687, 2013.

[Gresse von Wangenheim, 13b] Gresse von Wangenheim, C., Carvalho, O. P., Battistella, P. E.: Ensinar a Gerência de Equipes em Disciplinas de Gerência de Projetos de Software. Revista Brasileira de Informática na Educação, 21(1), 15-22, 2013 (in Portuguese).

[Gresse von Wangenheim, 14] Gresse von Wangenheim, C., Rausis, B., Soares, G., Savi, R., Borgatto, A. F.: Project Detective a Game for Teaching Earned Value Management. International Journal of Teaching and Case Studies, 5(3/4), 216-234, 2014.

[Hamari, 16] Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., Edwards, T.: Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. Computers in Human Behavior, 54, 170-179, 2016.

[Hays, 05] Hays, R.T.: The Effectiveness of Instructional Games: A Literature Review and Discussion, Naval Air Warfare Center Training System Division, Orlando, FL, USA, 2005.

[Hussein, 15] Hussein, B. A.: A Blended Learning Approach to Teaching Project Management: A Model for Active Participation and Involvement: Insights from Norway. Education Sciences, (5), 104-125, 2015.

[Ibrahim, 11] Ibrahim, R., Yusoff, R. C. M., Omar, H. M., Jaafar, A.: Students perceptions of using educational games to learn introductory programming. Computer and Information Science, 4(1), 205–216, 2011.

[Kosa, 16] Kosa, M., Yilmaz, M., O'Connor, R., Clarke, P.: Software engineering education and games: a systematic literature review. Journal of Universal Computer Science, 22(12), 1558-1574, 2016.

[Keller, 87] Keller, J. M.: The systematic process of motivational design. Performance Inprovement, 26(9-10), 1-8, 1987.

[Kish, 94] Kish, L.: Multipopulation survey designs: five types with seven shared aspects. International Statistical Review, 62(2), 167–186, 1994.

[Navarro, 07] Navarro, E. O., van der Hoek, A.: Comprehensive evaluation of an educational software engineering simulation environment. Proc. of the 20th Conference on Software Engineering Education & Training, pp.195-202. Dublin, Ireland, 2007.

[Ojiako, 11] Ojiako, U., Ashleigh, M., Chipulu, M., Maguire, S.: Learning and teaching challenges in project management. International Journal of Project Management, 29, 268–278, 2011.

[Olgun, 17] Olgun, S., Yilmaz, M., Clarke, P., O'Connor, R.: A systematic investigation into the use of game elements in the context of software business landscapes: a systematic literature review. Proc. of the 17th International Conference on Software Process Improvement and Capability Determination, pp. 384-398. Palma de Mallorca, Spain.

[Petri, 16a] Petri, G., Gresse von Wangenheim, C.: How to evaluate educational games: a systematic literature review. Journal of Universal Computer Science, 22(7), 992-1021, 2016.

[Petri, 16b] Petri, G., Gresse von Wangenheim, C., Borgatto, A. F.: MEEGA+: An Evolution of a Model for the Evaluation of Educational Games. Technical report INCoD/GQS.03.2016.E, Version 1.0, INCoD/INE/UFSC, Florianopolis/Brazil, ISSN 2236-5281, 2016.

[Petri, 16c] Petri, G., Battistella, P. E., Cassettari, F., Gresse von Wangenheim, F., Hauck, J. C. R.: A Quiz Game for Knowledge Review on Project Management. Proc. of the 27th Brazilian Symposium on Informatics in Education. Uberlândia, MG, Brazil, 2016 (in Portuguese).

[Petri, 17] Petri, G., Gresse von Wangenheim, C.: How games for computing education are evaluated? A systematic literature review. Computers & Education, 107, 68-90, 2017.

[Petri, 17b] Petri, G., Gresse von Wangenheim, C., Borgatto, A. F.: A Large-scale Evaluation of a Model for the Evaluation of Games for Teaching Software Engineering. Proc. of the IEEE/ACM 39th Int. Conf. on Software Engineering: Software Engineering Education and Training Track, pp. 180-189, Buenos Aires/Argentina, 2017.

[Petri, 17c] Petri, G., Gresse von Wangenheim, C., Borgatto, A. F.: Quality of Games for Teaching Software Engineering: An Analysis of Empirical Evidence of Digital and Non-digital Games. Proc. of the IEEE/ACM 39th Int. Conf. on Software Engineering: Software Engineering Education and Training Track, pp. 150-159, Buenos Aires/Argentina, 2017.

[Petri, 18] Petri, G., Gresse von Wangenheim, C., Borgatto, A. F.: MEEGA+, Systematic Model to Evaluate Educational Games. In Newton Lee (Eds) Encyclopedia of Computer Graphics and Games. Springer, Cham, pp. 1-7, 2018.

[Pfahl, 01] Pfahl, D., Ruhe, G., Koval, N.: An Experiment for Evaluating the Effectiveness of Using a System Dynamics Simulation Model in Software Project Management Education, Proc. of the 7th Int. Symposium on Software Metrics, pp.97-109, London, GB, 2001.

[PMDome, 17] PMDome. (2017). PMDome Workshop. Available at: <https://ricardo-vargas.com/pt/workshops/pmdome/> Access: 27 November 2017.

[PMI, 13] PMI – Project Management Institute, A Guide to the Project Management Body of Knowledge, 5. ed., Newtown Square, 2013.

[Prensky, 07] Prensky, M.: Digital Game-Based Learning. New York: Paragon House, 2007.

[Ross, 06] Ross, J. A.: The reliability, validity, and utility of self-assessment. Practical Assessment, Research & Evaluation, 11(10), 1-13, 2006.

[Santos, 18] Santos, A. L., Souza, M. R. A., Figueiredo, E., Dayrell, M.: Game Elements for Learning Programming: A Mapping Study. Proc. of the 10th Int. Conf. on Computer Supported Education, (pp. 89-101). Funchal, Portugal, 2018.

[Savi, 11] Savi, R., Gresse von Wangenheim, C., Borgatto, A. F.: A model for the evaluation of educational games for teaching software engineering. Proc. of the 25th Brazilian Symposium on Software Engineering, (pp. 194-203). São Paulo, Brazil, 2011 (in Portuguese).

[Sharma, 16] Sharma, R., Jain, A., Gupta, N., Garg, S., Batta, M., Dhir, S. K.: Impact of self-assessment by students on their learning. International Journal of Applied and Basic Medical Research, 6(3), 226–229, 2016.

[Schneider, 15] Schneider, M. F.: SCRUM'ed: Um jogo de RPG para ensinar Scrum. Undergraduate thesis. Federal University of Santa Catarina, Florianópolis, SC, Brazil, 2015 (in Portuguese).

[Sitzmann, 10] Sitzmann, T., Ely, K. Brown, K. G., Bauer, K. N.: Self-Assessment of Knowledge: A Cognitive Learning or Affective Measure? Academy of Management Learning & Education, 9(2), 169-191, 2010.

[Thomas, 11] Thomas, G., Martin, D., Pleasants, K.: Using self- and peer-assessment to enhance students' future-learning in higher education. Journal of University Teaching & Learning Practice, 8(1), 1-17, 2011.

[Tonussi, 17] Tonussi, L. P., Hauck, J. C. R.: Um Módulo de Jogo de Perguntas e Respostas para apoio ao Ensino de Gerência de Projetos Integrado ao Moodle. Proc. of the Conference Computer on the Beach, pp. 100-109, Florianópilis/SC, Brazil, 2017 (in Portuguese).

[Trochim, 08] Trochim, W. M., Donnelly, J. P.: Research methods knowledge base (3rd ed.). Mason, OH: Atomic Dog Publishing, 2008.

[Wiebe, 14] Wiebe, E. N., Lamb, A., Hardy, M., Sharek, D.: Measuring engagement in video game-based environments: Investigation of the User Engagement Scale. Computers in Human Behavior, 32, 123-132, 2014.

[Wohlin, 12] Wohlin, C., Runeson, P., Höst, M., Ohlsson, M.C., Regnell, B., Wesslén, A.: Experimentation in Software Engineering, Springer-Verlag Berlin Heidelberg, 2012.

[Yin, 17] Yin, R. K.: Case study research: Design and methods (6th ed.). Sage Publications, Inc., 2017.