Proceedings of the Federated Conference on Computer Science and Information Systems pp. 995–1004
DOI: 10.15439/2018F300
ISSN 2300-5963 ACSIS, Vol. 15

What Can Go Wrong in a Software Project? Have Fun Solving It

Miguel Ehécatl Morales-Trujillo
University of Canterbury,
Christchurch, New Zealand
miguel.morales@canterbury.ac.nz

Gabriel Alberto García-Mireles
Universidad de Sonora,
Hermosillo, Sonora, México
mireles@mat.uson.mx

Polina Maslova
Universidad Nacional Autónoma de
México, Ciudad de México, México
pmaslova@comunidad.unam.mx

***Abstract* — Providing stimulating and real-life experiences is a key component in teaching software project management in Computer Science or Software Engineering programs. The diversity of topics that need to be addressed and restrictions that should be considered in university courses make a challenging task of it. This paper presents a serious game, called "White Crow PM" whose objective is to make students aware of the risks they might face during software development projects. The paper describes the game design steps and provides results of its validation in Computer Science programs in two Mexican universities. The collected data showed that the participants had fun playing the game and its content is relevant for software project management courses. Although the game needs to be validated in other settings with more participants, we conclude that it fulfills the goal of motivating discussion and increasing awareness of project management concerns among students.**

I. Introduction

DEVELOPING software systems require organizations to implement appropriate software project management practices. Industrial standards, such as ISO/IEC 12207 [1] or ISO/IEC 29110 [2], include specific processes to address activities and tasks for planning, monitoring, and controlling a software project. Indeed, software project management activities represent a core knowledge area in Software Engineering (SE) [3] and teaching them is supported by organizations such as IEEE and ACM through guidelines for curricula development [4].

SE curricula guidelines recommend students carry out activities in which they develop projects for a real client or get involved in software development during professional training [4]. However, in the area of software project management, a future IT professional lacks practical skills given that most project management syllabi are highly theoretical [5]. In addition, to understand technical challenges, software professionals also need to understand nontechnical issues such as management, communication and teamwork [4] [6].

In contrast with current practice of teaching SE topics by means of lectures, addressing these topics in SE courses require learning strategies that promote application and transfer of knowledge to authentic contexts where knowledge supports making decisions in real-life scenarios [7]. Furthermore, other constraints, such as class duration and instructor's effort impact on the extent project management practices can be carried out in either real or simulated scenarios [6] [8].

An attractive approach to address the aforementioned issues, within a risk-free environment, is the use of games with learning objectives as outcomes [5]. Educational games, also known as *serious games*, pursue the purpose of teaching, changing an attitude or behavior, or creating awareness of a certain issue [9].

Games offer enjoyment, motivation, social interaction and gratification; factors that support learning process [10]. Besides, serious games provide a variety of approaches for learning and teaching, becoming a complimentary tool to achieve specific learning outcomes [6]. According to [11], using games motivates students, immerses them in learning materials and supports learning from their own mistakes.

Several serious games have been proposed to achieve learning goals in SE. They address knowledge areas such as software process, software design, and professional practice [6]. However, few serious games proposals have been evaluated in the computer science domain and even less in software project management [5]. Therefore, given the complexity of SE topics, specificities of teaching SE in universities, and the variety of domains related to software project practices, there is a necessity to explore the advantage of using serious games in supporting SE related learning outcomes.

Serious games can be classified as digital or non-digital. While the former might be a computer application game, the latter might include card games and board games, among others [5]. Board games, in particular, are easy to use, allow interactivity between players, and provide a platform to carry out frequent and inexpensive updates [10].

This paper presents a board game whose objective is to make students aware of risks they might face during a software project and practices they can apply to mitigate them. The board game simulates an environment of a small organization carrying out a software project during a month. The game is targeted to undergraduate students in Computer Science and SE programs who already have introductory knowledge of project management.

This paper is organized as follows, Section II presents the concept of serious games and project management board games. Section III presents White Crow, the original board game. The adapted board game and its validation are

described in Sections IV and V respectively. Finally, conclusions and future work are presented in Section VI.

II. Background

A. Serious Games in Software Engineering

A game is defined as "an activity engaged in for diversion or amusement" [12] as well as "an activity…usually involving skill, knowledge, or chance, in which you follow fixed rules and try to win against an opponent or to solve a puzzle" [13]. While preserving the element of entertainment, a serious game focuses on achieving learning outcomes or educational goals, such as learning specific skills and concepts [6].

The increasing use of serious games inject more fun in both learning and training context due to the power of game to motivate players and the capabilities of them to facilitate cognitive gain, awareness and behavioral change [14]. The use of games on different educational levels has been demonstrated to motivate players to achieve goals, to stimulate interaction, and to encourage players to learn by doing, among other benefits [15]. Although digital games provide a lot of opportunities to incorporate multimedia resources to improve the user experience, they can be prototyped in paper [16].

Thus, working with non-digital games, such as board games, provides the opportunity to explore and gather the initial ideas on the game by the developer team and other stakeholders. In addition, learning from one another while at the same time having fun are experiences that a board game can provide [15].

In the context of SE, the use of games is motivated by the fact that traditional lectures barely address in practical way real life experiences where students make decisions and explore scenarios [6] [10]. Limitations on time or students' availability for participating in software projects are challenges that make deployment of software practices in real-life contexts difficult [6]. Indeed, providing real life experience in managing projects becomes almost impossible in SE education [6].

There is a growing presence of studies related to serious games in SE. Souza et al. [6] reported 86 papers that describe the use of serious games in SE education, and whose learning goals are related to the knowledge areas of software process, software design and professional practice. However, the authors do not decompose the 'software process' category in order to identify studies related to software project management. In a literature review on serious games in education, Calderón and Ruiz [5] reported that only 10% of papers correspond to the Computer Science domain and only two papers present games related to software project management.

B. Board Games for Project Management

Board games support understanding and learning of abstract concepts; their immersive nature facilitates attention, concentration and motivation [17]. Board games allow a learning-by-doing approach; in addition, game competitiveness urges players deeply understand the rules behind the game, and promotes reflection and discussion among players [17].

However, board games for project management are barely addressed in the education domain [5] [18]. Telukunta et al. [19] developed a game called StrateJect, which is similar in design to the Monopoly game. It is a computer game in which players experience consequences of executing or neglecting important project management functions in alignment with PMBoK 5 concepts. Taran [10] proposed a risk management board game in which students gather experience in making decisions involving risks. The game does not include teaching specific practices for risk management because it expects students to learn by their own experience.

Another board game is Deliver! [8]; its objective is to reinforce and teach the application of earned value management concepts targeted to students in undergraduate computing programs. In addition to the perceived potential to learn earned value management concepts and procedures, the game is reported to have a positive effect on social interaction, engagement, immersion, attention and relevance to the course objectives [8].

Other proposals address games for either training software practitioners in daily scrum meetings or learning software processes. In the first case, Yilmaz [20] provides a case study in which the focus is on identifying issues in testing scenarios related to the way a daily scrum meeting is conducted. Within a virtual reality environment, learners interact with virtual personas that have distinct personalities traits in order to trainees get clues about the issue presented in a scenario.

With regard to software processes, Aydan et al. [18] proposed a serious game, called "Floors", to introduce a preliminary training about both vocabulary and processes of the ISO/IEC 12207. The game was designed to visualize a virtual office environment and 3D character models that explain definitions and activities of the processes. Based on quests and dialogues, players can follow the processes organized by a software life cycle model.

C. Evaluating a Serious Game

The primary method to assess a serious game is a questionnaire that is typically applied after the game is played [5]. Questionnaires may include both quantitative and qualitative questions, however, the Likert scale is the most common method to gather participants' perceptions of the game [5]. Students' perceptions are measured by such variables (constructs) as belief, motivation state, expectations and emotions [8]. Actually, "evaluation from student's perceptions represents a simple, quick and less intrusive alternative to obtain feedback" [8].

We used a questionnaire from Wangenheim et al. [8], which focuses on evaluating students' feeling after playing a serious game; we adapted this standardized questionnaire and added concepts from the Kirkpatrick's evaluation model [21]. Altogether the questionnaire assesses motivation, game user experience, learning aspects, and students' perceptions.

Observation is another method used to evaluate serious games [5]. Observations are carried out by facilitators who observe game sessions either to get a general impression or to monitor any particular aspect of interest.

Several aspects can be evaluated in a serious game. Calderón and Ruiz [5] report that learning outcomes, usability and user experience are the most commonly evaluated. The first aspect refers to what learners should know or be able to do as a result of playing a serious game. Usability evaluates both ease of use and learnability while user experience assesses behavior, attitude and emotions.

Other commonly assessed aspects are user's satisfaction (user's attitude towards the serious game), motivation (how the serious game influences users' attention and behavior towards learning outcomes), and enjoyment (whether the serious game is able to provide a fun experience), among others [5].

There are few frameworks to design and evaluate a serious games [16] [22] [23] where mechanics-dynamics-aesthetics (MDA) model is a relevant one. Hunicke et al. [24] proposed this model to understanding games considering both designer and player perspectives in the context of three levels of abstraction: mechanics, dynamics, and aesthetics. The game creators design the mechanics of the game in order to provide a player experience, while player address the game from the aesthetics of the game, i.e., the user experience of playing the game. The model can support the specification of design goals, provides a means to discover game enhancement opportunities and allow to determine the measures to assess the progress in an improvement effort.

The MDA abstractions levels are described as follows [24]. Mechanics defines the game components, including actions, behaviors and control mechanisms. Some game mechanics are levels, tokens, questions and answers, game turns, resource management, and movement [23]. On the other hand, dynamics focused on the behavior of the game considering inputs and outputs. This abstraction level works at systemic level in order to create aesthetic experiences. The aesthetics level is related to the emotional responses of the players when interact with the game. This level can include a fun vocabulary composed of concepts such as: sensation, fantasy, narrative, challenge, fellowship, discovery, and expression.

D. Agile and Lean Approaches for Teaching Project Management by Means of Serious Games

Several games have been proposed to learn principles and practices of lean and agile methods in managing a software project. For lean approaches, Przybylek and Olszewski [25] proposed a game-based extension to Open Kanban. They suggested 12 games to address the four principles: visualization of the workflow, learn and improve, limit work in progress and lead using a team approach. As a result of validating the game-extension of Open Kanban, authors reported improvements in participants' communication, commitment, motivation, and the teams understood the main values and practices of Open Kanban [25]. Another proposal presented a collaborative Kanban board game for a software project management course [26]. The game's learning goals addressed both general description of the Kanban process and detailed aspects of the relationship between work in progress limits, lead time, and bottlenecks. The empirical results showed that learning goals were partially achieved. As for the attitudes towards the game, the participants' feedback reported a positive and highly motivating experience [26].

Incorporation of Scrum in the industrial sector has also been addressed. Several researchers have developed serious games to introduce and reinforce scrum practice. For instance, Przybylek et al. [27] [28] proposed to equip Scrum teams with a set of serious, collaborative games to address social aspects of software development. In turn, De Souza et al. [29] designed SCRUMI, an electronic serious board game for teaching Scrum concepts. In order to move forward through the game, participants have to answer questions on Scrum practices, which are grouped into five phases: preparation, analysis, execution, monitoring and control, and closing. Having evaluated the game, the authors reported that students felt motivated, satisfied and had fun playing the game [29].

SCRUMIA, on the other hand, is a manual paper and pencil game to reinforce the application of Scrum in undergraduate computing programs [30]. The game's main objective is to create artifacts while executing the Scrum process. In the validation results, the authors reported that SCRUMIA was effective, efficient and engaging for teaching Scrum practices [30]. Authors in [30] [31] mention several other games centered on different learning goals related to Scrum; however, despite the relevance of agile and lean methods, there is still a shortage of games addressing these topics [26].

III. WHITE CROW BOARD GAME

The board game presented in this paper is based on a Russian board game called Belaya Vorona (Белая ворона), which is White Crow in English. The label "white crow" in Russian describes a person who is different and stands out in the crowd; it may have a negative connotation similar to "black sheep". As the inventors of the game wrote, "try on the feathers of a white crow: break free and get individuality". The game was created in the post-soviet period, pursuing the idea of changing and embracing the world of business.

The game simulates a month of economic life with the objective of maintaining a healthy economic status by doing business. In the course of the game, the players are constantly affected by unexpected situations that impact their finances for the better or for the worse and, if they do not act accordingly, may result bankrupt.

The original board game consists of:

- A dice
- Five tokens
- A game board (see Fig. 1)
- Play money
- 64 mail cards
- 16 business cards
- A notepad for tracking loans and investments.

During the game, the players get familiar with such concepts of business and banking as investments, deposits, loans, rates, bank shares, clients, profits and expenses. It also shows the importance of risks, luck, enterprise and caution.

Fig. 1. Game board. Image taken from the original game Belaya Vorona produced by Design Studio Art Lestnitsa, Centre of Prospective Projects.

Each player decides their banking policy in advance: whether they will invest or ask for loans. Besides, at the beginning of each round, players receive an amount of money, with which they can buy businesses (square Бизнес "business") and cover unexpected expenses. Any business they own pays back in case the player gets on the square Клиент "client". The unexpected expenses are either laid out on the game board or come by mail (square Почта "mail"). Each month corresponds to one round, and the winner is the player who saves the biggest amount of money by the end of the game.

A business can be bought by any player who lands on the square Business. The player must take a business card and decide whether to use the opportunity or to discard it. For example, Fig. 2 shows a business card Subway "Falcon". If a player decides to invest in this business opportunity, she/he must pay 1,500 units of play money[1], which is indicated in the first upper line as плата "charge", to the bank.

The investment pays off when the player lands on the square Client. In the case of the card in Fig. 2, the lucky player receives 2,000 rubles as indicated in the second line by the word цена "price", thus obtaining a 500 rubles profit.

The third, bottom line комиссионные "commission" indicates the amount of money that is given to another player. To do so, all the players except the business card owner roll the dice, and the player with the highest points receives the "commission" money, 150 rubles in the case of Fig. 2 card. In the adapted version of the game, this transaction was omitted for reasons of simplification.

Fig. 2. Business card. Image taken from the original game Belaya Vorona produced by Design Studio Art Lestnitsa, Centre of Prospective Projects.

If a player lands on the square Mail, he/she must take a mail card and to act according to its instructions. In Fig. 3 mail card the player must pay 150 rubles, indicated in the left top corner as оплатить "to pay", to the bank for an emergency surgery the player had to undergo, which is explained in the right top corner of the card while the bottom of the card contains the name of the charging establishment.

We considered the White Crow board game to be suitable for adaptation due to its similarity with running a software project. The adapted game, White Crow PM, is based on simulating software project related activities and is meant to convey concepts of project management, risks and decision making. Similar to the original game, in the adapted version, players decide how to manage their money working on a software project during a month.

Fig. 3. Mail card. Image taken from the original game Belaya Vorona produced by Design Studio Art Lestnitsa, Centre of Prospective Projects.

One of the main goals of the adapted game is to make players aware of unexpected risks and associated expenses in software project management alongside with helping software engineering students realize what can go wrong or right and how well they can be prepared for it.

[1] In the case of the original game, rubles are used.

IV. WHITE CROW PM FOR SOFTWARE PROJECTS

A. Ad-hoc methodology to adapt the game

In order to narrow the general business-related scope of the original game and to shift its focus onto software projects context, we adopted an ad-hoc methodology, which was composed of 7 major steps.

The first step was to play the game to ensure it had an acceptable level of entertainment and challenge. Then it was translated from Russian into Spanish by two of the authors.

The second step was to analyze the original translated game, looking for the elements to be modified in order to simulate a software project without affecting the game's logic and flow. The 64 mail cards and the 16 business cards were reviewed, concluding that the prices were to be preserved but the number of cards might be increased. Moreover, the commission related rules were eliminated in order to simplify the game.

The third step consisted in rewriting the mail and business opportunity cards to suit software project related situations. The situations were designed by Computer Science students and professors, which was part of the final assignment of a Software Engineering advanced course and were based on their practical experience. In addition, selected papers and books were provided by the professors as a source of ideas for the students.

The fourth step was to develop a proof of concept for the new version of the game. The game was played by Computer Science students; the following aspects were examined:

- A1. Readability and clarity of the game rules.
- A2. Coherency and accuracy of the situations.
- A3. Students' perception of gaining knowledge.
- A4. Level of entertainment of the game.
- A5. Duration of the game.

Once the aspects to be improved were identified, a new version of the game was created.

During the fifth step we carried out a beta test of the game with students enrolled in an introductory Project Management course. 10 Applied Mathematics and Computation students, divided in 2 groups of 3 and 1 group of 4, played the game.

Afterwards, they answered an online questionnaire that measured aspects A1 to A4 using a Likert scale (1 to 5 scale values) while aspect A5 was measured by the two authors of the paper who observed the activity.

The results of the survey were as follows. For A1. Readability and clarity of the game rules, a median of 4.0 (42 out of 50 points) was obtained. For A2. Coherency and accuracy of the situations described in the cards and board, a median of 5.0 (46 points) was obtained. A3. Students' perception of gaining knowledge produced a median of 4.5 (45 points). Lastly, A4. Level of entertainment reached a median of 5.0 (50 points).

Regarding A5. Duration of the game, it was noted that a round to the board took 19 minutes in average while a recommended duration was two rounds. Overall, a 60 minutes class provides enough time to present the game, explain its rules, play two rounds and discuss the outcomes.

Through the same questionnaire we collected improvement suggestions to the board game, most of which concerned the game board and cards aesthetics. However, an important adjustment to the rules was suggested. The first round of the games was perceived as "slow" by the participants because of the "small" amount of money they received at the beginning of the game, hampering the possibility to invest and take advantage of the business opportunities early in the game. With that in mind, the players will receive a one-time initial bonus at the beginning of the first round.

The sixth step consisted in validating the new version of the game. This step is described in detail in Section V.

The last step was the socialization of the game, making it available to other professors and students.

B. White Crow PM [2]

In this subsection, the latest version of the board game is presented.

At the beginning of the game a bank manager is appointed, and each player decides their banking policy: they can either make savings or ask for loans. The purpose of this restriction is to offer the players a moment of decision making, facing up to its consequences later. The rates and interest can be agreed upon, those recommended by the game are 10%. Each player receives a one-time bonus of 1,000 units of play money and decides how much money they want to keep or deposit.

The game is best suitable for 3 to 5 players and it includes: a game board (see Fig. 4), 72 email cards, 20 Opportunity cards, tokens, a dice and play money. These components correspond with the Mechanic abstraction level of the game, according to the MDA model.

The Dynamic abstraction level of the game is described as follows: When a player gets to:

Email square: they have to take an email card. Email cards describe various aspects of a software project, such as Process related (Planning, Monitoring, Closure, Requirements, Design, Construction, Integration, Testing); Product related (Functionality, Reliability, Usability, Efficiency, Maintainability, Portability, Compatibility, Security) or Team related (Organization, Collaboration, Communication, Environment), which are indicated on the left side of the card. At the top, there is a short title of the situation, followed by an indication to pay or to receive, and a more extended description of the situation. The majority of the email cards requires the player to pay for some unexpected expenses while the rest recover money for the player.

[2] The White Crow PM latest version (in Spanish) can be downloaded from https://goo.gl/NjqMKo

Fig. 4. White Crow PM board

Fig. 5 shows email cards related to the Team communication and the Integration phase in a project. All the transactions must be made at the moment of getting the card. In case an email card indicates the amount to be paid per month (see Fig. 5, right), the player must multiply this amount by the number of months already played. This type of cards contains situations that have a wider impact on software projects, for example, an appearance of bugs in modules from first iterations. The rationale behind this modification was the importance of timing in discovering and solving issues.

Improvement opportunity square: the player has to take an Opportunity card and decide whether they want to use it or not. An Opportunity card offers an improvement related to software projects and mitigates unexpected expenses from email cards. The player must pay an indicated price to use it, however, they may choose to discard it without using.

The Improvement opportunity cards replaced the Business opportunity cards from the original game. An opportunity card does not provide any financial benefit for the player; it, however, mitigates risks or expenses from Email cards.

Fig. 6 shows an Improvement opportunity card, in which an investment in a software architect mitigates possible extra costs related to software construction and maintainability, while Fig. 7 shows an agile oriented opportunity.

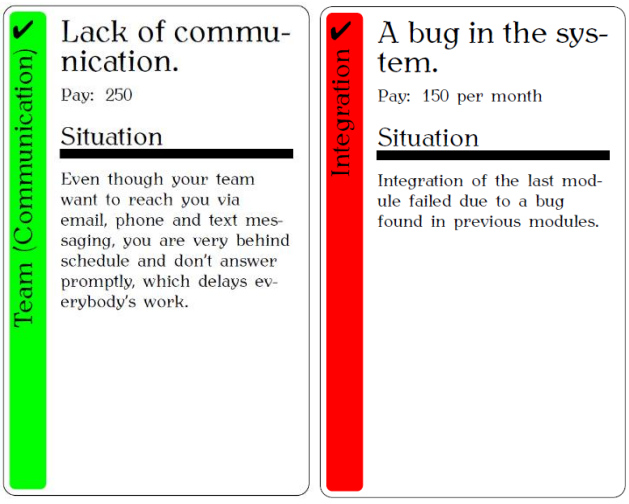

Fig. 5. Email cards, from White Crow PM

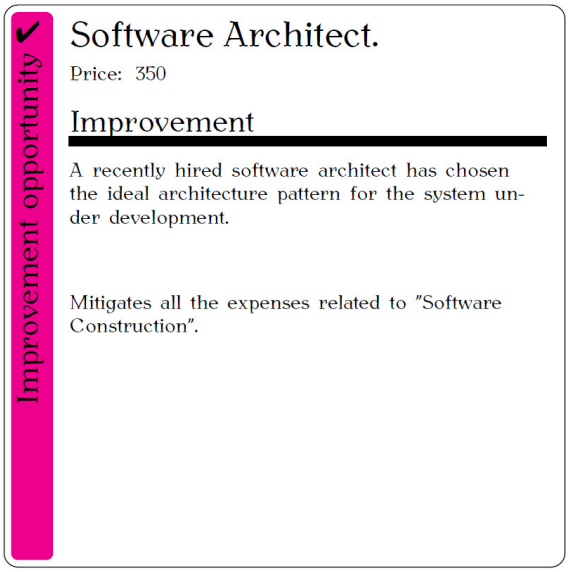

Fig. 6. Opportunity card, from White Crow PM

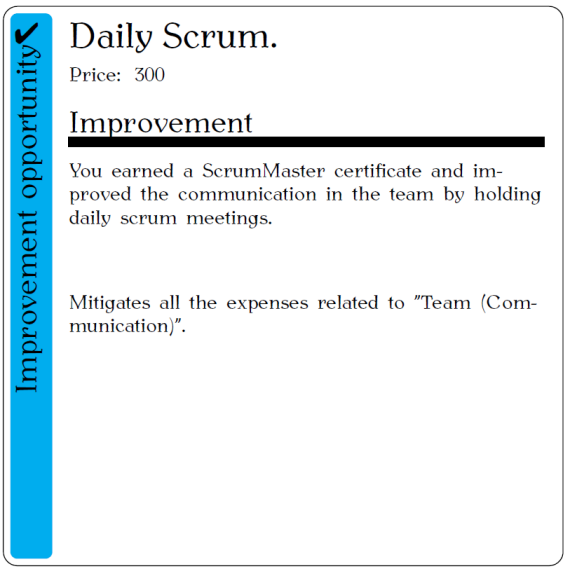

Fig. 7. Opportunity card, from White Crow PM

Bonus: players follow the instructions on each respective Bonus space, which always have a positive effect.

Expense: players follow the instructions on each respective Expense space, which always have a negative effect.

Gambling: each player bets 100 units of play money and throws the dice. The player to get the highest number wins all the money. This feature is preserved from the original game; it highlights occasional good or bad luck and gaming experience.

Last minute change: every player must go back one space and follow its respective instructions. Students become aware of unexpected changes in the project development.

A new project manager on the team: each player must hand over 50 units of play money. The money is kept in the space at the bottom of the board till one of the players gets a six on a dice roll and collects all the money.

Special offer: the player's expenses for the next two weeks will be reduced by 50%.

Break: players take a "day off".

Day of the White Crow: each player must pay any rates generated by bank loans, and receive 325 units of play money and interests, if any.

The game finishes by the end of the agreed number of rounds, and the player with the biggest amount of money is announced the winner.

V. Validation and Results

The hypothesis that guided this work is defined as follows: educational games contribute positively to achievement of learning objectives, motivate students, and promote a pleasant user experience.

With the aim of testing this hypothesis, the board game was validated in four groups of students from two Mexican universities. In total, 15 participants played the game; Table I presents a summary of the groups composition. The 4 groups were considered to have a homogenous academic background, cultural context and interest in the topic.

Table I.
Groups composition

Summary of groups			
University	**ID**	**Size**	**Degree**
A	Group 1	4	3 Engineering 1 Mathematics
	Group 2	3	3 Computer Science
B	Group 3	4	4 Computer Science
	Group 4	4	4 Computer Science

To obtain feedback and the student's perception of the game, a 4-section questionnaire was applied to the participants:

- **Basic information (5 questions):** questions in this section targeted students' academic background and experience, if any, in software projects.
- **Gaming Experience (15 questions):** questions in this section were based on the questionnaire presented in [8], and evaluated motivation, user experience and learning components. We used a Likert scale with response alternatives ranged from "strongly disagree" to "strongly agree" on a five points scale from 1 to 5.
- **Emotions (18 options):** this section consisted of a list of emotions, and each participant was invited to choose those experienced during the game.
- **General opinion:** the last section invited the participants to suggest improvements and to write their perceptions and opinion. We also included a question to evaluate how similar email and opportunities situations were to real projects, which was graded using Likert scale.

Table II shows a summary of the results of the Gaming Experience section, column M represents the median.

The analysis of the results points out that the participants had fun playing the game (5.0) and found it easy to understand (5.0). Moreover, they believe that the game content is relevant to their interests (4.0), is connected to other knowledge they already acquired (4.0) and suits their way of learning (4.0). As a whole, the dimensions of relevance, fun, satisfaction and learning were graded highly.

TABLE II.
GAMING EXPERIENCE SECTION RESULTS

Motivation	
Attractiveness	**M**
1. The game design is attractive.	**4.0**
2. The form, content and activities helped me to stay focused on the game.	**4.0**
Relevance to learning interests	
3. The content of the game is relevant to my interests.	**4.0**
4. The way the game works suits my way of learning.	**4.0**
5. The game content is connected to other knowledge I already have.	**4.0**
Confidence	
6. It was easy to understand the game and start playing it as learning material.	**5.0**
7. While playing the game, I felt confident that I was learning.	**4.0**
Satisfaction	
8. I feel positive because I know I will have opportunities to use what I learned playing this game in practice.	**4.0**
User experience	
Social interaction	
9. I had fun playing with other people.	**5.0**
10. The game promotes moments of cooperation and/or competition among players.	**5.0**
Fun	
11. This game has an adequate level of challenge for me; the tasks are neither too easy nor too difficult.	**4.0**
12. The game progresses at an adequate pace and does not become monotonous; it offers new obstacles, situations or task variations.	**4.0**
Competence	
13. I had fun playing the game.	**5.0**
14. When interrupted at the end of the class, I was disappointed that the game was over.	**4.0**
Learning	
Short-term learning	
15. I achieved the goals of the game applying my knowledge.	**5.0**

The participants' comments highlight learning aspects of Risks, Planning and Resource Management, in their own words: "Risks can affect and hamper my projects"; "It is better to be prepared to face them"; and "Good investment can help me to avoid risks". The comments also point to an increased PM-related awareness among students; measuring PM-related learning is out of the scope of this research stage.

An important factor to take into consideration was students' feelings and emotions while playing. Their evaluation allows us to gain insight into the user's experience and attitude towards the game.

This information was collected in the Emotions section, in which the participants were offered a list of emotions to choose from. These data is a first approach to describe the Aesthetics abstraction level of the game.

The results are shown in Table III. Positive emotions are preceded by a plus sign (+) while negative emotions are preceded by a minus sign (-). The number in the second column indicates how many participants chose the respective emotion.

TABLE III.
EMOTIONS QUESTIONNAIRE RESULTS

Emotions	
+ Interested	13
+ Eager	7
+ Optimistic	7
+ Focused	6
+ Confident	6
+ Happy	5
+ Capable	5
+ Relaxed	4
+ Immersed	4
+ Challenged	4
+ Satisfied	3
+ Encouraged	2
+ Useful	2
- Angry	2
- Bored	2
- Sad	1
- Lost	1
- Stressed	0

It can be noted that the negative emotions where chosen by far less frequently than the positive ones.

Finally, the last section of the questionnaire provided improvement suggestions and opinions of the game. On the one hand, the general opinion expressed was positive; it was fun, interesting, and a good idea that could be used more frequently in classrooms. The similarity of the presented situations with real projects obtained a median of 4.0, which we consider a positive score.

The participants mentioned: "It was a game but those things (situations presented) might happen in real life"; "My

interest for the subject increased"; "Very entertaining and easy to play, moreover, it gave me a good perspective of a software project"; and "I had a lot of fun, I like it, the situations are real".

On the other hand, creation of more opportunity cards was suggested; reading them before the game starts in order to have a wider vision of the game possibilities was also mentioned.

Another repeatedly commented aspect was the possibility to increase opportunities for collaboration between players. Lastly, an inclusion of a tip or advice in the email cards is seen as a possible path to provide more leaning opportunities. These improvements will be tackled in a future version of the game.

A. Threats to validity

In order to mitigate threats to validity, various factors were considered during the board game design and validation. Different causal relations were examined:

- **The number of participants.** Although the number of participants is not large, we consider the sample to be representative of students enrolled in Computer Science courses. However, validating the game with a small set of participants reduces the possibility of generalizing the results.
- **The questionnaire's trustworthiness.** The applied questionnaire is an adaptation of a recognized and proven instrument specialized in the evaluation of training and learning resources [8]. We are aware, however, that such aspects as game appropriateness and engagement are difficult to measure and were captured through subjective measures.

In spite of the limited number of students that participated in the validation, each student can be categorized as a typical Computer Science student, which is the target audience of White Crow PM. The selection of the participants was not intentional; the students who participated in the validation expressed their interest in participating.

Another factor to highlight is that the game applications were guided by several facilitators, 3 out of 4 groups were guided by professors not familiar with the game before. This factor supports the easy to use and apply claim.

The case studies were carried out by three researchers and the results were constantly triangulated to third parties, such as colleagues and members of the research group.

In order to improve the validity of this study the following approaches cited in [32] were taken into account:

- **Triangulation** was possible due to an active participation of two professors in the data collection process. Thus we were able to analyze different data sources: questionnaires and direct observations.
- **Peer debriefing** took place in all game applications. In addition, findings and results were periodically discussed with other members of the research group.

The game board applications demonstrated that the objective for which it was created was achieved, as it made students aware of risks they might face during a software project and of practices they can apply to mitigate them. In addition, the board game motivated students and promoted a pleasant experience.

Finally, the limitations of the case studies can be summarized in two points:

- The sample size is small, which therefore limits the power of generalization. It is necessary to apply the game in bigger populations.
- Bias in the game application could have occurred due to the participants' feeling of being observed and evaluated. This may have led to an alteration in their actual behavior.

VI. Conclusions and Future Work

Simulating a software project and making students face consequences of their decisions pose a challenge due to diverse internal and external factors. Therefore, games and simulations play an important role in creating abstractions and simplifications of real life software development [6].

Serious games represent a powerful learning tool in the field of education. Their teaching potential and entertaining aspect provide an alternative to traditional learning process in the classroom. Moreover, serious board games are cheaper and easier to apply, and allow educator to identify on-site advantages.

White Crow board game, adapted to the software projects context, resulted in a successful and useful resource to introduce students into software project management, and make them aware of its complexity, unexpected variables and the importance of decision making.

The students' opinions obtained through the questionnaire and the observations allowed us to conclude that the game supports enjoyment, motivation, social interaction and gratification; factors that support learning process.

As future work, improvements on the cooperative factor of the board game are considered, for example, being able to make agreements between players and the bank as well as between players. Besides, since cultural aspects also count, and this version of the game is based on the Mexican way of running a project, the situations in the cards could be tailored to other cultures.

Another interesting future research line might be creating an agile-oriented version, based on a 30-day sprint with players using a product backlog and specific PM events explicitly included in the board. More validation forms, such as in-depth interviews with experts and participants, are considered in order to enrich the qualitative analysis of the results.

Acknowledgment

The authors would like to thank Computer Science students Mauricio Esquivel Reyes, Anahí Quiróz Jiménez, Nancy

Matias Hernández and Karla Andrea Contreras Maya, who collaborated in the adaptation and validation of the game.

Also, special thanks to the professors Guadalupe Ibargüengoitia González, Gabriela Martínez Quezada and Maribel Santiago Luna, who kindly agreed to apply the game in their groups.

REFERENCES

[1] ISO/IEC 12207:2008 Systems and software engineering — Software life cycle processes (2008)

[2] ISO/IEC TR 29110-5-1-2:2011 Software engineering—lifecycle profiles for Very Small Entities (VSEs)—part 5-1-2: Management and engineering guide: Generic profile group: Basic profile (2011)

[3] Bourque, P, Fairley, R.E. eds., *Guide to the Software Engineering Body of Knowledge*, Version 3.0, IEEE Computer Society (2014)

[4] ACM and IEEE, Software Engineering Curriculum Guidelines; http://securriculum.org (2014)

[5] Calderón, A. and Ruiz, M.: *A systematic literature review on serious games evaluation: An application to software project management*. Computers & Education, Vol. 87, pp. 396-422, DOI: 10.1016/j.compedu.2015.07.011 (2015)

[6] Souza, M. R. A., Veado, L., Moreira, R. T., Figueiredo, E. and Costa, H.: *A Systematic Mapping Study on Game-related Methods for Software Engineering Education*. Information and Software Technology, Vol. 95, pp. 201-218, DOI: 10.1016/j.infsof.2017.09.014 (2017)

[7] Choi, J-I. and Hannafin, M.: *Situated cognition and learning environments: Roles, structures, and implications for design*. Educational Technology Research and Development, Vol. 43, No. 2, pp. 53-69, DOI: 10.1007/BF02300472 (1995)

[8] von Wangenheim, C. G., Savi, R. and Borgatto, A. F.: *DELIVER!–An educational game for teaching Earned Value Management in computing courses*. Information and software Technology, Vol. 54, No. 3, pp. 286-298, DOI: 10.1016/j.infsof.2011.10.005 (2012)

[9] Alonso-Fernández, C., Calvo, A., Freire, M., Martínez-Ortiz, I. and Fernandez-Manjon, B.: *Systematizing game learning analytics for serious games*. In Proc. Of the IEEE Global Engineering Education Conference, pp. 1111-1118, DOI: 10.1109/EDUCON.2017.7942988 (2017)

[10] Taran, G.: *Using games in software engineering education to teach risk management*. In Proc. Of the 20th IEEE Conference on Software Engineering Education & Training, pp. 211-220, DOI: 10.1109/CSEET.2007.54 (2007)

[11] Teed, R.: *Game-Based Learning*. SERC, Carleton College. https://serc.carleton.edu/introgeo/games/index.html (2018)

[12] Game, in Merriam-Webster.com. Retrieved May 15, 2018, from https://www.merriam-webster.com/dictionary/game

[13] Game, in Collins Dictionary. Retrieved May 15, 2018, from https://www.collinsdictionary.com/dictionary/english/game

[14] Arnab, S.,\ and Clarke, S.: *Towards a trans-disciplinary methodology for a game-based intervention development process*. British Journal of Educational Technology, Vol. 48, No. 2, pp. 279-312, DOI: 10.1111/bjet.12377 (2017)

[15] Retalis, S.: *Creating adaptive e-learning board games for school settings using the ELG environment*. J. UCS, Vol. 14, No. 17, pp. 2897-2908 (2008)

[16] Kosa, M. and Yilmaz, M.: *The Design Process of a Board Game for Exploring the Territories of the United States*. Press Start, Vol. 4, No. 1, pp. 36-52 (2017)

[17] Chiarello, F. and Castellano, M. G.: *Board games and board game design as learning tools for complex scientific concepts: some experiences*. International Journal of Game-Based Learning, Vol. 6, No. 2, pp. 1-14, DOI: 10.4018/IJGBL.2016040101 (2016)

[18] Aydan, U., Yilmaz, M., Clarke, P. M. and O'Connor, R. V.: T*eaching ISO/IEC 12207 software lifecycle processes: a serious game approach*. Computer Standards & Interfaces, Vol. 54, pp. 129-138, DOI: 10.1016/j.csi.2016.11.014 (2017)

[19] Telukunta, S., Kota, M. S. K., Potti, M. S., Shashank, M. H. and Triloknath, M.: *StrateJect: An Interactive Game for Project Management Experiential Learning.* PMP Conference, PMI Bangalore chapter (2014)

[20] Yilmaz, M.: *Virtual Reality-Based Daily Scrum Meetings*. In: Encyclopedia of Computer Graphics and Games, Publisher: Springer, Editors: Newton Lee, pp. 1-6. DOI: 10.1007/978-3-319-08234-9_160-1 (2017)

[21] Kirkpatrick, D.L. and Kirkpatrick, J.D.: *Evaluating Training Programs: The Four Levels*. Berrett-Koehler Publishers (2006)

[22] Duarte, L. C. S. and Battaiola, A. L.: *Distinctive features and game design. Entertainment computing*. Vol. 21, pp. 83-93 (2017)

[23] Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., De Freitas, S., Louchart, S., and De Gloria, A.: *Mapping learning and game mechanics for serious games analysis*. British Journal of Educational Technology, Vol. 46, No. 2, pp. 391-411, DOI: 10.1109/TETC.2015.2504241 (2015)

[24] Hunicke, R., LeBlanc, M. and Zubek, R.: *MDA: A formal approach to game design and game research*. In Proc. of the AAAI Workshop on Challenges in Game AI, Vol. 4, No. 1, p. 1722, DOI: 10.1.1.79.4561 (2004)

[25] Przybylek, A. and Olszewski, M. K.: *Adopting collaborative games into Open Kanban*. In Proc. of the Federated Conference on Computer Science and Information Systems, IEEE, pp. 1539-1543 (2016)

[26] Heikkilä, V. T., Paasivaara, M. and Lassenius, C.: *Teaching university students Kanban with a collaborative board game*. In Proc. of the 38th International Conference on Software Engineering Companion, ACM, pp. 471-480, DOI: 10.1145/2889160.2889201 (2016)

[27] Przybylek, A. and Kotecka, D.: *Making agile retrospectives more awesome.* In Proc. of the Federated Conference on Computer Science and Information Systems, IEEE, DOI: 10.15439/2017F423 (2017)

[28] Przybylek, A. and Zakrzewski, M.: *Adopting Collaborative Games into Agile Requirements Engineering.* In: 13th International Conference on Evaluation of Novel Approaches to Software Engineering (ENASE'18), Funchal, Madeira, Portugal (2018)

[29] De Souza, A. D., Seabra, R. D., Ribeiro, J. M. and Da S. Rodrigues, L. E.: *SCRUMI: a board serious virtual game for teaching the SCRUM framework.* In Proc. of the 39th International Conference on Software Engineering Companion, IEEE Press, pp. 319-321, DOI: 10.1109/ICSE-C.2017.124 (2017)

[30] von Wangenheim, C. G., Savi, R. and Borgatto, A. F.: *SCRUMIA—An educational game for teaching SCRUM in computing courses.* Journal of Systems and Software, Vol. 86, No. 10, pp. 2675-2687, DOI: 10.1016/j.jss.2013.05.030 (2013)

[31] Mahnič, V.: *Scrum in software engineering courses: an outline of the literature*. Global Journal of Engineering Education, Vol. 17, No.2, pp. 77-83 (2015)

[32] Runeson, P., Host, M., Rainer, A. and Regnell, B.: *Case Study Research in Software Engineering: Guidelines and Examples*. Wiley, DOI: 10.1002/9781118181034 (2012)