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Bridging the Gap between SPI and SMEs in Educational Settings: A Learning Tool Supporting ISO/IEC 29110

Mary-Luz Sanchez-Gordón[1], Rory V. O'Connor [2], Ricardo Colomo-Palacios [3] and Eduardo Herranz[1]

[1] Universidad Carlos III de Madrid, Computer Science Department
Av. Universidad 30, Leganés, 28911, Madrid, Spain
mary_sanchezg@hotmail.com, eduardo.herranz@uc3m.es
[2] School of Computing, Dublin City University
Glasnevin, Dublin 9, Ireland
rory.oconnor@dcu.ie
[3] Faculty of Computer Sciences, Østfold University College
Halden 1783, Norway
ricardo.colomo-palacios@hiof.no

Abstract. The software development industry is dominated by a myriad of smaller organizations world-wide, including very small entities (VSEs), which have up to 25 people. Managing software process is a big challenge for practitioners. In 2011, due to the VSEs' increasing importance, a set of ISO/IEC 29110 standards and guides were released. Although other initiatives are devoted to small entities, ISO/IEC 29110 is becoming the widely adopted standard. But it is an emerging standard and practitioners need to be actively engaged in their learning. In this sense, serious games offer the potential to entertain and educate. This study shows empirical evidence to support the overall applicability of the game proposed as learning tool. Moreover, the results indicate that the learning tool creates a positive experience, and therefore could be used as a strategy to promote the standard.

Keywords: VSE, ISO/IEC 29110, Very Small Entity, Project Management, Game-based learning, Game-based training

1 Introduction

Typically project teams tend to be small, even in large companies. In 2011, driven by the increasing importance of *very small entities*' (VSEs) and the growing need for systems and software life cycle profiles and guidelines, the International Organization for Standardization (ISO) and the International Electro technical Commission jointly published a set of standards and guides ISO/IEC 29110 [1], which are targeted at meeting the specific needs of "*an enterprise, organization, department or project having up to 25 people*" [2, 3]. The software industry recognizes the value of VSEs in

contributing valuable products and services [4, 5], where certain VSEs also provide software components that are being assembled in larger software companies in order to generate critical and intensive software configurations [6]. In fact, there are a myriad of small software companies. According [4], the OECD (Organization for Economic Co-operation and Development) SME and Entrepreneurship Outlook report (2005) *"SMEs constitute the dominant form of business organization in all countries world-wide, accounting for over 95 % and up to 99 % of the business population depending on country"*.

Previous experiences in software process improvement (SPI) in graduate software engineering programs [7] reveled that a large percentage of students attending the SPI course were working in small organizations. The emphasis on the use of the CMMI framework in that course was gradually reduced to switch to the ISO/IEC 29110. Besides, it may not be appropriate at the undergraduate level to dedicate significant time of a related course and provide details about process models such as CMMI [8]. Likewise, the acceptance level and priority of any type or model of software quality or lifecycle standard in VSEs is very low [9] but the level of awareness of standards and potential benefits are high. Software is a complex product, difficult to develop [10]. Accordingly to the Standish Group "*a low percentage of successful projects delivering software on time, on budget, and with required features and functions*". VSEs deal with this fact every day therefore the implementation of controls and structures to properly manage their software development activities is necessary and challenging [11]. The knowledge and skills required to do that imply training. For instance, software engineering courses at the university usually consist of lectures along with a small software project [12], but software process is often treated as an additional module to the core curriculum. Trainings in an industry environment are, on the other hand, organized in a workshop style with theoretical and practical parts interwoven [13]. Although ISO/IEC 29110 is well-structured and described in great details in the guides, it is a technical text on complex subject. It is easier than the ISO/IEC 12207 but practitioners could find software development difficult to understand and deploy it [14]. Thus international software standards are considered important in improving the software process but teaching them remains a challenging issue [15, 16]. Therefore new tools to facilitate teaching and learning process can be useful. There is also a growing interest in games for purposes beyond entertainment [15, 17, 18] and a consensus that serious games have a significant potential as a tool for instruction [19]. Thus the goal of our study is to investigate the potential of a learning tool for the Project Management (PM) process of ISO/IEC 29110.

The remainder of this paper is structured as follows: Section 2 presents the background of this study. Section 3 outlines the learning tool. In Section 4 authors report on the results of the pilot study. Section 5 summarizes a conclusion as well as outlines future work plans.

2 Background

This section summarizes the ISO/IEC 29110 standard (section 2.1) and related work on games in software engineering (section 2.2).

2.1 ISO/IEC 29110

The ISO/IEC 29110 Software engineering — Lifecycle profiles for Very Small Entities standard is aimed to approach Software Engineering and Project Management good practices to VSEs. It is aimed at addressing the specific needs of VSEs [20, 2, 21] and to tackle the issues of low standards adoption by small companies [9, 22–24]. Although there is still much work to be completed, there is an increasing interest on the standard [25]. There are profile Groups which are a collection of profiles related either by composition of processes (i.e. activities, tasks), by capability level, or both. The "Generic" profile group has been defined [3] as applicable to a vast majority of VSEs that do not develop critical software and have typical situational factors. To date the Basic Profile [3] and Entry Profile [26] has been published. It is worth noting that the Entry profile is contained in the Basic Profile. The guides are based on subsets of appropriate standards elements, referred to as VSE Profiles (ISO/IEC 12207, ISO/IEC 15289, ISO/IEC 15504, ISO 9001) [4, 6]. The so-called guides are gathered into the ISO/IEC 29110 Software engineering — Lifecycle profiles for Very Small Entities standard, which describes processes for project management and software implementation [27] and pretends to facilitate access to, and utilization of, ISO software engineering standards in VSEs [5].

Additionally, the guides are available in several languages: English, French, Portuguese and Spanish. Moreover, there is a series of Deployment Packages (DPs) and Implementation Guides which are not prescriptive but outline guidelines and explain in detail the processes defined in the ISO/IEC 29110 profiles in order to assist with its deployment and to provide guidance on its actual implementation in VSEs [28]. DPs are freely available from `http://29110.org.`

2.2 Games in Software Engineering

Given that there are some concepts related to the term "game", this section include the following discussion which is based on [29, 30]. But it is not comprehensive and is only intended to avoid misconceptions. *Games* are played just for entertainment. They include game thinking, game elements and gameplay. Examples are poker, solitaire and monopoly (see Figure 1).

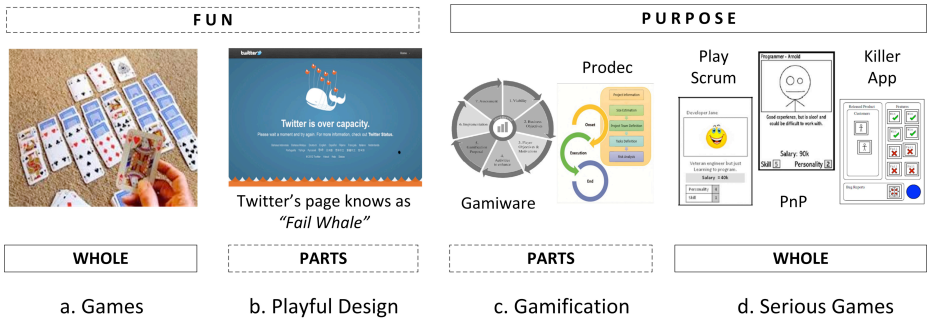

Fig. 1. Examples of games, playful design, gamification and serious game adapted from [29]

Playful design or *Gameful design* is using game-based aesthetics or limited usability based on game elements in non-game contexts with the purpose of drawing the user's attention. These elements are used to amuse users and cause an emotional response [29]. One successful example is the fail whale from Twitter. Rather than a boring old error when twitter is over capacity, they have the Fail Whale (Figure 1-b).

Gamification is the use of game design elements in non-game contexts [30] (Figure 1-c). In recent years, there is a growing interest in gamification [29, 31] as well as its applications and implications in the field of Education since it provides an alternative to engage and motivate students during the process of learning [29]. It proved to have potential to support education [32], although further research is needed. Moreover, there are few gamification approaches to improve the software development process [33, 34], and few experiences in education, for example project gamification of an introductory computer science class [35] and gamified Software Engineering courses [36, 37].

Serious games are games designed for non-recreational environments and for educational purposes. The term "serious" is employed because these games can focus on areas as diverse as economics, education, health, industry, military, engineering, and politics [29]. The main goal of this sort of training-environment is to convey information to the user. Seen from the perspective of the designer, serious games have all the elements of a real game (Figure 1-d) — i.e. gameplay. Therefore, they are complete games whereas gamification is a way of designing products and services with the intention of a system that includes elements from games, not a full 'game proper' [30]. There are only several games related to software PM which have been used in educational area as a supplement to classroom-based teaching with some success [15, 38]. They fall into two broad groups: work based on computer games, and work based on non-computerized games. Authors focus on the last one because it is simple and fun to play, and also include relatively low development overhead, tactile immediacy, and direct face-to-face player interaction [39] — e.g. Problems and Programmers (PnP), SimulES, Killer App and PlayScrum. Moreover, the international initiative Semat (Software Engineering Methods and Theory) is aiming to collect the core elements essential to the development of software projects. It has games [40] such as SemCards, MetricC, Semat board-crossing and Semat game that are being used as a strategy to promote it. In relation to specialized decks of cards are not uncommon in

the professional field [41–43]. They are used in poker planning, delegation poker, moving motivators, and so on. Moreover, some games have also been designed to teach the practices, values and concepts behind XP and object-oriented programming, one of the best known is XP War game.

Finally, as far as authors know, there are not any serious games in the state of the art for the ISO/IEC 29110 standard.

3 Learning Tool for Project Management Process of ISO/IEC 29110

This section describes different aspects of the learning tool (see our previous work [44] for details about its design. Regarding with the key requirement of the learning tool, our approach should be fast, painless and cost-effective because of VSEs having limited resources. That means it should not need software and hardware resources. Therefore, the learning tool for project management of ISO/IEC 29110 could be used by a wide audience of software engineers at different stage of their career – undergraduates, graduates or education for industry professionals - in order to promote and provoke awareness, and ultimately, understanding of the standard. Moreover, the game should be quick to play, and easy to learn and use in order to create a positive attitude towards their adoption and eventually promote the introduction of the standard beyond the academic and research areas. Thus, the idea behind non-computerized games was very attractive for us because they include relatively low development overhead, tactile immediacy, and direct face-to-face player interaction as they are simple and fun to play. If the game were complex, it would lose most of its effectiveness as a learning tool. And enjoyable is certainly important due to the players would want to play the game. Consequently, authors adopted a familiar and popular game concept: Card Game and authors created a specialized deck of cards.

In order to facilitate comprehension, learning, memory, communication and inference of the PM process, authors define a virtual board and color code based on the four activities in the PM process. Figure 2 shows as each activity is a suit: *Project Planning* (blue), *Project Plan Execution* (green), *Project Assessment and Control* (yellow), and *Project Closure* (red). The white color represents the input and the output of the PM process – «*Statement of Work*» and «*Software Configuration*». Each suit has two types of cards: an activity card and a state card. The first one depicts the work products and has a list of tasks related. The second one depicts the possible states of each work products.

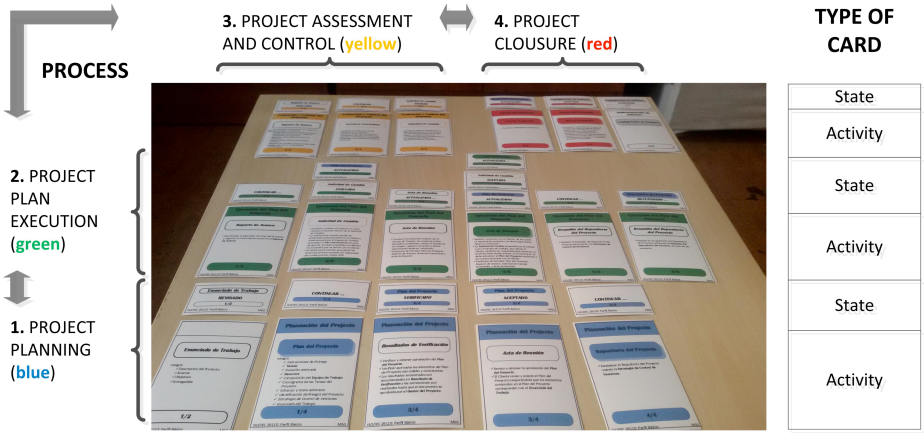

Fig. 2. An example of Virtual Board

The game can be played between 2 to 5 players, new or relatively new to project management process. They are the project team members and their mission is to complete the project management during which each player must develop a set of tasks. Thus, the relationships between the game's rules and best practices make the last one more intuitive and easy to remember. The Figure 3 depicts the elements of the game: activity and state cards (mentioned before) and card reference guide.

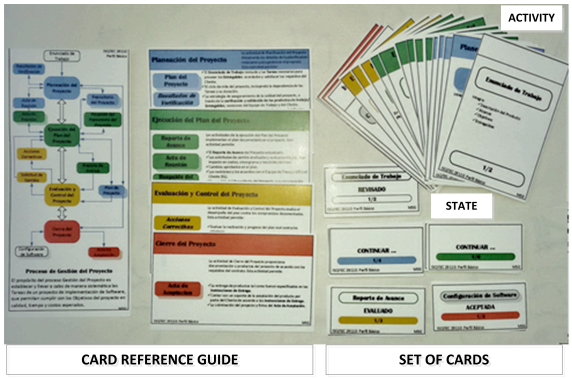

Fig. 3. Elements of the game

In this study, the proposed gameplay is a variation of our previous study [44]. The time activity was restricted up to 30 minutes, including a brief introduction of the game and the standard. Instead of the single elimination tournament, there are two leaderboards: one for teams and one for team members. Before starting the game, the participants are grouped in teams — every team has up to 5 members. Then, the cards are distributed among the team members. The first sub-mission starts with the player who holds the «*Statement of Work*» activity card. The player reads it and asks other players for the tasks, so they raise their hands to answer and he/she will add one point for each correct answer. The player who holds the activity card decides if the answer

is valid and places it faces up on the table to make a first pile of the virtual board (see Figure 2). After that, the state card should be played by the player who holds it. Play continues with the blue suit until the highest card of it is reached. Next, the second and third mission must be carried out in the same way. The fourth mission starts with the player who holds the «*Software Configuration*» card. Finally, the red suit is played. The game is over when players run out of cards or time is up. The winner of this game is the team that had more point.

The biggest challenge was the integration of learning content with core mechanic of the game in order to gain balance of fun and learning. The idea is to provide a participant engagement loop (i.e. the flow [45]), which helps player to learn and participate more frequently and ultimately create planned participant behavior. Therefore, the players interact with each other and the game. In addition, some degrees of accomplishment and whose outcomes can directly affect the session game were included in order to raise the player's experience. Also, some rewarding mechanisms were threaded throughout the game.

4 Pilot Project

Before launching the pilot project, the game was positively evaluated by an expert in the ISO/IEC 29110. The aim of this study is to provide empirical evidence in order to support the overall applicability of the game proposed as learning tool. The game was applied to three sub-groups: a 16-student sub-group (A) belonging of the course "*Software Engineering*" from the *National Polytechnic School of Ecuador* and 30-student group distributed in two sub-groups (B/C) belonging of the course "*Software development projects management*" from the *Carlos III University of Madrid.* The major difference between them is that participants in subgroup C were studying a dual degree in Computer Science Engineering and Business Administration. After the game, it was applied a 20-item survey with the aim of gathering information from the players. It is important to note that this survey has been used in our exploratory study about the design of this tool [44]. The results are summarized as follows.

Table 1 shows an overview of the background of the participants in this study. All the participants (39 men and 7 women) accepted voluntarily to take part in the study. Only three of them had previous Software Engineering experience in the industry. Three game sessions were held, one per sub-group, in two countries. Participants heard about the standard for the first time during the sessions. Two sessions lasted about 20-25 minutes. The other one lasted less (10-15 minutes). It was observed that participants in Ecuador overwhelmingly (100%) agreed that would like to play again. Whilst 37% of participants in Spain would not want to play again the reason behind could be that one of the sessions lasted less than 15 minutes such as one participant point out "*a short time to assimilate the rules and performance"* and other one claims "*more time is required to play*".

Table 1. Background

	Ecuador	**Spain**	
	A	**B**	**C**
Gender (Female/Male)	3/13	1/15	3/11

SE Experience (Industry)	0	2	1
SE Experience (Academic)	16	16	14
Semester	5	6	8
Group Size	16	16	14
Individuals per group	3-5	3-5	3-5
Game Length per round (minutes)	20-25	10-15	20-25
Would Play Again (YES/NO)	16/0	9/7	10/4

Table 2 summarizes the answers of all participants about the game in terms of arithmetic means and standard deviation. Responses were based on a five-point Likert scale ranging from "Strongly Disagree" (1) to "Strongly Agree" (5). Authors can see that two groups arose from the data. In the first group, the means vary between 4.04 and 3.70. 74% of students stated that they were involved and engaged during the game while 78% of participants pointed it was fun. It is worth noting that 30% of out of the total strongly agreed with the last statement. In addition, 70% of participants report that the game is an alternative to a traditional classroom activity. Although 63% of the participants kept themselves interested during the game when authors analyzed the raw data, the remaining 35% was neutral and 56% of them are belonging to the sub-group C therefore the short playing time could be a disruptive factor as exemplified by the next quotes from two of the participants "*It [the game] is not well understood it would be better if you will understand it*" and "*It [the game] may be interesting, but there was not time neither was clear what had to be done"*. The rest (2%) belongs to one individual. In this group, 67% of the students also pointed that the game design is useful. They think that the game has a meaningful design because the cards include color coding and numbered linked with the processes flow. Once again, authors analyzed the raw data the 47% of the remaining (33%) are belonging to the sub-group C. In addition to the aforementioned quotes from this sub-group C another respondent stating that "… *It [the game] was explained too fast*".

Table 2. Frequencies, mean and standard deviation

	1	**2**	**3**	**4**	**5**	**Mean**	**Standard Deviation**
Participant Involvement	1	6	5	12	22	4.04	1.141252
Fun Factor		4	6	22	14	4.00	0.884651
Engaging	2		10	22	12	3.91	0.928441
Kept Me Interested	1		16	18	11	3.83	0.867388
Alternative to Classroom	4	3	7	15	17	3.83	1.238939
Design useful	4	4	7	18	13	3.70	1.213503
Knowledge acquisition		9	17	12	8	3.41	0.990741
Encourage to Knowledge	5	7	12	14	8	3.28	1.227635

In the second group, the means vary between 3.41 and 3.28. Authors note that 43% of the students say that they improved their knowledge on the standard and 48% of the respondents report that they are more encouraged to know more about the stand-

ard. Therefore, no indication for a significant difference on learning effectiveness could be shown. In order to understand the lowest scores, the data were analyzed by participant and by answers. 9 participants (20% of the respondents) strongly disagree with some of the six issues studied - i.e. 100% of these answers not included the issues: Fun Factor and Knowledge acquisition. However 4 of them (45%) are belonging sub-group C. And another 12 participants (26% of the respondents) disagree with some of the six issues studied - i.e. 100% of these answers not included the issues: Engaging and Kept Me Interested. However 7 of them (58%) are belonging sub-group C. Authors can see that a short playing time can affect perceptions of the players during the game and after.

Moreover, the lowest scores in each issue, excluding Encourage to Knowledge, appeared as outliers point when Pierces criterion were applied [46] (see Table 3). In order to do that, we obtained R from the table for one measured quantity assuming one doubtful observation and 46 measurements: R = 2.560. Then, authors calculated the maximum allowable deviation $|x_i - x_m|_{max} = R * SD = 2.92$ where x_i is a measured data value and x_m is the mean of the data set. Finally, authors obtained the actual deviations for the suspicious measurements $|x_i - x_m| = 3.04$ and authors eliminated the suspicious measurements if: $|x_i - x_m| > |x_i - x_m|_{max}$. As a result, there are 8 respondents (17%) strongly disagree with five issues: Participant Involvement, Engaging, Kept Me Interested, Alternative to Classroom and Useful Design and disagree with the issue Fun Factor.

The two open questions shed light on the above results. Certainly, one important issue is that everyone has enough playing time as before mentioned. In general, the most respondents commented that the game was interesting, fun, didactic and intuitive as exemplified by one respondent "*I think it was an interesting and funny experience*" another participant stated "*Thus it is much easier to learn the ISO*". Most players positively embraced the game as someone put it concisely *"It is a good experience…"* with another respondent confirming that *"It [game] has a great future"*. The gameplay environment forced participants become familiar with the ISO/IEC 29110 standard. Finally, the respondents suggested i) make more iterations of the game, and ii) create a game mechanics to link task.

Table 3. Pierces criterion

	Mean	**Standard Deviation**	**Pierce's Criterion**	
			R * SD	**$\|x_i - x_m\|$**
Participant Involvement	4.04	1.141253	2.92	3.04
Fun Factor	4.00	0.884652	1.77	2.00
Engaging	3.91	0.928442	2.13	2.91
Kept Me Interested	3.83	0.867389	2.22	2.83
Alternative to Classroom	3.83	1.238940	2.47	2.83
Useful Design	3.70	1.213503	2.42	2.70
Encourage to Knowledge	3.28	1.227635	2.33	2.28

5 Conclusions and Future Work

This paper describes the proposal of a learning tool, which is based on a serious game as a way to understand and support the project management process and activities of the ISO/IEC 291110 standard. The main limitation is the sample size of the study which was limited. Although it consisted of a pilot project carried out among students in two countries, Ecuador and Spain. The learning tool allows learners to gain an understanding of the standard quickly that might otherwise have been poorly understood or overlooked altogether. Indeed, the card game could be used as a checklist and support the project management in both academic and professional settings, but further study is needed. The present findings are consistent with the previous one [44], although there is a variation of gameplay, the game seems to be fun, immersive and certainly involve the participants. Nevertheless short playing time could be a disruption and the participants suggest "make more iterations of the game". Finally, the results give us confidence that this is a positive experience. Therefore, the game could be used as a strategy to promote the standard and show practitioners that learning a standard does not have to be boring and painful. In future work, authors propose to focus on improving the game mechanics in order to make the game as simple as possible, but no simpler. Moreover, authors are planning to increase the sample size and the learning tool could eventually become a software application.

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