Sánchez-Gordón, Mary-Luz, Rory V. O'Connor, Ricardo Colomo-Palacios, and Sandra Sanchez-Gordon. "A Learning Tool for the ISO/IEC 29110 Standard: Understanding the Project Management of Basic Profile." In *International Conference on Software Process Improvement and Capability Determination*, pp. 270-283. Springer International Publishing, 2016.

A Learning Tool for the ISO/IEC 29110 Standard: Understanding the Project Management of Basic Profile

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Abstract. The "*best practices*" of international software standards are considered important in improving the software process. The ISO/IEC 29110 standard defines lifecycle profiles for Very Small Entities (VSEs) and VSEs have also been recognized important in the software industry. Since this standard is novel, practitioners need to be actively engaged in their own learning. Serious games offer the potential not only to entertain and educate, but can also operate as a strategy for promoting the standard itself. The findings of this explorative study make possible an initial judgment about its potential as a fun standard learning tool as well as to analyze its pertinence, engagement, strengths, and weaknesses as guidance for further evolution.

Keywords: VSE, ISO/IEC 29110, ISO, Standards, process improvement, project management, serious game, learning.

1 Introduction

According to Eurostat [1][1], in 2012, 99.8% of enterprises in this software industry were medium-sized (< 250 employees). Small enterprises (< 50 employees) made up at least 98.8% and micro (<10 employees) were 93.9%. In this sector, micro enterprises employed more than 32.2% of people. In this context, the term Very Small

[1] The General Industrial Classification of Economic Activities within the European Communities (NACE Rev.2) that identifies computer software and related computer services as division 62: computer programming, consultancy and related activities and division 63: information service activities

Entities (VSEs) has been defined as being "*an enterprise, organization, department or project having up to 25 people*" [2].

Although the acceptance level of any type or model of software quality or lifecycle standard in VSEs is very low and less priority [3], the level of awareness of standards and potential benefits are high. The relationship between the success of a software company and the software process it utilized has been investigated [4–6] showing the need for all organizations, not just VSEs to pay attention to software process practices, such as ISO standards [7]. However, most VSEs can neither afford the resources, in terms of number of employees, budget and time, nor do they see a net benefit in establishing software life cycle processes [8]. To rectify some of these constraints, a set of guides has been developed according to a set of VSE characteristics. Thus, ISO/IEC 29110 is an international standard which is aimed at meeting the specific needs of VSEs [9].

Despite the fact that ISO/IEC 29110 is a well-structured and detailed technical text on complex subject, easier than the ISO/IEC 12207, practitioners could find it difficult to understand and adopt it. In general, international software standards are considered important in improving the software process, but teaching international software standards remains a challenging issue [10]. Therefore, new learning tools to complement training among practitioners can be useful. The question is how such standards, particularly ISO/IEC 29110, can be learned with less time and efforts invested for both practitioners and VSEs.

A possible and feasible approach is using a serious game. Although, non-technological methods have still low usage in SE teaching [11], a non-digital game-based environment can be turned into a powerful tool for teaching [12]. Therefore, designed card games or board games as an activity (even instead of a computerized version) for software engineering and management training have great potential. Serious games offer the potential to not only entertains and educate [13], but can also operate as a strategy for promoting the standard itself. In fact, there is a growing interest in games for purposes beyond entertainment [10, 12] and a consensus that serious games have a significant potential as a tool for instruction [14]. Consequently, the goal of the study is to investigate the potential as a fun standard learning tool of a card game that is designed for raising awareness and understanding the project management process of ISO/IEC 29110.

The rest of the paper is structured as follows. Section 2 presents the background study of the study and outlines ISO/IEC 29110 and Games in Software Engineering (SE). Section 3 describes how the game was designed. A section 4 we present the results we obtained during the pilot study. Section 5 summarizes the conclusions of the paper and outlines challenges that may lead to future research.

2 Background

2.1 ISO/IEC 29110

The ISO/IEC 29110 is an international software engineering standard which defines lifecycle profiles for VSEs [2]. It is aimed at addressing the issues identified above and addresses the specific needs of VSEs [15–17] and to tackle the issues of low standards adoption by small companies [3, 18–20]. In fact, there is an increasing interest on the standard [21], although there is still much work to be completed.

The approach [22, 23] used to develop ISO/IEC 29110 started with the pre-existing international standard ISO/IEC 12207 dedicated to software process lifecycles. The overall approach consisted of three steps: (1) Selecting ISO/IEC 12207 process subset applicable to VSEs of up to 25 employees; (2) Tailor the subset to fit VSE needs; and (3) Develop guidelines for VSEs.

The guides are based on subsets of appropriate standards elements. There are a profile Groups which are a collection of profiles which are related either by composition of processes (i.e. activities, tasks), or by capability level, or both. The "Generic" profile group has been defined [2] as applicable to a vast majority of VSEs that do not develop critical software and have typical situational factors. To date the Basic Profile [2] and Entry Profile [24] has been published, their purpose is to define a software development and project management guide for performing one project at a time. The Entry profile is defined for the case when more flexible and more light-weight software process is needed than the Basic profile scope, e.g. for the case when user-risk is very low, using period is very short, and process responsibility is appropriately divided between the acquirer and the developer. It is worth noting that Entry profile is contained in the Basic Profile.

At the core of this standard is a Management and Engineering Guide (ISO/IEC 29110-5) [2] focusing on *Project Management* and *Software Implementation*. The purpose of the Project Management process is to establish and carry out in a systematic way the tasks of a software implementation project, which complies with the project's objectives in terms of quality, time and cost. It is intended to be used by the VSE to establish processes to implement any development approach or methodology including, e.g., agile, evolutionary, incremental, test driven development, etc. based on the VSE organization or project needs.

In the nutshell, Project Management generates a *Project Plan* to direct the software project. During the execution of the project *Change Requests* may cause revisions to the *Project Plan*. The project is the subject of *Project Assessment and Control* during the lifetimes of the project until the *Software Implementation* is complete and *Project Closure* occurs.

Additionally, a series of Deployment Packages (DPs) and Implementation Guides, which are freely available from http://29110.org, have been developed to define guidelines and explain in detail more detail the processes defined in the ISO/IEC 29110 profiles in order to assist with the deployment of ISO/IEC 29110 and to provide guidance on the actual implementation of ISO/IEC 29110-5 in VSEs [25]. It is worth mentioning that a DP is not a process reference model, in other words, it is not prescriptive.

2.2 Serious Games in Software Engineering

Accordingly to the overview about serious games carried out in [13], there are many different terms, that all point to what is here called serious games. However, one issue most definitions agree upon, more or less, is that serious games are concerned with the use of games and gaming technology for purposes other than mere entertainment or "fun". Such purposes include education, training, health, and so on.

Games have been used in software engineering and project management educational settings as a supplement to classroom-based teaching with some success [10]. However, there are only several ones which are related to software project

management: SIMSE is an interactive, graphical, educational software engineering simulation game designed to teach students the process of software engineering, SIMSOFT is a kind of serious game which consists of two game boards, a printed board and a digital board, ProDec is a simulation-based serious game created with the intention to train and assess students in software project management, SESAM is a natural language based serious game which motivates players to gain software project management techniques, DELIVER is another type of serious game which consists of a printed board. It helps students to develop controlling projects performances. Problems and Programmers (PnP) is using a physical card game to teach students about the software engineering process. SimulES-W [26] is the digital version of SimulES, an educational board and card game. SimulES is an evolution of the ideas of the PnP game but differs because SimulES does not have any specific development process. In Software development Game [11], players must build origami boxes with one of the following four groups of letters, SO, FT, WA or RE. Every box represents a software module (a part of a software piece that can be exchangeable with others). One group of four modules forms one software piece (a complete word, SOFTWARE, made of four modules).

Furthermore, Semat (an acronym for Software Engineering Methods and Theory) have some games [27] - e.g., SemCards, MetricC, Semat board-crossing and Semat game - such as a strategy for promoting its theory and practice. Semat is an initiative for gathering together the core elements essential to the development of software projects [28]. In Semat game, players are encouraged to understand the concepts of the topic proposed by the game, such as the main features of a PMBOK process [27]. It is worth mentioning that using specialized decks of cards is not uncommon[2,3]. Games have also been designed to teach the practices, values and concepts behind XP and object-oriented programming, such as the popular XP War game.

Finally, no games were found in the state of the art for learning the ISO/IEC 29110. Although, there is a preliminary study [10] that investigates the need of a serious game to improve the ability of learners of ISO/IEC 12207 standard from an industrial perspective.

3 The Game - Go for It!

3.1 Design Process

Accordingly to Adams [29], there are three stages of the design process: concept, elaboration and tuning. In the concept stage, the following considerations were made: i) learning must be active and collaborative ii) it does not need software and hardware resources, iii) the approach to be fast, painless and cost-effective. Considering all of the above, this study adopted a familiar game concept: *Card Game*. The aim of the game has been to promote and provoke awareness, and ultimately, understanding of ISO/IEC 29110 standard among practitioners of SE.

[2] http://www.drdobbs.com/xp-war/184415908
[3] http://www.industriallogic.com/games

During elaboration stage, the design work begins to move from the theoretical to the concrete. Some prototypes of the game were created and the rules were volatile. The topic of the game is ISO/IEC 29110 standard and how some of its elements - such as activities, tasks, work products, and roles - are related. The object of the game proposed is teaching the project management process and showing how to interact with its elements when a particular profile - Basic profile - is selected. The inputs of the activities are the required work products and the outputs of the activities are the generated work products when a team member performs a set of tasks. Furthermore, a process of iterative refinement was introduced. Early game models were created and sessions were played with friends and family of the first author. Based on what was learned from the experience, the game was refined. Once the authors felt that the design was completed and harmonious, the design was locked.

Then, design work entered the tuning stage, during which the authors made small adjustments to the rules of the game. At this point, the game was positively evaluated by an expert in the ISO/IEC 29110 standard and a play session was carried out with third year students (33) in a project management class at a university in Ecuador, to gain experience and fine tune the definition and satisfaction of the learning objectives.

3.2 Game Description

This section will only briefly describe the gameplay and the various components of the game. Go for it! was designed as a non-Technological educational game for contributing to teaching the ISO/IEC 29110 standard elements where players are encouraged to understand the project management process of Basic profile. It is designed for use in conjunction with PM education or reinforces PM teaching points. The game environment is one that forces them to follow good practices. They experience the consequence of lack of knowledge in a way that simulates the actual project experience, through the delays of a project - length of the game - and loss of credibility – loss of points. They are also challenged to do their best in order to win. The idea is provide a participant engagement loop (i.e. the flow [AbCs12]), which help player to learn and participate more frequently and ultimately create planned participant behavior. As Korsa and Yitmaz stated in [12], the teacher do not actively participate. They act just like a game master to facilitate the game. Instead, students interact with each other and the game. After the play sessions, students draw their own conclusions about the experience based on time spent and points earned. The teacher actually just provides support mechanisms and follows an instructional scaffolding attitude. The game elements are presented in Figure 1 and the key game concepts are described below.

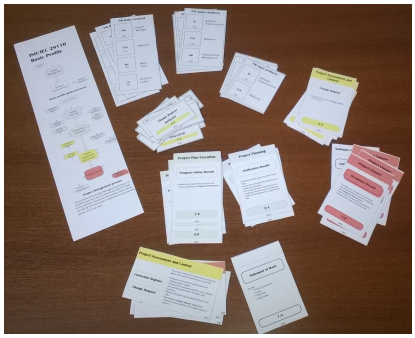

Fig 1. Deck of cards

Players, *Go for it!* is made for novices – 1 to 5 players new or relatively new to project management process. The players are the project team members.

Card Reference Guide is useful as a memory aid for the team. It includes the Figure 2 which shows the Project Management processes, a brief description of its activities and task, roles involved and source/ destination of input/output work products.

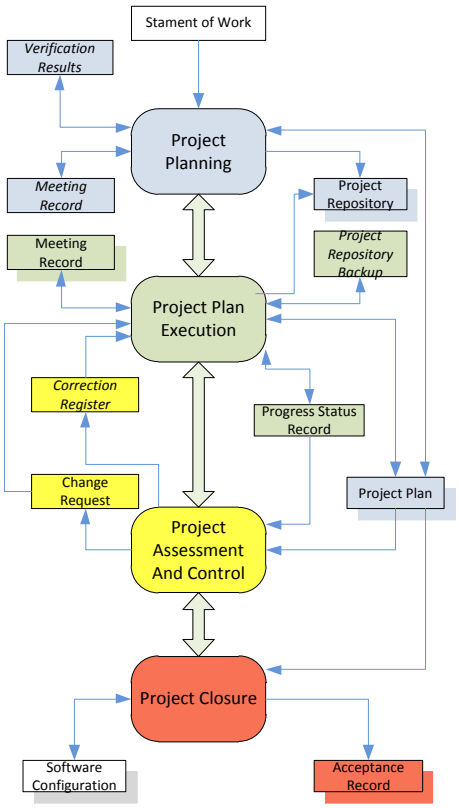

Fig 2. Project Management processes - Basic profile adapted from [2]

The Deck of Cards covers the four activities in the Project Management process: Project Planning, Project Plan Execution, Project Assessment and Control, and Project Closure. Each one of them corresponds to a group differenced with a color (blue, green, yellow or red) (see Figure 1). The white color represents the input and the output of the Project Management processes - *«Statement of Work»* and *«Software Configuration»*. Each one of them has two types of cards: Activity and State. A pair of cards is composed of one of each type.

Activity Card, an activity card is composed by four elements (see Figure 3): On the top, the name of the activity "*Project Planning"*. Below, the name of the resulting work products *"Project Plan"* the team generate when they do the activity, if it is an output the element is color and shadow. In the middle, it provides a checklist of tasks to be performed. On the bottom, the basic sequence of activities to follow.

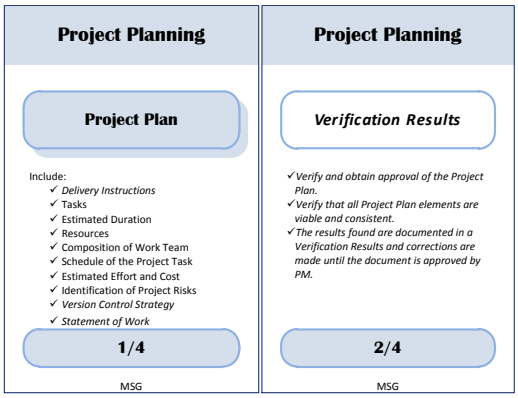

Fig 3. Activity Card

State Card, a state card is composed by three elements (see Figure 4): On the top, the name of the work product associated *"Project Plan"*. In the middle, the state achieved *"Verified"* by the product as result of the activity. On the bottom, the state sequence associated with the activity. When the word *"Continue …"* appears in the state, the players should continue with the next activity card.

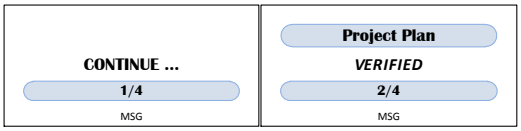

Fig 4. State Card

Gameplay has been defined as *"One or more causally linked series of challenges in a simulated environment"* [29]. Thus, a contest is organized as a single elimination

(or knockout) tournament by teams. In this format, everyone on the team has to make an effort in order to advance to the next stage. The winner advances to the next round while the loser is eliminated from the competition.

First, two pairs of teams simultaneously compete in two semifinals. The two winners (one in each semifinal) compete in the final, and the winner of the final obtains the prize. The losers of the semifinals do not compete further. The prize is defined by the facilitator. In each round, a mission should be complete by the teams. In order to accomplish their mission, they must complete four sub-missions; each one of them is one activity. The sub-missions are: Project Planning (blue), Project Plan Execution (green), Project Assessment and Control (yellow), Project Closure (red). The *«Card Reference Guide»* could be used as a map to guide the future moves.

Each team designates a delegate (player) who will play the cards. Any player may deal first. The dealer shuffles the cards and then deals them out, one at a time face down, to each player in rotation, until all the cards have been dealt. Each player plays one card from their hand which is selected by consensus among the team members. The team should justify it clearly based on the standard and the facilitator decides if it is valid and well enough justified. Then, the player places it face up on the table to make a pile. Next, the state card associated should be played by who hold it.

The first sub-mission starts with the player who holds the *«Statement of Work»* activity card. 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.

Winning. The winner of this game is the team that had more right moves in each round. As a result, they identify and recognize the largest number of best practices of the ISO/IEC 29110 standard.

4 Pilot Study

The research objective of this pilot study is to test the overall applicability of the game as learning tool. The game was applied to a 33-student group distributed in two sub-groups belonging of the course *"Software Quality"* from the *National Polytechnic School of Ecuador*. All the participants (25 men and 8 women) accepted voluntarily to take part in the study. Only four of them have previous Software Engineering experience in the industry. The game was practiced in two different sessions which had distinct facilitators and lasted 2 hours each. Before the sessions, the facilitators encouraged participants to read the standard on their own pace. Also, the facilitators planned the game session and agreed what would be the prize for the winners. On the game day, the facilitator spend one hour in order to present the ISO/IEC 29110 standard and the card game using a power point presentation. The second hour, the game session started, teams were formed (3-5 individuals), the tables and chairs were placed properly, and the teams played a two-round tournament, the winner of which played the top player. Finally, the prize was allocated to the winner team. Each round lasted about 15 minutes. Also, it was observed that individuals overwhelmingly (94%) agreed that would like to play again. Figure 4 depicts the interactions during the game session.

Fig 4. Game Session

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 was validated by two experts for face validity and amendments were accordingly. The results are summarized as follows. Table 1 shows a snapshot of the background above mentioned.

Table 1. Background to the two groups

Background	Groups	
	A	B
Gender (Female/Male)	4/11	4/14
SE Experience (Industry)	1	3
SE Experience (Academic)	15	18
Semester	7	7
Group Size	15	18
Individuals per group	3-5	4-5
Game Length per round (minutes)	10-15	10-15
Would Play Again (YES/NO)	15/0	16/2

For most of the questions, a five point Likert scale was used (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree) in order to measure the level of agreement. Table 2 presents the frequencies of each of the responses, along with their arithmetic means and standard deviation values.

Table 2. Frequencies, mean and standard deviation

	1	2	3	4	5	Mean	Standard Deviation
Participant Involvement			5	18	10	4.15	0.656954
Alternative to Classroom	1		6	14	12	4.09	0.899954
Fun Factor		2	3	20	8	4.03	0.758182
Engaging		2	5	18	8	3.97	0.797148
Design useful		2	6	17	8	3.94	0.814244
Kept Me Interested			9	17	7	3.94	0.693668
Knowledge acquisition		2	16	12	3	3.48	0.743506
Encourage to Knowledge	2	2	13	11	5	3.45	1.017749

As a result, two groups arose from the data. The arithmetic means in the first group vary between 4.15 and 3.94. The question from the first group "Participant Involvement" has the highest average with a 4.15 arithmetic mean and 0.656954 standard deviation. From here, 85% of students stated that they were involved during the game and pointed it was fun. In fact, 25% of out of the total strongly agreed with the last statement. In addition, 79% of participants report that the game is an alternative to a traditional classroom activity. Although one defeat was enough to eliminate a team from the tournament, the game engaged 79% of the participants. And 73% of the participants kept themselves interested during the game.

In this group, 76% of the students also pointed that the game design is useful. They believe that the game has a meaningful design because the cards include color coding and numbered linked with the processes flow. Likewise, the card reference guide helped students to familiarize themselves with the standard.

The arithmetic means of the questions in the second group vary between 3.28 and 3.45. When the questions in this group are examined, it can be seen that 45% 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 standard. And, nearly the same number of the participants remained neutral. 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. Bear in mind that two participants strongly disagree with the issues about encourage to knowledge and alternative to classroom - i.e. 100% of these answers. Also, they disagree with the items about fun factor and design useful - i.e. 100% of these answers. One of them also disagrees with the items about engaging and knowledge acquisition - i.e. 50% of these answers. And the remaining (50%) come from another participant (third). This last participant in conjunction with another one (fourth respondent) also disagree with the item of encourage to knowledge, his remaining answers has the average with a 3.57 arithmetic mean and 0.494871 standard deviation. In fact, the lowest scores in Alternative to Classroom Activity, Fun Factor, Engaging, Useful Design and Encourage to Knowledge appeared as outliers point when Pierces criterion were applied [30]. Below is a briefly description about the process and results (see Table 3).

Table 3. Pierces criterion

	Mean	**Standard Deviation**	**Pierce's Criterion**	
			R * SD	**$\|x_i - x_m\|$**
Alternative to Classroom	4.09	0.899954	2.18	3.09
Fun Factor	4.03	0.758182	1.63	2.03
Engaging	3.97	0.797148	1.71	1.97
Useful Design	3.94	0.814244	1.75	1.94
Knowledge acquisition	3.48	0.743506	1.60	1.48
Encourage to Knowledge	3.45	1.017749	2.18	2.45

First, obtain R from the table for one measured quantity assuming one/two doubtful observation and 33 measurements: R = 2.425/2.146. Secondly, calculate the maximum allowable deviation $|x_i - x_m|_{max} = R * SD$ where x_i is a measured data value and x_m is the mean of the data set. Third, obtain the actual deviations for the

suspicious measurements $|x_i - x_m|$. Finally, eliminate the suspicious measurements if: $|x_i - x_m| > |x_i - x_m|_{max}$. Therefore, there are three respondents (9%) disagree.

In the light of this, the two open questions about the game and the experience of these participants were analyzed in order to gain a more comprehensive view. The biggest issue rested with the game rules as exemplified by the next quotes from two of the participants *"A lack of easy understanding of the rules"* and *"I liked it [the game], but it requires a more detailed manual"*. Furthermore, another participant stated *"It [the game] seems boring and little interactive"* and the last one of them pointed out *"In my opinion … there should [in the game] be a greater degree of complexity and not have many clues for playing ..."*, but conversely, most respondents commented that the game was interesting, fun, didactic and intuitive as exemplified by other respondent *"It's something fun and also teaches"*, with another respondent confirming that *"It is a very interesting game and encouraging"*. A further respondent highlights that *"It was cool to learn with a game"*. With another respondent stating that *"you can learn about the standard in your own pace"*. Consequently, the game was embraced by most of them as someone put it most succinctly, *"It's a good experience to understand the structure of the ISO/IEC 29110"*.

In discussions after gameplay, the facilitators observed that participants were more comfortable with the ISO/IEC 29110 standard. The gameplay environment forced participants to gain awareness and understand what they had previously read about ISO/IEC 29110 standard in order to accomplish the mission. The main benefit appeared to be the ability to bring relative PM novices together to leverage each other's knowledge and begin a PM dialogue. Moreover, the facilitators supported the findings and recommended i) create exclusive materials for them in order to lead the session game easily, and ii) Translate the game to Spanish.

Finally, the respondents suggest improvements such as clarify the rules, create a demo or tutorial, translate it to Spanish, highlight color and numbering, and include figures.

5 Conclusions

This study was explorative in nature. Although, it could not statistically demonstrate a learning effect, subjective evaluations indicates the potential of such a game to support education. In addition, the study provided first insights on the game and its main strengths and weaknesses, which will systematically guide its further evolution. Based on results from this study, the game seems to be fun, immersive and certainly involve the participants, who engage in a game that reflect Project management demands in VSEs. Therefore, overall applicability of the game as a learning tool is achievable. However this study had reveled issues that need to be addressed through further studies. Thus, the authors are planning to repeat the experiment with certain modifications to the initial training of the facilitators to enable the acquisition of a more comprehensive understanding as well as adaptations to the experiment material and the game itself. Once the enhanced version of the game becomes available, the authors will repeat the experiment. In this sense, the results of the study presented in this paper will also be useful as a baseline for comparison.

Some work is still to be done about this topic: i) improvement of the game by analyzing the suggestions made by the participants, ii) improving the game by including other elements, like memory challenges, visual clues, time pressure, iii) practicing the game with undergraduates students in others locations in order to reveal if the gameplay allow the transference of the concept across cultures, and iv) future works should include new ways to game that involve more interaction among team members, hence extending the individual learning opportunities.

Acknowledgments: The authors would like to thank Andrés Larco, the course tutor, who played a major role in the use of the game. A special thanks also to all the students of the course "Software Quality" in 2015 of the National Polytechnic School of Ecuador, who participated in the evaluation of Go for It!.

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