

Game-based Learning in Requirements Engineering: An Overview

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Abstract—The use of games in the teaching and learning process is not new. It is said to be able to improve students understanding when the subject matters are taught in a less formal but more meaningful way. With the advances of technologies, educational games have evolved into digital games too. They have been introduced into many areas of study such as medicine and engineering. Software engineering is not spared. Since the last few decades, gamification through the use of digital and non-digital games are seen applied in the teaching of various topics of software engineering such as requirements engineering, design and testing. In this paper, a review is specifically made on the games that have been introduced to teach requirements engineering (RE) to the students. Particularly, the types, the learning objectives and the possible classification of the games are presented and discussed. The aim of the review is to identify the current state of RE games with respect to the above. Keyword searching was used to identify the relevant literature to be included in the review. Results showed that the existing RE games can be broadly divided into digital and non-digital games with role playing prevalently used as the game mechanics. Details on the learning objectives of the games and the evaluation performed on the games are also collected and analysed.

Keywords—gamification, software engineering, educational game, serious game, active learning

I. INTRODUCTION

Requirements engineering (RE) comprises activities such as requirements elicitation, requirements specification, requirements verification and validation, as well as requirements management [1]. All of these activities are required to be performed at the beginning of a software development project to ensure correct requirements are collected from the clients. Thus, RE is one of the crucial early stage activities of a software development cycle [2]. This is the stage where clients can communicate about the scope and requirements of the system with the developers. Any misunderstanding and miscommunication at this stage will affect the subsequent stages of the development cycle. For example, wrongly captured requirements will lead to incorrect system design and subsequently wrong implementation. Thus, RE often becomes the main factor that determines the success or failure of a software development project and regarded as a very challenging task from the perspective of the software developers [3]. The misunderstanding of the clients' requirements could have occurred as a result of the RE process that is taken lightly and hence, not done thoroughly. This could have originated from the lack of interest in performing the RE activities. Therefore, firm understanding on the importance of RE activities should be instilled during the time the students learn about this subject at the universities. The common perception amongst the students with respect to the RE subject is that, it is very theoretical and to some extent, boring. As a result, they could not appreciate the importance

of each activity in the RE process. Subsequently, the matter is not being taken seriously when they begin working.

Apart from the content, another reason that could have contributed to the lack of understanding of and interest in the RE process is the way the content is being presented or delivered in the class [4]. With monotonous lecture on theoretical subject, the students are having difficulties in absorbing the knowledge. A number of delivery methods have therefore been proposed to improve the students' understanding on the subject. These methods mostly require the students to actively participate and interact in the class. Thus, this approach is also known as the 'active learning' method. Active learning is generally defined as an instructional method that requires interaction with the students to do meaningful learning activities or thinking about what they are doing in the classroom. The core element of the method is students' engagement throughout the learning process [5]. Unlike passive learning, this learning approach is said to be better because it involves students' interaction among themselves and the teacher through discussions and collaborations, critical thinking as well as problem solving [6].

There is a lot of methods that can be used to adopt active learning in the teaching process such as think pair share, role playing, discovering plate boundaries, peer review, and game based learning [7]. Another form of active learning is through the development of 'serious game'. A serious game is a digital game, simulation, virtual environment and mixed reality or media that provides opportunities to educate or train through responsive narrative or story, gameplay or encounters [8]. In addition, it is well established and has growing presence across diverse domains, such as science, engineering, business, psychology and healthcare. The difference between a serious game and an ordinary game is that serious game is not primarily served for entertainment [9]. In fact, what really differentiates between a serious game and any other games is the learning objective. As digital gaming is getting trendy among the youngsters, which include the university students, applying serious game in the teaching of RE seems to be a potential way to help students understand RE better. As shown by the statistics, 97% of the boys and 83% of the girls play digital games in general [8].

Therefore, in this study, a review on serious games used in RE subject is performed. This study does not intend to provide an extensive overview of the games used in the teaching of software engineering as a whole as there are already a number of extensive review done on this [10][11][12]. Thus, the focus is more specific to RE subject. Listed below are the research questions addressed by the study.

- RQ1. How many serious games used for the teaching of RE that have been reported so far and what are they?

- RQ2. How can these games be classified?
- RQ3. What are the learning objectives of these games?
- RQ4. What are the outcomes of the implementation of these games?

In order to answer the research questions mentioned, firstly, the existing games used so far in the teaching of RE at the tertiary level were identified and classified. Next, the learning objectives of the games were extracted and finally their evaluation outcomes were analysed to determine the extent to which they have contributed to the RE learning process. The rest of this paper is organised as follows. The next section explains about the method used in performing the review. In section III the review results are presented and analysed. Finally, section IV concludes the paper.

II. METHOD

In this section, the search strategy used to obtain the relevant articles to be included in the review and the study selection is presented.

A. Search Strategy

An exhaustive literature search was conducted to collect related work to be analysed. Keywords were used in performing the search from the identified databases, which included IEEEExplore, ACM Digital Library and Scopus. Listed below are the keywords used in searching the articles from the databases, which are divided into three fields; education, software engineering and game-related approaches.

- *Education*: teach, learn, education, train
- *Software engineering*: software requirements, requirements engineering
- *Game-related approaches*: game, serious games, edutainment, gamification, game based learning, GBL

In the searching process, keywords that belong to the same field are searched using the logical query 'OR' while 'AND' is used to connect between the keywords from different fields. As for the keywords that consist of more than one word, double quotes "" are used to enclose the words to avoid ambiguity and misinterpretation by the system.

B. Study Selection

In order to select the relevant articles from the results returned by the search process, inclusion and exclusion criteria were determined. Papers were included in the analysis only if they fulfil both criteria. The inclusion criteria are shown below.

- The study is written in English
- A game is being developed in the study
- Full article is available
- The study focuses on enhancing students' understanding in RE through the use of the proposed game(s)

At the same time, some work needed to be opted out from the review if they were found to be out of the scope of the study. In this respect, the following types of work were excluded from our further analysis (exclusion criteria).

- Work that is not focusing on enhancing students' understanding of RE
- Work that develops game as means to practice the requirements engineering knowledge learnt, also known as game development based learning (GDBL)

Each selected article was analysed to extract the required information to answer the research questions listed earlier.

III. RESULTS AND ANALYSIS

Table I shows the results obtained from the literature search performed. Initially, a total of 12 publications that describe about the use of serious games in the teaching of RE was found. However, after some preliminary analysis, it was found that a number of these publications are describing about the same work. Since the objective of this study is to identify the games rather than the publications (RQ1), papers describing the same work/game were combined. Therefore, a total of nine games used in the teaching of RE was gathered at the end of the search as shown in Table I.

TABLE I. LIST OF PUBLICATIONS

Pub. ID	Year	Publication Type	Game Name	Ref.
G01	2008	Conference	SESAM-based	[13]
G02	2007, 2011	Journal, Conference	SDSim	[14]–[16]
G03	2007	Conference	Groupthink-based	[17]
G04	2007	Conference	MO-SEProcess	[17]
G05	2010	Conference	REWIKI	[18]
G06	2008	Conference	Re-O-Poly	[19]–[21]
G07	2010	Journal	MMORPG-based	[22]
G08	2003	Conference	-	[23]
G09	2009	Conference	TREG	[24]

A. Types of RE Games

Based on the existing studies on serious game in requirements engineering collected, it can be seen that the games can be broadly divided into three categories; digital, non-digital and hybrid.

1) *Digital*: Digital games are the games that are played using electronic devices such as laptops and smart phones. It can be either web-based or standalone applications. Web-based applications are the applications that are accessible through the internet and users will need to use the web browsers to launch the applications. For standalone applications, they are the applications that run on standalone computers and do not need web browser to access. From the list of the games in Table I, the following games are categorised as digital games.

- SW Quantum (G01) – a game that evaluates the correctness of requirements that the players grabbed from customers through the conversation dialog provided.

- SDSim (G02) – a software development team (single player or multiplayer) that has to manage and deliver several projects.
- Groupthink (G03) – a game for the users to answer software development related questions in pop-up dialogs and get evaluated by the system.
- MOSEProcess (G04) – a game for players to choose their roles from the six roles provided and complete the projects given within the due dates.
- TREG (G09) – a branching stories genre game that involves software development team meeting.

From the above list, G01 is a standalone digital game and the rest are web-based digital games. The digital games were further categorised according to their development platforms. For the standalone application, there was an applet, a Java application that was embedded into the webpage to produce the dynamic content [25]. For the web-based applications, there were plenty of platforms used for developing the games such as using Web 2.0 technologies [26] and Secondlife Virtual World [27]. Table II below shows the categorisation of the platforms used to develop the digital games.

TABLE II. PLATFORM USED TO DEVELOP THE GAMES

Pub. ID	Tool
G01	Java
G02	Java
G03	Secondlife Virtual World
G04	Secondlife Virtual World
G09	Secondlife Virtual World

2) *Non-digital*: Non-digital games are the games that the players have to play physically where they will have to interact with each other face-to-face in order to complete the game. As opposed to the digital games, these games do not require the use of computers in order to play. From the list of the games in Table I, the following are identified as non-digital games.

- RE-O-POLY (G06) – a Monopoly-based board game with RE tasks and projects on the board instead of properties in conventional Monopoly game.
- MMORPG (G07) – a game for the users to act as different roles in software development team in each level and have to complete tasks to advance to new level.
- Role Play (G08) – a class of students that are divided into customers and development teams communicate with each other to produce SRS.

3) *Hybrid*: There is also another category of games that use both physical and online interaction. This is classified as hybrid. Hybrid games are the games that use digital means to assist the physical activities. From the list of the games in Table I, there is only one game that falls under this category as shown below.

- Role Play and RE Wiki (G05) – a group of students that forms a software development team, produces

documents and communicates using RE Wiki and other communication tools such as emails.

B. Game Mechanics

With regard to the game mechanics, it can be seen that *role playing* is dominating the RE games. Role playing is a learning concept where students will assume some roles that exist in the real situation. The students will have the opportunity to use their creativity in simulating the real tasks without worrying about the risks of the real world [28]. Learning by means of role playing has been practised in different fields such as nursing, medicine, engineering and management. In the context of software engineering, the roles that are involved are usually project manager, team leader, system analyst, software designers, software testers and customers. Therefore, each student belonging to a group will have to play one role. From the list of games in Table I, it is found that all of the games use role playing. However, the roles to be played by the students in each game differ as shown in Table III below.

TABLE III. ROLES AVAILABLE IN EACH GAME

Pub. ID	Project Manager	Req. Engineer	System Analyst	System Designer	Team Leader	Software Architect	Software Engineer	Programmer	Customer
G01		√							
G02	√		√	√	√				
G03	√		√	√	√				
G04	√		√	√	√				
G05			√						√
G06			√						
G07		√	√	√		√	√	√	
G08			√						√
G09			√						

From the table, it can be seen that all of the games, except G01 contain the 'system analyst' role. It shows the importance of this role in the requirements engineering process. This is not surprising because system analyst is one of the roles that analyse the requirements given by the clients. This role is essential in software development process as system analyst is the one who creates functional and technical specifications of the system to be developed [29], so it should appear in the games for the students to understand more about this significant role. As for G01, the term requirements engineer was used. Instead of playing the role as system analysts, students will be playing the roles of requirement engineers. Requirements engineer is the one who elicits, analyses and documents the requirements of a system [30], and it is important for a requirements engineer to know how to elicit and analyse the requirements clearly. In our opinion, there is an overlap between the system analyst and the requirements engineer role, i.e. they perform similar functions. This can be seen from Table III where most of the games only provide either one of these roles. With regards to the coverage, it can be seen that only G07 provides an almost

complete software development environment for the students to play. It has all the required roles from requirements engineer to programmer. The rest are mostly focusing on the requirements analysis and design only.

C. Learning Objective

Next, learning objectives of the games are identified to answer the third research question (RQ3). Table IV below shows the learning objectives of each game and the focus areas of the games. Although all of the games were developed in different ways and platforms, their makers' intentions are always to help the users to understand RE better. All of the games presented are also focusing on the different areas of the software development cycle. G02 and G03 focus on the more complete software development process; while G01 emphasises on the requirements validation and verification as well as software quantum. The other games are the RE games that concentrate on either RE practices or RE in general.

TABLE IV. LEARNING OBJECTIVES OF THE EXISTING SERIOUS GAMES

Pub. ID	Focus Area	Learning Objective
G01	Validation & Verification, Software quantum	To convey the flow rate phenomena that take place during requirement elicitation
G02	Principle of software engineering process	To enable the learner to take a disciplined approach to requirements collection and analysis, and to the high-level specification, design and implementation of information systems
G03	Fundamentals of software specification activities and principles of software development processes	To teach students the importance of software specification
G04	Fundamentals of software specification activities and principles of software development processes	To teach students the importance of software specification
G05	RE practices	To set up a collaborative and Web-based RE environment.
G06	RE practices	To introduce RE practices to complete novices and reinforce existing knowledge for others
G07	Principle of software engineering process	To be the first exposure for most software engineering technology students to large scale software engineering problems
G08	RE practices	To introduce students to the foundations of RE
G09	RE in general	To teach RE using simulations and collaboration

D. Evaluation of the Games

Most of the authors performed evaluation on their games and described about the evaluation in their work. The details are as shown in the table below. G09 however, did not report about evaluation in their work. Thus, Table V below shows

the findings from the evaluation performed on eight of the nine games (G01 to G08) only.

TABLE V. EVALUATION OF THE GAMES

Pub. ID	Method	Finding
G01	Observation	By learning about new options in the game, students also learn and experience important options and phenomena in software projects. The importance of oral communication and reviews, alternative routes of requirements flow, and the impact of different quality requirements are playfully introduced.
G02	Pre-test and post-test	Students who played the game tend to learn the intended concepts, and find it to be a relatively enjoyable experience. During the pre-test, both groups showed the same level of knowledge. Meanwhile for the post-test, the group that used game showed a significantly better result than the group who did not.
G03	Survey among students	34 percent of the 29 students who played Groupthink game thought that the game was definitely helpful, and 59 percent thought that the game was somewhat helpful.
G04	Survey among students	34.6 percent of the 26 students who played the game thought the game was definitely supportive, and 57.7 percent thought the game was somewhat helpful.
G05	Survey among students	The majority of the students who took part in the game agreed that - they knew what general responsibilities for different roles (in RE) are. - role playing method was useful to practice RE skills and understand the real problems during the communications for requirements. 45 minutes were enough for the external meeting between developer and customer team. - changing role every week was reasonable for each member to experience different roles in a development project, although it could cause some difficulties. - structures and templates for requirements documentation provided in RE-Wiki were well-organized.
G06	Observation Survey among students Pre-test and post-test	Pace University: Students found that the game was effective as a teaching tool. The facilitator observed that the game helped to unite teams of players through dialogue and laughter. The test scores of the participants from the combined two sessions increased by 26% in the aggregate after they played the game. All of the participants in ITC Cambodia showed an increase in knowledge at the end of the session. The participants who played the game or read the papers showed a more significant improvement of 32% and 25% respectively.
G07	Survey among students	Students could control the work better after applying the game to the study. Low performing groups were able to improve their skills to mid-level or higher. However, students were also found using

Pub. ID	Method	Finding
		shortcuts to complete the tasks given, which resulted in the work/assignments not being seriously taken.
G08	Survey among students, Observation	Overall, students were satisfied with the contents of the course and stated that they learnt a great deal about technical as well as non-technical issues of RE. Students seemed to enjoy and were motivated by the challenges of the active approach.

Overall, most of the evaluations showed good outcomes towards the developed games. With regard to the evaluation methods, there were three types of evaluation methods used by the authors to assess the games used in their work; observation, survey among students (questionnaire) and pre-test/post-test. Survey seemed to be the most common method used for evaluation as it was the most direct way to get the feedback about the games. The students were the users who experienced the games and could provide on the spot feedback on anything that went wrong or needed improvement. Observation was also one of the easiest and most direct way to get the reaction of the users. By observing the interaction between the users and the games, we can easily know about the parts where the users are having problems with the games. As for the pre-test/post-test, it will be able to show more accurate results of the improvement of the students' learning. However, more work is needed for the tests preparation.

Based on the findings, students showed improvement in understanding the RE subject after playing the games. They were able to control their work flow (their RE subject assignments) after they applied the games to their studies. Most of the students were also satisfied with the content of the games, either digital games or physical role play games. They were able to understand about the general responsibilities of each role in the software development process. However, for G03, only around 34% of the students who participated in the game thought that the game was definitely helpful, while around 57% thought that it was "somewhat" helpful. Less than half of the participants thought that the game could help them in understanding RE subject better. Therefore, the game content or the platform should be revised and improved so that the objective of enhancing the understanding among the students can be achieved.

Based on the findings from the review, it can be concluded that game based learning provides positive impact on the learning process, especially for the subjects that the students think are "boring" and "uninteresting", i.e. the subjects which the contents are mainly theoretical. When the students involved themselves in the games, they would have to understand the situation and the instructions in order to advance to the next level, not to mention the good acceptance level of the students to learn through games. Thus, the learning path becomes more interesting. Although all of the studies showed that the students managed to improve their RE knowledge after playing the games, room for improvements are still plenty in this area. One notable gap is the missing of a guideline or framework that can be referred to determine the elements that should constitute a serious game for requirements engineering. In most of the studies reviewed, there were no mention of any specific framework followed in

developing the game. The presence of such framework will be a great contribution to the development of serious games in this area as more consistent and uniform games can be produced.

IV. CONCLUSION AND FUTURE WORK

This paper presents the results and findings from the review performed on the use of games in the teaching and learning of RE subject. Included in the analysis and discussion are the types of game, the development platforms, the learning objectives and the evaluation performed after testing and experimenting with the users. Most of the studies found that the use of games in the teaching and learning of RE brought positive impact to the students that enhanced their understanding on the subject matter. Moving forward, this research will focus on the development of a unified serious game framework that can be used in assessing the identified games.

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