Gameplay to Introduce and Reinforce Requirements Engineering Practices

Renel Smith and Orlena Gotel

Department of Computer Science, Pace University, New York
r-smith@comcast.net; ogotel@pace.edu

Abstract

This paper reports on the design and use of a board game to introduce students and organizations to Requirements Engineering (RE) good practices. Our position is that the awareness and adoption of RE practices can be facilitated via simple, low-cost and creative gameplay as part of an educational or training program. This paper describes a game called RE-O-Poly that was developed to introduce and reinforce a fundamental set of established RE good practices. It then reports on a series of studies that were undertaken with undergraduates, graduates and IT professionals to gain preliminary validation of the game concept, to investigate results from use and to explore its positioning for adoption in an RE program. The findings are presented and inform a discussion about the wider role of gameplay in RE education and training.

1. Introduction

Requirements Engineering (RE) deficiencies are considered one of the common causes of project failure in the software industry [16]. While the literature is replete with new processes and techniques that can address these deficiencies in large organizations with requisite resources (i.e., time and money) for comprehensive training programs, much less attention has been paid to how to effectively introduce simple RE good practices into small novice organizations where the RE experience and resources for developing RE competence are limited [10].

This work draws upon the many RE good practices [1, 19, 22] described in the literature and identifies a lightweight set that is anticipated to help small novice organizations in their initial requirements development and management efforts. In considering how best to introduce and reinforce the use of these practices, the work explores the use of games as a pedagogical tool and proposes a game-based approach as a way of helping such organizations convey awareness and institute these practices in a fast, painless, relatively transparent and cost-effective manner. This paper describes an example RE game, called RE-O-Poly, based upon the popular board game Monopoly®. It is intended to teach RE good practices to novice requirements engineers by introducing and reinforcing a set of lessons based upon the good practices, and posing challenges based upon knowledge of these practices, as players accumulate and discharge project RE responsibilities. In the process of developing and validating this game, the authors have explored its role as a general educational tool for software engineering students.

The structure of this paper is as follows. Section 2 discusses the RE challenges common to many software development projects and draws upon the literature to identify a set of good practices that can potentially assist with the most pressing ones. Section 3 discusses the pedagogical potential for games in RE education and training, describes how games can help organizations introduce and adopt new ideas, and presents a number of challenges to creating effective games. Section 4 discusses the motivation behind the RE game concept and the learning objectives. RE-O-Poly is described fully in Section 5. Section 6 outlines the method for preliminary validation and the threats to validity of its results. Section 7 presents a series of three case studies and analyzes the data collected. Based upon these findings, Section 8 discusses the role of gameplay in RE education and training, and then summarizes our ongoing efforts.

2. RE Good Practices

One typical challenge confronting the engineering of better requirements is a lack of awareness amongst software development practitioners and their management of basic RE principles and practices, along with an appreciation of their potential value in their working context [13]. This is compounded by perceptions as to the cost of investment required for RE training and application.

The premise of this work is that there are many simple things that an organization can do to create an environment and culture for RE, and that there are basic good practices that practitioners should be aware of, can adopt and build upon. However, often buried in texts and papers, we seek to examine alternative ways to promote awareness of these RE building blocks amongst a group of practitioners.

The Requirements Engineering Good Practice Guide (REGPG) provides a list of 66 good practices that cover RE processes and activities and are applicable to novice organizations with little prior use and knowledge of RE [15]. Coupled with popular

practitioner-oriented literature designed to help get a reader started with RE [1, 19, 22], we assembled a list of ten foundational RE practices. Table 1 depicts the practices we focus upon in this study. Note that the research does not seek to validate this consolidated set. Rather, it seeks to explore and validate ways in which this set of practices can be introduced and reinforced. In particular, alternative ways to supplement their availability as personal reading material and to actively encourage a dialogue about them.

Table 1. Sample RE good practices

Good Practice	Description	Benefit
Defining Goals	Defining the intentions that stakeholders have for a project.	Provides project focus and scope.
Identifying Stakeholders	Identifying anyone who gains or loses something as a result of the project.	Ensures requirements are what the stakeholders want and mitigates missing requirements.
Consistent Structure	Using a clear structure in requirements documents.	Provides higher quality and lowers the cost of requirements documents.
Versioning	Ensuring requirements documents are easy to change.	Reduces the likelihood of freezing requirements prematurely or implementing obsolete requirements.
Unique Identifiers	Uniquely identifying each requirement.	Supports traceability and requirements change.
Agreeing Policies	Defining and agreeing policies for requirements management, prioritization, conflict resolution, etc.	Provides guidance and standard operating procedures for all involved.
Using Templates	Using standard templates for representing individual requirements.	Presents requirements in a recognizable manner, so easier to consult and see what is missing.
Simple Language	Writing requirements simply, consistently and concisely.	Leads to requirements that are easier to read and understand.
Running Inspections	Organizing formal requirements inspections and acceptance testing.	Finds a high percentage of requirements problems early.
Consulting Checklists	Employing checklists for validation and analysis, etc..	Helps to focus activities and avoid forgetfulness.

3. Education and Training Games

Colloquially labeled 'edutainment', games have the ability to provide entertainment and play while at the same time educating the players [18]. When games draw upon real life and modern culture, they can be powerful tools for facilitating learning. For example, a role-playing computer game-based environment has been used to simulate everything from managing a football game (e.g., Madden NFL® 200X and NCAA Football®) to constructing entire civilizations (e.g., Sid Meier's Civilization® game). The military has long used simulation games to evaluate strategies, explore scenarios and reveal unexpected weaknesses in battlefield positions [12]. Recently, management consultants have been engaging with business leaders to use games to explore possible futures and trends in their industries [2, 3]. A significant amount of research has gone into using games as a teaching and learning tool. Since the players in a game are actively engaged as participants, the hypothesis is that they are more motivated and so are more likely to learn and remember new information than they would from mere passive listening or reading [4, 12].

Games have been used in software engineering and project management educational settings as a supplement to classroom-based teaching with some success. Recent examples include games for teaching software project risk management [17], SimVBSE for teaching value-based software engineering [6] and SimSE for learning about software processes [8, 9]. Using specialized decks of cards, games have also been designed to teach the practices, values and concepts behind XP and object-oriented programming, including the popular XP War game [5, 7]. Given the centrality of RE to the success or failure of software development, we were surprised to find no prevalent or commonly used games for this discipline.

Designing a game for education and training is not trivial and presents a number of challenges:
- Will the game capture attention of all players and encourage participants? There is a need to engage the learner without being overly pedantic.
- Are there unintended consequences? Beyond the anticipated content and learning objectives, what other types of information might be conveyed by the game? Will negative themes or undesirable perspectives be conveyed? Will playfulness undermine the seriousness of the topic?
- How do you best achieve the pedagogical objectives and potential of the game and further evaluate whether these have been achieved?

More specifically, and in relation to RE:
- Can a game provide a broad overview of RE and accurately reflect its challenges?
- How can a game teach the value of RE, its processes and good practices, while helping players to start to learn to apply this knowledge?
- How can domain-specific RE concerns be adapted to an educationally relevant context?
- Since RE is predominantly an interactive and discursive activity, how can participant co-design of the experience be ensured during gameplay?
- Given that RE crosses cultural boundaries in its practice and application, how will the game work for an international audience?
- If the game is to supplement regular class sessions or training, how can participants gain an intense but rewarding RE experience in one hour or less?
- How do you make learning RE basics anything that might be approaching fun?

4. RE Game Concept

During concept development for our RE game, the design and the rules were volatile. Input was gathered from various sources: industry material, academic literature, and Pace University faculty and students. Initial attempts were made to incorporate the Clue® whodunit concept into an RE game, but the

model became undesirably complex. We also struggled to design card games with no success.

Given that we desired a fast, painless, relatively transparent and cost-effective approach to introduce and reinforce RE practices, that further addressed the challenges of Section 3, we decided to adopt a familiar game concept: Monopoly. Monopoly was developed in the public domain and claims to be 'The World's Most Popular Board Game' [11]. Further, it is sold in 103 countries and produced in 37 languages. Using the Monopoly interface as a model provided the dual benefit of shortening the game design time as well as offering players a proven and recognizable interface to lower the start-up time for any instance of gameplay. Also, the board game actively encourages face-to-face communication, especially in the form of negotiation amongst a set of players, which is valuable for learning about a discursive activity like RE. RE-O-Poly is a first-generation, board-based and project-based simulation game that incorporates the set of ten RE good practices of Section 2 into its gameplay.

One might think that a more appropriate concept for an RE game would be one where players are encouraged to collaborate to achieve success on a shared project, rather than the traditional Monopoly game where one player wins at the expense of everyone else. However, the winner of RE-O-Poly is the player who competently selects projects and runs the RE activities on them. Further, we actively engender collaboration via consensual decision-making, where articulating, questioning and negotiating answers to challenges within the game fosters a natural and safe team-building environment.

Early game models were created, and sessions were played with family members of the first author and with second year students in a computer technology class at a community college in New York City to fine tune the definition and satisfaction of the learning objectives. In discussing the game concept with others, RE educators and practitioners have since suggested using the Snakes and Ladders game concept (the ups and downs of RE projects), the poker game concept (for gambling on requirements), as well as many other possibilities. These ideas suggest enthusiasm and scope for a compendium of RE games.

5. RE-O-Poly

RE-O-Poly was designed to explain and explore RE good practices. Since requirements are often conflicting and unprioritized, players have to learn to resolve conflicts and determine priorities in the game. The game environment is one that forces them to answer both general and project-specific RE challenges, make constant proactive decisions about projects they are responsible for, and respond appropriately to unanticipated situations that impact their projects. They experience the consequence of those decisions in a way that simulates the actual project experience, through the loss of a project, loss of credibility or a backwards step in overall progress.

The game board is shown in Figure 1 and the key game concepts are described below. For a larger and easier to read game board and a copy of the game rules, please visit *http://home.comcast.net/~r-smith*.
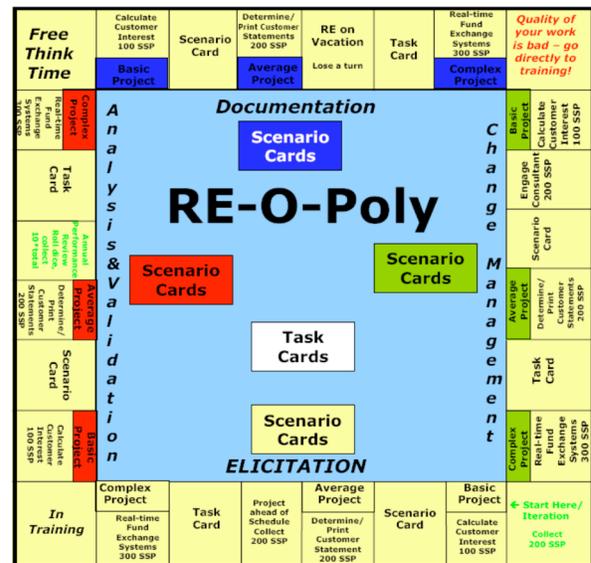

Figure 1. RE-O-Poly game board

Players. RE-O-Poly is best played by novices – 3 to 8 players new or relatively new to RE. It is designed for use in conjunction with RE education or training to introduce or reinforce RE teaching points. Gameplay is desirably facilitated and the projects used in the game need to be tailored to the domain or industry of the group undertaking the training for best relevance and impact (e.g., defense, media, finance, telecommunications, etc.)

The Game Board covers four basic stages in a general RE process: Elicitation, Analysis and Validation, Documentation, and Change Management. Like Monopoly, play is advanced by the roll of the dice. One circuit around the board represents one pass through a typical RE process for three types of project: a basic, average and complex project. The intention is to convey the fact that multiple circuits or iterations through these RE stages are required on any one project to engineer requirements. The Monopoly board positions have been modified to reflect an RE context For example, 'Go Directly to Jail' has been replaced by 'Go Directly to RE Training' -- for poor quality work of course!

Projects. As players move around the game board they may 'buy' the projects they land on if not already owned. There are twelve project cards pertaining to the three project types spanning the four stages of RE the projects could be in. Basic projects cost the least to buy (i.e., stakeholders have more trust when the stakes are lower), while complex projects cost the most to buy (i.e., risky so demand safe hands). Players can purchase projects if they have sufficient Stakeholder Satisfaction Points (SSP). Players receive project cards representing their ownership of an RE project, which means that the player becomes responsible for the project in a specific RE stage. Purchase of ownership is not always a wise decision as the player then becomes open to challenge about stage-specific RE activities in the context of the project. If a player lands on a project that is owned by another player, the landing player must challenge the project owner by asking one of the three questions indicated on the back of the corresponding project card. The premise of the challenge is that a project owner should know the answers to the questions on their projects. If the project owner successfully answers the challenge, then the landing player must pay the designated SSP to the project owner. Alternatively, if the project owner fails to correctly answer the challenge (see consensual decision-making below), then that player must pay the designated SSP to the challenger. A project owner achieves 'expert' status, and immunity from further challenge, if they successfully answer all three questions on the project card. A project owner who fails to satisfactorily answer two challenges loses control of that project and must turn in the corresponding project card to the facilitator. So, players need to consider when they are ready to be responsible for a project's RE activities, else face losing their SSP.

Stakeholder Satisfaction Points (SSP). The object of the game is to amass the most SSP. SSP represent a stakeholder's belief in the RE skills of a player and their ability to effectively carry out RE tasks related to projects. All players receive the same number of SSP at the start of the game and then either earn or forfeit SSP as the game progresses. While a player can amass SSP at another's expense, SSP are generally gained through competence and luck.

Consensual Decision-Making. Challengers decide whether or not they are satisfied with the answers given by project owners. Project owners are expected to explain their reasoning for answers and all remaining players, as a group, decide whether the response is acceptable. This discussion promotes deeper thinking about RE questions by the players as a set. The facilitator can mediate where necessary, though this was rarely found necessary in our studies, as discussed in Section 7. Consensual decision-

making is also used to agree upon responses to task cards (see below).

Scenario Cards. Players who land on a scenario card position must draw a card as shown in Figure 2. Scenario cards are instructional teaching points. They show what happens when RE good practices are implemented or not on a project. For example, they may inform the player they are to receive SSP because they used an accepted requirements template that aided communication or to lose SSP because they failed to write atomic and unambiguous requirements. Each scenario card explains an RE good practice, gives an example of its use or misuse, and repercussions, then directs the player to gain or lose SSP according to perceived importance and the effort required to learn the technique. These cards form an instructional deck that the players can take home.

RE-O-Poly: Scenario 5	
Volere templates from The Atlantic Systems Guild offer a way to document requirements consistently. They also promote the use of a unique identifier. You used Volere templates on your project and now your requirements are easy to share, discuss and change. Good practice! (see www.volere.co.uk).	
Req #: Unique ID	
Req Type: Functional, etc.	**Event/Use Case #:** Need req
Description: Intention of req	**Rationale:** Justification of req
Source: Person raising req	**Fit Criterion:** Test
Customer Satisfaction: 1 to 5	**Customer Dissatisfaction:** 1 to 5
Priority: Customer value	**Conflicts:** Other reqs
Supporting Materials: Pointer to	**History:** Creation, changes, etc.
Collect 100 SSP	

Figure 2. RE-O-Poly scenario card

Task Cards. Players who land on a task card position must draw a card. These cards provide players with an opportunity to earn SSP by answering general RE questions based on one of the practices revealed in the scenario cards, such as re-wording a problematic requirement or suggesting techniques to identify stakeholders. Note that these will have been introduced in the scenario cards and are randomly stumbled upon. The players consensually decide whether the answer is satisfactory.

Wild Cards sprinkled in the task card deck allow for some fun and additional teaching points. For instance, buying a requirements management tool and believing it will solve traceability problems on a project will cost a player hard, while a 'Get out of RE Training FREE' card becomes a prized possession.

Facilitator. This person holds the SSP not distributed to the players and the project cards. The facilitator pays out SSP to players when directed by the board, scenario and task cards. The facilitator is also responsible for selling and giving out project cards when purchased and monitoring an owner's project profile for questions answered satisfactorily or not. The facilitator collects all SSP for fines and can adjudicate if consensual decision-making breaks down.

Gameplay has been defined as: *"One or more causally linked series of challenges in a simulated environment"* [14]. On almost every roll of the dice in

RE-O-Poly, a player will either face an RE challenge or receive an RE teaching point in the form of a scenario card. While the latter is passive, it is the foundation for being able to tackle the challenges. Every teaching point is based upon a good practice, and associated with a generic task in the task card deck and a project-specific task on the back of a project card to contextualize the practice. The gaming environment promotes multiple opportunities to introduce good practices and then for players to demonstrate their initial understanding of these. Having to reach consensus about answers to challenges reinforces the points. Time-boxing the challenges, using an egg timer, further adds momentum and energy to the gameplay.

Winning. The player with the most SSP (i.e., the happiest customers) wins. SSP are scored for projects owned and correct challenges tabulated. Bonus SSP are scored for ownership of all projects in one RE stage (double points) and all RE stages for one project (triple points). Expert status leads to further SSP according to project base value.

6. Evaluation Design

To evaluate the effectiveness of RE-O-Poly for introducing and reinforcing RE good practices, our research called for an empirical and qualitative study of gameplay in a novice setting. To discover whether the results of the game could be replicated by different groups and in different environments, we followed a multiple-case exploratory case study methodology. We conducted preliminary validation with undergraduates and graduates in a classroom setting, and IT practitioners in an industry setting, and we considered both U.S. and non-U.S. contexts.

Our unit of analysis was each study group, as a whole, rather than its individual members. The rationale behind this decision is that playing the RE game is intended to be a dynamic experience in which players benefit from sharing in the activity and learning from each other. We gauged the effectiveness of the game in increasing RE knowledge by analyzing the performance of individual players on a post-gameplay test against that demonstrated on a pre-gameplay test. Increased knowledge implies greater awareness and so greater potential for adoption. For each study we used experimental play groups and control groups.

To pilot gameplay and evaluation strategy prior to initiating the first case study, the game was played with an experienced RE professor and a Chief Information Officer of a FTSE 250 company. Not too surprisingly, the RE professor won the game by a huge margin. More importantly, the input of the RE professor was used to validate the game's learning objectives and to assess whether it addressed the game design challenges outlined in Section 3. The industry professional provided feedback on the entertainment and educational value of the game as well, and gave valuable input on how the game could be fine-tuned for the RE novice in industry and teams.

6.1 Selection of Subjects

In selecting the study groups for our studies, we established inclusion criteria that were consistent with our research framework and the game design:

- The participants had to be made up primarily of RE novices. We defined a novice as someone with no knowledge of RE or whose knowledge was limited to a first RE course.
- The participants had to have practical experience with software development projects, whether in industry or academia.
- The participants had to be interested in participating in a new approach to learning about RE. The authors believed that the case study would be compromised if approached as a "yet another classroom exercise".
- The experimental (i.e., play) group for each study had to consist of fewer than nine participants, given the limited number of playing pieces and the desire to have each player actually play the game, along with the ability to form a control.
- At least one study group had to be industry professionals where they functions as a team.

The second author of this paper is a professor at Pace University in New York City and teaches computer science classes at the graduate and undergraduate level. She also teaches courses to IT professionals studying for a Masters degree at a global bank in the financial district and periodically teaches at universities in Cambodia. The authors were able to enlist students from her classes.

6.2 Definition of Projects

RE-O-Poly employs the concept of projects, so they need to be instantiated for any instance of the game. Since the banking industry and software development students emerged as the central test bed, we designed several projects that would be relevant for participants in this domain. These projects were general enough so that most non-banking participants could easily grasp the idea with a simple introduction. We developed project cards for three sample projects: basic (calculate customer interest); average (determine and print customer statements); and complex (real-time electronic funds transfer and exchange system).

6.3 Study Sessions

Three case studies were undertaken, one with U.S. graduate students, one with Cambodian undergraduate students and one with U.S. IT professionals employed within a large bank (henceforth called ABC Bank), who were also graduate students. These studies are described individually in Section 7. Each session with a study group lasted approximately two hours and included one round of gameplay, surrounded by pre-game and post-game activities. At the beginning of each session, all the participants took a pre-session test and the facilitator gave a 30-minute overview slide presentation of RE good practices. Members of the control groups were then asked to leave the room and tasked to read three articles related to RE good practices [1, 19, 22]. The facilitator introduced the RE-O-Poly game to the remaining participants in the room, who then played RE-O-Poly, as the play group, for a maximum of one hour under the guidance of a facilitator. Following gameplay, the control group was brought back into the room and both groups completed the post-session test. Participants who played the game filled out an evaluation of the game and the gameplay experience via questionnaire and also participated in an oral debriefing with the facilitator.

6.4 Data Collection

Several common data metrics are of interest when researching the impact of gameplay on participants. For this study, we chose to measure the increase in RE knowledge and to assess the participants' impression of the game and gameplay. Due to the highly interactive nature of the gameplay, it was also important to capture and contextualize participants' personal interactions during the game. To achieve some quantifiable understanding, questionnaires, tests and debriefing tools were used, with observation.

For most of the study groups, the participants filled out questionnaires in advance of the gameplay that described their academic and professional background in software and requirements engineering. After participating in a gameplay session, they either took part in a briefing session where the facilitator took detailed notes or they filled out a questionnaire that captured their impression of the experience: teaching and learning method, enjoyment factor, effectiveness, etc. For the questionnaires, most of the questions solicited answers based on a range of Strongly Agree to Strongly Disagree. Additionally, participants were asked to answer a few open-ended questions. Data from the questionnaires, the recorded observations of the facilitator and the post-game

debriefing sessions, were aggregated and analyzed for each study group to generate overall findings.

To gauge learning and knowledge acquisition, to assess increased awareness and hence capacity for adoption, all the participants were tested to establish a baseline for their knowledge of basic RE practices at the start of a session. At the end of each session, the participants were re-tested to determine how much they had learned (i.e., retained and were able to make use of on a simple test). To minimize the stress of taking a test, the testing tool was a crossword puzzle. The pre- and post-session puzzles were different but covered the same RE material. The results of each participant's performance on the post-session puzzle were analyzed against that individual's performance on the pre-session puzzle. Individual results for each study session were then pooled to determine the overall change in performance (stated as a percentage) for each study group. Members of the control groups did not participate in or observe the gameplay but they also took both the pre- and post-session tests.

These measures focus purely on the knowledge obtained and retained during a two-hour session. To better understand the retention of this knowledge, a similar test was administered to one of the study groups five weeks after the gameplay. However, ability to apply this knowledge in daily practices was not examined since the game was only designed to provide an RE building block.

6.5 Research Question

This research focuses on promoting an awareness of RE good practices, introducing these practices, explaining their value and encouraging adoption. It does this also by demonstrating the role of group communications and negotiation in RE. A simple game is proposed to introduce and reinforce these good practices to novice requirements engineers by emphasizing a small set of lessons and getting players to perform both generic and project-specific tasks based upon these. The overall research question and hypothesis for the study are informed by and contribute to pedagogy and can be summarized as:

RQ: How can awareness of RE good practices be introduced and reinforced in novice organizations to help build RE competence?

HYP: Multiplayer face-to-face discursive gameplay is an effective way to increase a player's knowledge of RE good practices.

6.6 Threats to Validity

The evaluation phase of the research followed the case study approach as described by Yin [20]. Threats to the validity of the inferences drawn from our studies

are described below, along with an explanation as to where these threats have been addressed or mitigated.

Construct validity refers to having established correct operational measures for the constructs being studied. Two of our constructs are 'novice' and 'RE good practice'. We define novice as someone with little or no practical experience in the subject matter and these were the targets of our study groups. Our list of ten good practices was derived from industry experts. Our measured construct was the knowledge increase of study groups as a whole. This was measured pre- and post-session using a standardized instrument demanding more than memorization and was not identical pre and post. These gathered factual responses to crossword questions, a suitable measure of knowledge growth. The scores were counted and averaged for the whole to obviate outliers and focus on group learning. To mitigate threats, we gathered data from additional sources: debriefing sessions, observation, and focused and open-ended questions to collect data on pre- and post-session knowledge.

Internal validity is concerned with establishing a causal relationship, here between the gameplay and the group test results. Were the results the consequence of the activity? We mitigated this threat by triangulating data collection instruments and we discarded the test results of subjects who consulted readings in answering their post-session tests. The potential influence of the facilitator was addressed using two facilitators and by noticing no substantive difference in the results produced. More critical was the impact of the group dynamic rather than the activity per se, but we take this to be a benefit of playing the game. Validity is subject to the immediacy effect where the results are probably simply due to immediate pre-exposure. The test questions were designed in an attempt to avoid this effect. There is no measure of knowledge retention or its longevity in our study though we attempted to examine this through one follow-up session with one study group. The study claims nothing about the practical application of this knowledge since beyond the scope and intention of the game. Insufficient quantities of data were gathered for in-depth statistical and significance reporting.

External validity is concerned with establishing the domain to which a study's findings can be generalized. To address external validity of the results, this study involved three separate study groups in three different settings, including one that was industrial and one that was international, and study groups were mixed in background. We cannot say whether our findings apply to large organizations, mature RE teams and other RE practices, since each instance of gameplay was unique and dependent upon the spirit of the players, though a pilot with an advanced RE educator to examine the impact of expertise was undertaken.

Reliability is concerned with demonstrating that the study's results can be replicated. The main threat to reliability is the dependence of the results on the representativeness of the subjects and the skills of the facilitators. We mitigate this threat by using the same session protocol for all study groups, using two facilitators and developing a database for the collected data. Where time constraints applied, the protocol did not change, just got applied faster. This produced interesting results but complicates replication.

7. Case Studies

In this section, we discuss three case studies. For each case study, we explain how it was run, the data collected and the analyzed findings. The data discussed in summarized in Tables 2, 3 and 4.

7.1 Study #1: U.S. Graduates

Pace University offers graduate courses in RE (CS775) and Software Reliability and Quality Assurance (CS777). Students from these classes participated in one of studies. All twelve of the students were Master's degree candidates in either computer science, or software development and engineering. Ten students were also working in the IT industry full time. This group satisfied the inclusion criteria because they had mixed exposure to RE and software development experience. All had taken at least one undergraduate-level or graduate-level software engineering course and had participated in a team software development project. During the RE overview presentation, they were all able to personally relate to many of the RE practices identified.

This study group was divided into two different sessions. The first session comprised five software development and engineering students who were just completing the CS775 course. The session was run as described in Section 6.3. The participants played RE-O-Poly for one hour. All had played Monopoly before, so the game was easy to explain and play, and the concept went over well. They completed four iterations of the board and exhausted all the task cards. The second session comprised seven students. These students had not yet taken CS775 and were embarking upon CS777, so had little exposure to dedicated RE materials. This group was randomly split, so four students played the game and three students read the RE good practice literature. Since not all of these subjects had played Monopoly before, the gameplay was slower as rules had to be explained. The scenario, task and project cards were all discussed as played.

On average, based on the questionnaire and testing data, the participants of session 1 found the game enjoyable and showed a slight increase in knowledge of RE practices. We attribute the very small increase to the fact that the participants had almost completed the RE course at the time of the study session. They had also had time to bond with one another and were comfortable working together, which translated to confidence in playing the game and more challenging of each other, but building upon what they knew rather than gaining new materials. The participants of session 2 found the game enjoyable and showed a significant increase in RE knowledge. The game served to bring together a group of students who had never met each other before and RE discussion ensued. Unfortunately, the control group's data was spoilt through consultation of reading material.

On the whole, the students in this study group felt 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 questionnaire data also supported this assessment. The test scores of the participants from the combined two sessions increased by 26% in the aggregate after they played the game, a number balanced by a high percentage for session 2 and a low one for session 1. The game introduced RE practices to complete novices and reinforced existing knowledge for others.

The authors had the opportunity to follow up with the participants from the first session five weeks after playing the game. They offered the following retention information: *"the game helped me on the final exam"*; *"reinforce what I already knew"*; *"the game helped me in my daily work routine - language, formulating problems and delivery [of] what people needed."*

7.2 Study #2: Cambodian Undergraduates

Pace University has an ongoing initiative with the Institute of Technology (ITC) of Cambodia in Phnom Penh to teach practical global software development to undergraduate and graduate students. Seventeen computer science undergraduates from ITC embarking upon their first software engineering course volunteered to participate in our second study group. The members of this study group were complete RE novices – they had never even heard of the term 'requirements engineering' but they had had some practical software development experience and were about to work together on the global software development project. The session was run as per Section 6.3 but, due to the size of this group, the presence of only one facilitator, and the desire to keep teams small to handle any language barriers, the participants were placed randomly into one of four

groups: a group of four that read the RE articles; five that played the game; four that reviewed the RE overview slides that the facilitator presented; and four who did nothing whatsoever. This was a little serendipitous due to lack of copying facilities and electrical power cuts, but reflected different recommended ways to learn a topic (i.e., go over class notes, read around the topic, play a game or incubate).

Given the constraints, participants were only able to play RE-O-Poly for 30 minutes. The game was therefore played standing up and in rapid-fire style along the lines of an XP stand-up meeting or daily SCRUM [21]. This additional dimension actually appeared to intensify the interaction and fun of the game. Crowds of students gathered round the players as a couple of iterations of the board were made.

Participants who played the game expressed disappointment that the gameplay period was so short and requested a copy of the game to play with their instructor. They liked the fact that they talked, discussed, laughed and felt empowered in making decisions. They embraced the challenge aspects associated with the projects and when not happy with an answer, they explained why in constructive and considerate ways. In the debriefing session, they indicated that games had never been incorporated as a learning approach this way before.

All study participants showed an increase in knowledge at the end of the session, regardless of the four groups they were in. However, the participants who played the game or read the papers showed a more significant improvement, 32% and 25% respectively. We attribute the general increase in performance to the fact that all participants had taken detailed notes during the initial slide presentation.

It is worth noting that none of the Cambodian students had ever heard of the Monopoly game before. Even though its packaging claims it to be 'The World's Most Popular Board Game', it is not a game played in Cambodia. Also, many of the students struggled with the crossword puzzle until it was explained. Even those students who were familiar with crosswords had some issues with English language and spelling. While they all speak English, their primary language is Khmer and they are taught in French. However, the most surprising finding was that it was two Cambodian students who performed the best on the post-session puzzles out of all participants in the overall research study (a game player, a reader).

7.3 Study #3: ABC Bank

Pace University also has teaching initiatives with partners in industry. One such program is a Master's degree in software development and engineering

offered to IT professionals of ABC Bank. All of the instruction for the program is provided at ABC Bank's facilities by Pace University professors. One of our study groups consisted of ABC Bank employees enrolled in this program. All participants in this group had just completed the CS775 RE course, with the exception of five employees who had taken a software engineering course. The session was run as per Section 6.3 and the participants were randomly separated into three groups: a group of six that read the RE articles, and two groups of seven that played the game, each under a different facilitator. One group played the speed version adopted in Cambodia, where the emphasis was on completing as many of the scenario and task cards as possible, and in acquiring all the projects. The other group played at a slower pace.

The two groups played the game for approximately 50 minutes. During that time, the groups made from five to eight iterations of the board. The speed RE-O-Poly generated a lot more noise than the slower-paced game. On average, based on the questionnaire and testing data, all game participants found the game enjoyable and showed an increase in knowledge. Further, the more advanced participants who had taken CS775 were found to help the other players to articulate their answers and explained unsatisfactory answers, and in each game the highest scorers were the students who had taken CS775.

Participants who played the RE game seemed to successfully learn key practices. On the whole, they felt it was effective as a learning tool and test data also supported this assessment. Their test scores improved 23% after playing the game. However, the control group improved by a slightly larger measure. We suggest that this is because they were mature students who read the articles meticulously, triggering baseline pre-existing RE knowledge. Unlike reading, however, both facilitators observed the role of the game in uniting a group of players through intense dialogue and laughter, and saw value in the more advanced players coaching the new ones.

This study group was observed by an independent software engineering instructor. He suggested the game be used to also support an introduction to software development and team building.

7.4 Results Summary

Tables 2 through 4 highlight the data collected. Table 2 provides a snapshot of the background to the studies. Table 3 summarizes the collective responses to the post gameplay questionnaire. Most of the questions solicited answers using a five point Likert scale ranging from Strongly Agree (1) to Strongly Disagree (5). Participants overwhelmingly agreed that the game was fun, engaged all players and would play again. Participants' engagement is one benefit educational games seek as this is claimed to trigger deep learning [4]. Table 4 presents the accumulated group data on the pre- and post-session tests. Since only one participant turned in a valid post-session test for the graduate control group, we were unable to do any further analysis on this group.

Table 2. Background to the three studies

	Study 1: Graduates (2 sessions)	Study 2: Undergrads	Study 3: ABC Bank
Group Size	12	17	20
Prior Exposure to RE	CS775 (5) None (7)	None	CS775 (15) None (5)
SE Experience (Industry)	Limited	None	Medium-High
SE Experience (Academic)	Medium	Limited	Medium
Game Length	60 mins	30 mins	50 mins
Play Groups	4 and 5	5	7 and 7
Control Groups	3	4, 4, 4	6
Debrief	Yes	Yes	Yes
Observation	Yes	Yes	Yes
Questionnaires	Yes	No	Yes
Pre and Post-Game Testing	Yes	Yes	Yes
Facilitator	Author 1	Author 2	Author 1 and 2

Table 3. Post-gameplay questionnaires

	Strongly Agree (%)	Agree (%)	Neither (%)	Disagree (%)	Strongly Disagree (%)	Mean	Standard Deviation
Real-World Relevance	25	65	10	0	0	1.85	0.59
Fun Factor	65	26	9	0	0	1.43	0.66
Kept Me Interested	70	25	5	0	0	1.35	0.59
Participant Involvement	48	48	5	0	0	1.57	0.60
Intellectual Stimulation	24	71	5	0	0	1.81	0.51
Knowledge, Not Chance	9	82	5	5	0	2.05	0.58
Would Play Again	47	47	5	0	0	1.58	0.61
Alternative to Classroom	45	45	5	5	0	1.70	0.80

Table 4. Pre- and post session testing

	Study 1: Graduates (2 sessions) %	Study 2: Undergrads %	Study 3: ABC Bank %
Control Group			
Pre Test	n/a	3	13
Post Test	n/a	28	42
Improvement	n/a	25	29
Play Group			
Pre Test	31	3	22
Post Test	57	35	45
Improvement	26	32	23
Standard deviation (improvement results)	0.14	0.12	0.15

8. Discussion and Future Work

"When we think of games, we think of fun. When we think of learning we think of work. Games show us this is wrong. They trigger deep learning that is itself part and parcel of the fun. It is what makes good games deep." [4].

Small novice organizations need a fast, painless, relatively transparent and cost-effective way to introduce and reinforce RE good practices, hence the

idea for the concept of the RE-O-Poly game. Based on results from our preliminary studies, the game appears to be fun, immersive and certainly engaged the attention of the participants, especially when played in a time-boxed stand-up manner. In discussions after gameplay, participants were more comfortable with RE practices and testing showed an overall increase in RE base knowledge. The gameplay environment forced participants to contextualize RE practices they had learned to address different challenges. The main benefit appeared to be the ability to bring relative RE novices together to leverage each other's knowledge and begin an RE dialogue. Additionally, gameplay with international participants indicated the transference of the concept across cultures.

Our future work includes a closer examination of the potential of such games to improve the practical application of RE good practices. Awareness is one thing, adoption and use quite another. RE-O-Poly was designed to promote awareness of RE good practices and to nurture a foundation upon which to build competence. Such games obviously play a localized role in wider educational and training programs and need to be supported with additional types of game, as well as other strategies, with complementary teaching and learning objectives. Our game is offered as an early contribution to a compendium of RE games.

9. Acknowledgements

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