Inviting Everyone to Play: Gamifying Collaborative Requirements Engineering

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***Abstract*—Requirement engineering (RE) presents several challenges stemming from the required collaboration and knowledge transfer between analysists, developers and customers. In order to overcome these challenges and improve the effectiveness of RE, we developed REVISE: Requirement Elicitation and Verification Integrated in Social Environment. This tool is designed based on cognitive theories and implementing gamification elements, to motivate collaboration and knowledge sharing between programmers to encourage and enhance the task of RE. This paper presents our vision for enhancing software engineering via gamification, and the theoretical cognitive foundation on which this vision is based, starting with the example of RE.**

***Index Terms*—Gamification, Requirement Engineering, Boundary Object, Boundary Spanner**

I. Introduction

Requirement engineering (RE) is one of the most important tasks in software development. It contains several stages – identification, elicitation, specification and verification [12]. In recent years, serveral research works have focused on finding ways for enhancing requirement enginnering, mostly focusing requirement eliciation and verification [15]. The importance of collaboration among stakeholders in the various stages of RE in order to obtain high quality requirements, has also gained increasing attention [ibid]. However, additional tools and solutions are needed, in order to promote a better understanding among all stakeholders involved in the process [15].

Promoting collaboration among stkeholders in the RE engineering process can promote higher quality requirements [12], a better understanding of the requirements by the user resulting in more accurate requirements [6], and better use of the system [ibid].

Recent work has studied RE processes embedding gamification and crowdsourcing techniques [16]. However, while enabling interaction among different stakeholders to some extent, we did not find any tools that provide a platform where all stakeholders can share their perceptions on the requiements.

In this paper, we present a conceptual solution we propose for requirement elicitation and verification. This solution uses gamification techniques in the RE process, enabling and promoting collabraiotn between different types of stakeholder, in order to encourage and guide productive behavior during this process towards it successful completion.

The rest of the paper is organized as follows. Section II provides a literature review on gamfication, cognition in collaborative work and collaborative RE. Section III presents our proposed conceptual solution. Section IV presents the research questions, and section V describes the planned research method and our plan for the next steps of the research.

II. Scientific Background

A. Gamification

Defined as"the integration of Game Mechanics in non-game environments to increase audience engagement, loyalty and fun" ([7], p.1), gamification addresses the use of techniques taken from games in order to encourage users to participate and contribute in computer-supported applications. Detering et al. [7] focused on defining what gamification and gamefulness are, explaining that gamification and gamified applications are better called "gameful design", and their goal is "to have easy access to more ecologically valid user data on the different kinds of experiences and natural categories that arise from interaction with these systems" [ibid, p.6].Research was also conducted in the context of using gamification at early stages of software development. Dubois and Tamburrelli [8] suggested a framework to successfully integrate gamification elements into software engineering, starting from requirement elicitation. They identified three types of activities needed to be performed when engaging gamification into software engineering: analysis, integration and evaluation, and found that students performing these activities had better results in software engineering. Another attempt to use gamification at early stages of software development showed that using gamification in virtual teams during requirement elicitation assisted the teams to locate experts and share knowledge [13].

Comtemporary research works use gamification principles to enhance several software engineering tasks. The game "Code Hunt" [18] developed by Microsoft, provides a cloud-based environment, where programming languages skills can be earned and improved by coders of all leves, while solving unit-testing puzzles. The game was successfully played around the world, presenting Mircosoft opportunities for recruiting excellent coders chosen out of the hunderds of thousands who participated in the game. .

Gamification in software engineering has been researched in different contexts, mostly for education purposes. Several research works have explained gamified applications'

outcomes in terms of cognitive theories, but to the best of our knowledge, no attempts were made to create games for software engineering tasks based a-priori on cognitive theories.

B. Cognition in Collaborative Work

Software engineers increasingly rely on collaborative work. Collaborative work has been vastly researched, specifically in the context of cognitive psychology offering explanations to phenomena observed during collaborative processes related to knowledge and decision-making. The theory of distributed cognition[10], for example, looks for a broad class of cognitive events and does not expect all such events to occur within the physical boundary of an individual, in contrast with other popular cognitive theories. Distributed cognition is based on the principle that "cognitive processes are socially distributed across the members of a group" ([ibid], p.4). Memory is distributed among various units (subsystems), and each unit has its own cognition according to the actions it performs. In recent years, research works have also focus on the power of collaboration to enhance innovation in a group. For example, Sawyer [14] developed the concept of group flow,extending the theory of flow [4], where where the individual is immersed into the performed task (some of which can be extrinsically induced). Sawyer argues that the state of flow in group work is an essential foundation for developing breakthrough ideas and innovations.

A concept from a differen domain, called boundary objects [16], is a conceptual representation of artifacts that can help enhance collaboration among participants in a process. These include, for example, data objects that are shared by various participants, while each group of participants denotes its own social world and unique view on these objects.
Boundary objects were found helpful for the representation of knowledge and for detecting the challenges in transferring knowledge among actors in new product development settings [3], in software deployment [20], as well as in additional processes in various domains [1].

When addressing the common use of boundary objects, attention should be given to its users, and to the way they communicate with each other. The boundary spanning model, coined by Tushman [19], reflects the ongoing efforts to identify the employees who "fulfill the essential function of linking the organization's internal network to external source" (ibid, p.2). However, boundary spanners also contribute to problem solving and collaboration among workers in the organizations, and are considered leaders [22]. They are often "the sole sources of crucial knowledge for the entire team" [4]. In our context, identifying boundary spanners may be beneficial for selecting reviewers according to their knowledge and expertise. Moreover, when trying to influence behavior (e.g., participate in a game) boundary spanners are expected to highly influence the behavior of their peers.

C. Collaborative Requirement Engineering

Previous reseach works addressed the collaborative aspect of RE, mostly focusing on the potential of user involvement to enhance the quality of requirements.

Users` role in the design process can be classified to informative, consultative or participative, according to their level of participation in the process [6]. In the informative role, users are mostly passive as providers of information and objects of observation; in the consultative role, they can comment on predefined design solutions; and finally, in the participative role, they actively take part in the design process and have decision-making authority egarding the design solution. Kujala [12] conducted a systematic literature review about user involvement in various design processes. His conclusion was that "Early involvement of users appears to be promising, on the condition that user involvement methods are developed further and the role of users and designers are carefully considered. Designer should take an active role in user involvement."

An important aspect of the software development process is requirement traceability (RT). Gotel and Finkelstein [9] addressed the challenge of following the life of a requirement, and to trace its evolution. Several problems and solutions were detected in the context of RT, emphasizing the importance of managing and organizing information before, during and after requirements specification

III. REVISE

This paper presents a gamified environment for managing requirements for software products.

The game we designed has several key principles. We developed the game according to the principles of CARE – Create, Ask for review, Review, Extend [20] :

1. The stakeholders - the creator (usually a system analyst), the reviewer (who reviews the requirements) and the customer, can choose a requirement and discuss its features in a collaborative environment (see Fig. 1).
2. Each stakeholder can also add new requirements to trace (Fig. 2). They can give scores to each defined requirement, according to their perception of the percentage of the completion of the requirement.
3. There are individual and team score, where all players can gain points according to the rewarded tasks. The reviewers are given additional initial score.
4. Author is garnted points for each comment on a requirement.
5. Each time a stakeholder defines the requirement completion percentage an average completion precentage is calculated and presented to all stakeholders.
6. If the average percentage of requirement description is above the preiously defined threshold, the requirements leaderboard is updated, and the updated percentage of requirement completion is now visible to all stakeholders mentioned above.
7. The reviewers can also choose to share their comments with members of other teams, raising both individual and

team score. Additional mechanism is needed to evaluate the quality of the shared information and its contribution to other stakeholders in the project .

8. The creator can share tips and lessons learnt from the review with others, raising individual and team score.
9. All stakeholders are also given badges according to their individual scores. The badge indicates their level in the game, labeled kilo, mega, or giga, etc., according to the number of points they earned.
10. Each team has its own profile, where all members of the team can view information about the team score and their relative ranking among all teams (see Fig. 2). The teams are rewarded each month according to their scores. The reward can be in the form of monetary incentive or other rewards (e.g., breakfast with a high management. presentative or coupons for fun activities).
11. If other creators or reviewers use the knowledge and tips shared, the individual who wrote and/or shared this knowledge receives additional points.

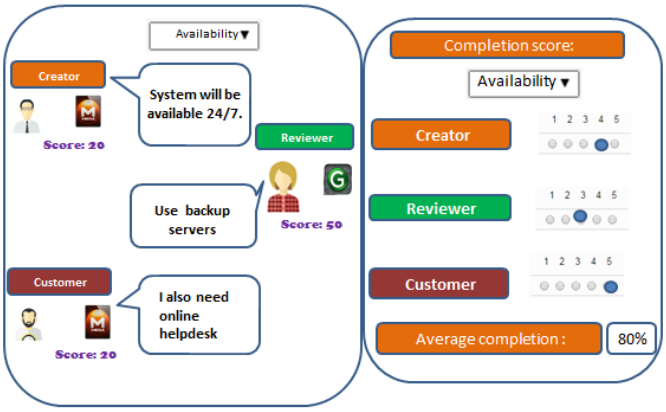

Fig.1. Stakeholders conducting elicitation together and give scores

Fig.2. Each stakeholder sets up requirement completion percentage

Fig.3. Requirement leaderboard

During the course of the game, the requirements being reviewed, and the explicit knowledge resulting from their review (shared comments and tips), both serve as a boundary objects among team members. Since each team is interested in gaining as much points as possible, its members are expected to assist each other in accumulating points and badges. Users have a participative role in the game, as they take active part in requirement creation and verification. Using the game also creates requirement traceability, as all user requests are documented and addressed, and can be later reviewed while creating and deploying the product.

The expert analysts and reviewers, who are the boundary spanners, take part in the game, encouraging other team members to gain points.

IV. Research Objectives and Questions

Developing the game, we relied on several cognitive principles, such as distributed cognition and boundary objects, to understand the importance of using requirement specification review and its outcomes for sharing knowledge. The complete requirement document serves as a boundary object, connecting different stakeholders with different knowledge and points of view. All the stakeholders serve as boundary spanners, as they promote the process by providing review of the code. Expert reviewers are encouraged to participate in the process, given extra points in the beginning of Our objective in creating the game was to enhance the process of requirement elicitation by the creators, and the verification of requirements fulfillment by the reviewer. Our research questions refer to two aspects - the behavioral, and the practical aspects - of the game, that may lead to higher-quality requirements specification.

Research Questions

1.What is the behavioral contribution of the game?

a.Does the game enhance collaboration among stakeholders?

b.Does the game support creating a shared understading of boundary objects, most notably – the requirement document?

2. What is the practical contribution of the game?

a.Does the game promote elicitation of relevant requirements for the project?

b.Does the game promote a more precise requirement specification?

c. Does the game promote better requirement traceability?

V. Research Method

The main population of the reserach will be system analysts, requirement reviewers and customers from the software products industry, with different levels of seniority.

This study will apply the qualitative research method. As derived from the research objectives and questions, the research focuses on human-related processes. According to Bogdan and Biklen [2], qualitative researchers try to

understand phenomena by empirical observations of human behavior and experience, in order to identify the processes.
During the research, data will be gathered using the following research tools: interviews, observations and questionnaires. We intend to perform a qualitative survey among practitioners, using open-ended questionnaires, in order to understand which elements of their work they think could be gamified and explore how this can be achieved. After a qualitative analysis of the findings [17] , the theoretical framework will be developed. In order to ensure the validity of the research, triangulation among different knowledge sources will be applied [2]. Additionally, the qualitative research results will be presented to a range of executives in the firm for feedbacks and refinement.

A. Solution Creation and Validation

Following the use of these tools and based on the findings, we plan to propose guidelines forcreating REVISE and embedding it in the current RE processes in various firms.. These guidelines will be implemented
and evaluated according to the principles of design research method (Hevner and March , 2003; Von Alan et al., 2004). We plan to develop a framework and a tool, which will help all mentioned stakeholders to perform their work in a gamified environment. We also plan to validate these research artifacts by conducting a quantitative study with practitioners, to find if, and to what extent, these means improve their performance and promote desired behavior.

We plan to implement a prototype of REVISE and examine its use. We intend to perform a user study among practitioners, to understand if and how they benefit from the different gamification elements of the tool.

REFERENCES

[1] S.F.Akkerman and A.Bakker, "Boundary crossing and boundary objects", . Review of educational research, vol.81,2011, pp.132-169.

[2] R. C., Bogdan and S. K. Biklen, Qualitative research in (validation) and qualitative (inquiry) studies.,2006.

[3] P.R. Carlile, "Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries," Organization Science, vol.15, 2004, pp.555-568.

[4] M. Csikszentmihalyi, Finding flow: The psychology of engagement with everyday life. Basic Books, 1997.

[5] R. Cross and L. Prusak, "The people who make organizations go-or stop," Harvard business review, vol.80, 2002 ,pp. 104-112

[6] L. Damodaran,"User involvement in the systems design process-a practical guide for users," Behaviour & information technology 15, vol. 6 ,1996, pp.363-377.

[7] S. Deterding, R.L. Khaled, L. Nacke, and D. Dixon, "Gamification: Toward a definition," In CHI 2011 gamification Workshop Proceedings, pp. 12-15.

[8] D.J. Dubois, and G. Tamburrelli, "Understanding gamification mechanisms for software development," In Proceedings of the 2013 9th Joint Meeting on Foundations of Software Engineering ,2013, pp. 659-662. ACM.

[9] CZ.Gotel, and A.Finkelstein. "An analysis of the requirements traceability problem." In Requirements Engineering, 1994., Proceedings of the First International Conference on, pp. 94-101. IEEE, 1994.

[10] J. Hollan, E. Hutchins, and D. Kirsh, "Distributed cognition: toward a new foundation for human-computer interaction research," 2000, ACM Transactions on Computer-Human Int.

[11] E. Hutchins,Cognition in the Wild. Cambridge, MA: MIT press, 1995.

[12] S. Kujala, "User involvement: a review of the benefits and challenges," Behaviour and information technology, vol.22,2003, pp.1-16.

[13] D.G. Marshburn and R.M. Henry, "Improving knowledge coordination in early stages of software development using Gamification,", 2013, SAIS.

[14] K.Sawyer, Group genius: The creative power of collaboration. Basic Books, 2008.

[15] R.Snijders., Ö.Atilla, F.Dalpiaz, and S.Brinkkemper,"Crowd-centric requirements engineering: A method based on crowdsourcing and gamification" ,2015.

[16] S. L. Star, and J. R. Griesemer, "Institutional ecology, translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology,1907-39," in Social studies of science, vol.19,1989, pp. 387-420.

[17] A. Strauss and J. Corbin, Basics of Qualitative Research Grounded Theory Procedures and Techniques, Sage Publications, Inc.,1990.

[18] N. Tillmann., J. Bishop, J., N.Horspool, D.Perelman, and T.Xie, "Code hunt: searching for secret code for fun," In Proceedings of the 7th International Workshop on Search-Based Software Testing ,2014, pp. 23-26. ACM.

[19] M.L. Tushman ,"Special boundary roles in the innovation process," Administrative science quarterly, 1977, pp. 587-605

[20] N. Unkelos-Shpigel and I. Hadar, "Using Distributed Cognition Theory for Analyzing the Deployment Architecture Process" The 1st International Workshop on Cognitive Aspects of Information Systems Engineering (COGNISE 2013), 2013 In conjunction with CAiSE 2013.

[21] N. Unkelos-Shpigel and I.Hadar, "Gamifying Software Development Environments Using Cognitive Principles," In CAiSE Forum,2015.

[22] P. Williams, "Special agents: The nature and role of boundary spanners," Presentation at the ESRC Seminar Series on Collaborative Futures: New Insights from Intra and Inter-Sectoral Collaborations, University of Birmingham, 2010.