Deploying a gamification framework for software process improvement: preliminary results

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Abstract. Gamification is intended to increase engagement and motivation among its users by means of a set of game design elements. This field of study has expanded in popularity in the recent years in several areas needed to improve engagement among their actors. One of this areas is software engineering. This discipline is a human-centric activity needed of motivated engineers performing a wide panoply of tasks. In this scenario, in this paper authors present an effort conducted to deploy a gamification framework devoted to increase engagement among software practitioners in software process improvement initiatives. Preliminary results show both encouraging outcomes and areas of improvement in the implementation approach and in the needed breadth of areas or processes involved in the gamification proposal.

Keywords: Software Process Improvement; Gamification; Deployment

1 Introduction

Gamification as a discipline is maturing in the last few years [1]. From their beginnings in which gamification was just a basic idea to more recent advances and researches, the field of study is evolving towards a more mature state. According to a recent study [2], Gamification started in marketing with mechanisms like loyalty cards, stamp books, competition and reward memberships, however the rise of gamification came with cheaper technology solutions and the generalization of game culture [3]. Not in vain, according to [4], Gamification has a greater impact in an online context. As a result of the importance of Gamification, researchers have focused on the phenomenon and are increasingly studying it, defining theories and documenting challenges and opportunities on its use.

Gamification presents many definitions. Maybe the simplest definition is as follows: gamification is the use of game elements in non-game contexts [3] in order to alter and inspiration the behavior of people [5]. The final intent is the injection of fun, play, and passion into tasks and processes [6]. However, in the context of this paper authors will adopt the definition provided by [7]: Gamification is a transformation process in which interaction patterns, game mechanisms, reusable game components are operationalized to solve problems in an intended environment that is situated within a real world context.

Literature reported the fact that the concept of game and games on the one hand, and gamification on the other hand are really close. According to [8], games are concentrated on entertainment and pleasure while gamification focuses on changing players' behavior, engagement with their environment and co-players towards achieving meaningful interaction and engagement and possibly achieve recompenses. There are also different names applied to the concept or similar endeavors, including pervasive games, game based learning or serious games.

Gamification is grounded on several well-grounded psychological theories, namely, the Fogg Behavior Model, the self-determination theory and the flow theory. Regarding its components, gamification is built on game elements: dynamics, mechanics and components of the game [5]. The first element, dynamics of the game, is about endowing the objectives and the potential effects on the people participating in the gamification proposal. Secondly, mechanics are the basic actions that motivate the user in order to accomplish the aims specified by the game [5]. Game mechanics aim to govern the behavior of people through incentive systems, feedback and competition, among others, with a reasonably predictable outcome [9]. The last element is game elements referring to specific instances of the dynamics and game mechanics [5]. A good explanation of game design elements can be found in the works of [3].

In this scenario, a gamification proposal can increase the engagement and motivation and by doing so, upsurge productivity and performance of the personnel [10]. However, gamification also entails some specific drawbacks. Thus, firstly, it is not easy to manage, secondly, there is a danger of misinterpretation the conceptualization and improper implementation of game elements [11] and lastly, gamification could go against the values of the organization by introducing unwarranted competitiveness, a factor that is highly demotivating [5].

Gamification has its impact in the broad field of software engineering. A recent paper [12] reviews current literature on the topic and concludes literature reports simple gamification mechanics and few provide empirical evidence of the impact of gamification. This paper aims at bridging the gap between gamification in software engineering and empirical evidence by presenting an effort to deploy a gamification framework devoted to software process improvement in real settings.

The remainder of this paper is structured as follows: Section 2 outlines the proposed gamification framework. In Section 3 the case study is presented including a description of the company, research approach and main deployment internals. Finally, in Section 4 authors present main preliminary results, wrap up the work and outline future developments.

2 The framework

In this chapter, authors will present the framework by explaining its phases and outcomes and, Gamiware, the supporting tool developed to deploy the framework in real scenarios.

2.1 Framework description

Previous works justified the need to develop a methodological framework for gamification efforts in SPI initiatives that takes into account specific features in terms of organization, processes and personnel. The last version of the framework was presented in a previous work [10] as an evolution of previous initiatives in the area [10, 13]. The latter version implemented the lean Startup (Build-Measure-Learn) method initiated by Ries [14]. The resulting framework (Figure 1) presents the following phases:

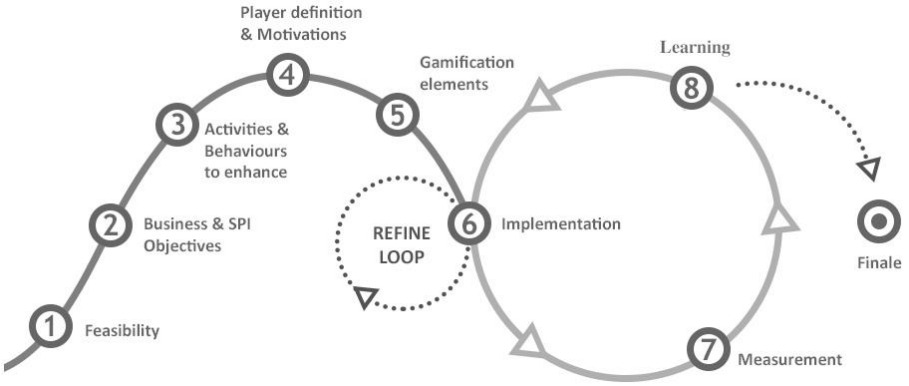

Fig. 1. Phases of the SPI-Gamification framework

PHASE 1: FEASIBILITY: There is a need to work out if the current organization and time is accurate for the deployment of the framework. Therefore, factors such as having the necessary resources, commitment of top managers and an SPI infrastructure to estimate the feasibility of implementing the SPI gamification initiative, need to be analyzed.

PHASE 2: BUSINESS and SPI GOALS: Once verified the applicability, the business objectives and their associated KPIs need to be established. These objectives are defined under the SMART criteria established by [15]. Lastly and aligned with the business goals, SPI objectives and their respective metrics need to be defined. If the software metrics are not very clear, GQM techniques [16] could be used in order to find those metrics.

PHASE 3: ACTIVITIES and BEHAVIOURS TO ENHANCE: SPI activities and the practitioners' behaviors are identified and analyzed. For SPI activities, the level of intrinsic motivation of the SPI activity is analyzed through the IMI test [17]. Next, the walk-through SPI activity is analyzed from the practitioner's perspective through the

Technical Customer Journey Map [18]. Finally, the practitioners' behaviors to be improved in the related activities are identified and analyzed.

PHASE 4: PLAYER DEFINITION and MOTIVATIONS: Consequently, it is necessary to analyse the motivational factors [19, 20] for each of the software practitioners groups or SPI roles. It is also desirable to identify each group of professionals or SPI roles with some type of players' classification [21] for the gamification proposal.

PHASE 5: GAMIFICATION ELEMENTS: For each SPI activity, it is necessary to outline:

1. Dynamic, mechanic and game elements, based on the approach of [5] and refined by means of the Octalysis framework [22] as explained in previous research [23].
2. Metrics for each of the game elements defined above.
3. The Feedback process through which the user receives information on practitioner's activity in real time.
4. Resistance to change and commitment must be considered.

PHASE 6: IMPLEMENTATION: Next, the gamification proposal from the previous phase is executed and implemented at the technological level. However, before implementing the proposal, it is necessary to communicate this to everyone in the organization in order to ensure all parties understand and adopt the process as a critical aspect in SPI initiatives [24]. For this implementation, Gamiware, the tool was developed. This tool is explained in the next section.

PHASE 7: MEASUREMENT: The different key performance indicators (KPIs) of the SPI, motivation metrics and the defined game elements are collected and measured.

PHASE 8: LEARNING: Results are evaluated and the main conclusions for future iterations are considered and documented.

REFINE LOOP: To conclude, taking into account the results of the previous phases, the necessary adjustments are made in stages 2-5.

2.2 Gamiware: The tool

Gamiware is a SaaS open source tool to support the gamification process in an easy and affordable way. This tool is able to support the defined gamified iterative process making viable gamification implementation easier. The tool has been designed and implemented to be project and process independent. Gamiware is able to adapt to any context by means of a form-oriented parametric customization. Thus, it is possible to code business objectives, software objectives or SPI objectives. Taking into account the intrinsic nature of software process as human capital intensive activity [25], it is also important the identification of software practitioners participating in the gamification process, their tasks and their associated KPIs. Furthermore, with the purpose of improving the alignment of business objectives and activities, it is possible to define the specific contribution of each task to the given business objective and by this mean check the fulfilment of these objectives. The tool is depicted in [26].

3 The case study

Due to increasing recognition of the importance of security throughout the entire life cycle, new initiatives strengthening ties for security within the SDLC have been conducted. However there is a need to assist organization in processes that minimize and ideally prevent security.

3.1 The company

ABC (fictional name) is a SME devoted to develop custom made software solutions placed in Madrid, Spain. This organization follows the ISO/IEC 29110 and some of its members hold the CSSLP (Certified Secure Software Lifecycle Professional) certification.

The aim of the company in the gamification is the improvement of its process of definition, execution and overall management of software testing, normally affected by a general lack of time and resources.

ABC decided to split the validation into two different phases. A first phase of 1 month, would make available 5 people involved in different types of projects. The second phase would extend to 2 departments in full, but its execution would be subject to the results of the first pilot phase.

3.2 Research approach

The main objective of this research is to validate the framework presented and to study its feasibility and application in practice. Although empirical studies on punctual implementation of gamification techniques are beginning to emerge [27], they do not have enough consistency [2]. Concerning these objectives, the research question that guided the research is,

RQ: does the motivation of the participants increase after carrying out SPI activities under the techniques of gamification established in the methodological framework presented?

To address this research question, participants will be given a questionnaire at the beginning and the end of the implementation. The aim of this instrument is to measure the variation of the motivation of participants in relation to the tasks. These questionnaires are based on task evaluation questionnaire from intrinsic motivation inventory [17]. These questionnaires were adapted to the organizational context and the tasks. Each of the questionnaires were composed of 23 items assessed by means of a 5-point Likert scale. In addition to this questionnaire, multiple data will be collected during the experiment. Data collection will be done in a manual basis.

3.3 The deployment

The deployment of the gamification proposal involves the implementation of each of the phases of the methodological framework presented. In this way, the viability of

the organization was analysed by validating one by one the different factors identified in the feasibility phase.

Once the viability of the initiative was confirmed, the business and SPI objectives were established, with their corresponding KPIs. In this line, established business objectives are related, on the one hand, to the requirement to improve customer satisfaction and, on the other hand, to the need to improve the accuracy in software testing estimation. Subsequently, SPI objectives were established to improve the specification, registration and execution of software tests, as well as the establishment of a data repository that allows to know the actual effort used in each type of project. Finally, it was verified that the objectives specified follow the SMART approach [15].

The next step was the definition of SPI activities, in this case, the definition, execution and registration of software tests. To do so, together with ABC, researchers developed a small Customer Journey Maps [18]. The aim of this instrument is the identification of the roles and the part of the process in which such software tests were executed.

Afterwards, the motivations and types of players of the participants were analysed. Using the models by Baddoo & Hall [19, 20], motivators and demotivators of the two roles involved in the deployment were analysed: project managers and software developers. In addition, the people involved in the gamification proposal were classified according to the player profiles specified by Bartle [21]. The results of this classification indicate a predominance of competitive profiles, at least as the first and second option among the participants.

Once all the information has been collected and analyzed, a fully adapted gamification proposal is proposed. In this line, a competitive dynamic 1 vs 1 was presented, where the people involved compete with each other in the definition, execution and registration of software tests. The gamification experience is divided into phases according to the different types of tests defined by the organization, in this case, unit tests, integration tests, system tests, and acceptance tests. For the accomplishment of each one of the activities, the participants receive a series of points previously collected in a scheme of rewards. This scheme has been agreed with top managers and is known and accepted by all participants. As a result of the activity, a ranking is created where possible to check the overall ranking, according to each phase is carried out. This is intended to enhance the sense of progress in the activity [5, 28] and social recognition, identified as one of the main intrinsic motivators [29, 30].

Since participants are involved in different types of software projects, the points assigned to each activity are weighted based on the complexity of each project. This weighting was specified by the manager and reviewed by the researchers.

One of the most relevant aspects of the experimentation was the analysis carried out in identifying the ideal tool to implement this proposal within the organization. The final decision and the implementation process of the proposal are detailed in the following section.

Finally, after the definition of the gamification proposal, it is the start of the cycle of the methodological framework in which we are at present, formed by the phases of Implementation, Measurement and Learning.

3.4 The gamification tool in practice

One of the most relevant aspects of the research was the analysis carried out at the time of implementing this gamification proposal within the organization. Taking into account the encouraging results of Gamiware in previous settings [26], it was initially considered as the tool to support the process. However, after analyzing the organization's work in relation to software testing, it was found that, at least in this case, the use of Gamiware could add additional complexity to the process. Therefore, in order to reduce resistance to change as much as possible, we opted for tools that were part of the company's current workflow and ecosystem. ABC is using Gitlab[1] to register software tests in software projects. In addition, the existence of a public API in Gitlab expands the possibilities of integration and automation of tasks in hypothetical later executions of a gamified workflow. Therefore, the following process was established:

1. Developers define software tests within Gitlab by doing an Open of one Issue for each type of test. The tests will be defined on the basis of a nomenclature and the 'Label' functionality will be used to identify the type of test.
2. Each test is self-assigned to each of the authors of the definition, and the researchers subscribe to the Issue in order to receive automatic notifications on updates.
3. In addition, in each test definition, the specific function of Gitlab '/ estimate' is used, which will reflect the estimated time to execute and register the test.
4. Manager gives a range of points according to the quality of the definition, based on the default rewards scheme.
5. For each type of test, the results are executed and recorded. The result is registered in the Issue and, in case of error, the error log is attached. In any case, it is marked with the function '/ spend' the time invested in its execution and registration. The use of these '/ estimate' and '/ spend' functions will allow us to analyze the efficiency in the estimation of the tests.
6. The manager reviews the execution and registration, checks that no cheating has been done, and assigns the corresponding points according to the rewards scheme. Once this is done, he or she marks the Issue as Closed.

4 Results and conclusions

When analyzing the preliminary results, we must take into account a series of constraints that not only compromise the validity of the results but, based on academic literature, can reduce the effectiveness of gamification techniques. Thus, it should be noted first of all that the feedback provided to the participants has not been possible in real time, but every 12-24 hours due to a lack of technological integration in the workflow of the company and after a manual review. This fact is against literature on the topic [5, 28–31] and this fact regarding the reduction of the effectiveness due to a lack of integration in the workflow becomes has been underlined in previous works by authors [26]. Secondly, participants have not only done the definition of software

[1] https://about.gitlab.com/

tests, their execution and registration, but also carry out associated software development. Literature reported biases and under performance in error detection by developers [32, 33]. In the third and last place, it is important to note that the sample is small, which connotes the generalization of the results. However, in spite of these limitations, a number of noteworthy preliminary results can be anticipated:

1. Although Gamiware has been designed in an adaptable and flexible way [26], It appears that its use in practice will only work in very controlled environments and under very specific activities. This conclusion is based on the lack of integration of Gamiware in the work workflow of the company and confirms one of the assumptions that were made in previous studies [26] where preliminary implementations of Gamiware were carried out in controlled environments. In organizations this lack of integration implies that, in order to implement gamification techniques through Gamiware, it will be necessary, on the one hand, to devote time to learning how the tool works, although it is not complicated, implies different ways of doing things and this leads to the emergence of resistance to change. Therefore, it does not seem recommendable to add factors that can lead to resistance to change in the implementation of gamification techniques in organizations.
2. The feedback of the activities carried out should not be extended, as much as 12-14 hours after completion. After that time, it is common for the participants to ask what their score is and deviations in the results of these tasks are perceived in advance. Feedback is one of the main motivators identified for developers, according to Baddoo and Hall [19, 20]. Due to the lack of real-time feedback, there is a risk of breaking the cycle of motivation: motivation-action-feedback [5, 31].
3. Achieving the commitment of the top managers is a very hard task. Even though they have been verbally committed, day-to-day orders and any urge tends to break that commitment and the gamification proposal execution. Probably one of the main reasons behind this fact is the lack of a perceived need for urgency in improving SPI activities. In fact, "Need sense of urgency" as feasibility factor has been one of the integrated modifications after the validation of experts reflected in a previous investigation [23].
4. As the sample is small, it becomes difficult to implement collaborative or social game mechanics, which are identified as the most effective gamification techniques in practical applications [27]. In addition, although it has not happened in this experiment, it is anticipated that with a small sample it is difficult to establish a uniform gamification proposal since there is a risk that the profile of the players involved will be very different from one another.
5. If the nonparticipants in the gamification proposal are aware that other partners are participating in an initiative in relation to performance in a given SPI activity that they also perform, there is an interesting effect: in the short term, non-participants raise their performance in such SPI activity artificially only by the perception that they are being observed and under the hy-

pothesis that their work will be evaluated / compared to that of the participants in the gamification proposal.

6. In the middle of the first pilot phase of the experiment, and in the absence of results of intrinsic motivation, it can be affirmed that the perceived performance increase in the definition, registration and execution of software tests has improved significantly.

Future work will focus on validating the framework presented in different types of organizations assuring a greater sample for the experimentation. In addition, the nature of SPI activities will be diverse. Other future developments include the evaluation of the framework through affective computing techniques with biometric signals during framework activities evaluation. Finally it is intended to deploy the framework in a setting covering all the ISO/IEC 29110 areas [34, 35].

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