Gamification of a Project Management System

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***Abstract*—Gamification is the use of elements of game design and mechanics in serious contexts for enhancing the value of a service or a product for its users. We describe psychological foundations and social motives for gamification, its principles and concepts, game rules (mechanics) and elements of game as well as techniques and patterns of gamification. As a case study, we analyze gamification of a Trogon Project Management System. For evaluation of gamified interface, we propose to use WCAG 2.0 rules, adapted for evaluating color contrast of game layer interfaces, and System Usability Scale (SUS) to evaluate usability of gamification.**

Keywords—gamification; game design; game mechanics, interface; usability.

I. INTRODUCTION

Recently, gamification has emerged as a new trend in development of enterprise information and e-commerce systems. Gamification is the use of elements of game design (game rules, game techniques, gamified interfaces) in non-game contexts [1], such as marketing, employee performance and training, and innovation. The aim is to enhance the value of a service or business product beyond its face value, as well as to boost user engagement, loyalty, and satisfaction. Game elements such as badges, levels and scoreboards implemented on top of the actual business processes and combined with meaningful game rules that encourage competition between game players may help to achieve positive outcomes such as higher sales of a product, drive marketing or increase job performance.

In a recent survey by Pew Research Center, 53% of people surveyed said that, by 2020, the use of gamification will be widespread [2]. A well know study of Gartner claimed that by 2015, more than 50% of organizations that manage innovation processes will gamify those processes [3]. Over 70% of Forbes Global 2000 companies plan to use at least some elements of gamification for product marketing and customer retention [4]. While some of the expectations of the spread of gamification may be overhyped, there are several examples of successful gamification, which include *Idea Street* [5], a social collaboration platform that uses game mechanics, *Badgeville* [6], a platform that enables businesses to apply gamification across their web and mobile experiences; and *RedCritter Tracker* [7], an Agile Project Management service with badges, rewards, leaderboards, and real-time Twitter-style feeds. These gamified systems have some common aspects: an attractive graphical user interface; strong emphasis on social competition; and an engaging award system.

However, gamification still poses great challenges to software designers: 1) how to design meaningful and engaging game rules as well as integrate them with business rules, 2) how to create an attractive game interface, which integrate smoothly with a user interface of a serious system, 3) how to evaluate success of gamification both in terms of its usability (aesthetic aspect) and customer retainment (pragmatic aspect).

In this paper, we describe our experience in gamifying a Project Management System. We formally describe game rules formally, present its architecture and implementation of gamified user interface. Furthermore, we propose using quantitative (modified WCAG 2.0 (Web Content Accessibility Guidelines) [8]) and qualitative (SUS (System Usability Scale) based [9]) evaluation methods to evaluate gamified interfaces.

The structure of the remaining parts of the paper is as follows. Section II discusses the related work. Section III describes psychological foundations and social motives of gamification as well as concepts and principles, rules and elements, techniques and patterns of gamification. Section IV describes gamification of a Project Management System *Trogon*. Section V proposes evaluating gamified interfaces using Web Content Accessibility Guidelines (WCAG) 2.0 [8] guidelines and System Usability Scale (SUS) [9] as well as presents the results. Finally, Section V presents conclusions.

Several cases of application of gamification are described in the literature in the context of enterprise information systems (IS) such as a generic platform for enterprise gamification [10], implemented using service oriented and event-driven principles and best practices; authentication games [11] for improving user's behavior regarding security; and the demand dispatch system [12] with a special scoring system, leader boards and social competition aspects embedded into user interface.

II. ANALYSIS OF GAMIFICATION

A. Psychological and social foundations

Primary motivation for gamification is a psychology-based one, namely, to enhance user or customer motivation to do a job or to increase and retain addiction to a service or a product using a game as a tool.

Gamification can be explained by Fogg Behavior Model (FBM) [13], which claims that both, motivation to perform

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and ability to perform, must converge at the same moment for a behavior to occur. Motivation must be supported by positive feedback from game mechanics that continuously triggers a user to perform specific actions and keeps him interested in the game.

Psychological foundation of gamification has been elaborated further by Wu [14], who analyzes why and how gamification is able to drive actions, and by Gnauk *et al.* [12], who studied extrinsic and intrinsic motivation and analyzed its relationship with external incentives and rewards.

Another motivation for gamification is social competition. Here, gamification is driven by the need to interact with other players and compare one's results. Thus, gamification requires introduction of real-time multi-user games with complex rules of game that have some similarity to social networking platforms.

B. Formal theory

Formally, gamified systems can be described using a theory of multi-games. Multi-Games is a class of games when each player can allocate its resources in varying proportions to play in a number of different environments, each representing a basic game in its own right [15]. Each player can have different sets of strategies for different basic games. The actors are permitted to play multiple games simultaneously. This multiplicity means that the actor must take interactions among relevant games and other players into account [16]. Gamified IS can be interpreted as a multi-game, i.e. a system of two games, where one game is a serious game (i.e., target IS) and another game is an entertainment game (i.e., gamification layer in target IS), where an action in the serious game leads to a reward in the entertainment game.

Following Grunvogel [17], each game G is a triple (S, M, F), where S is a set that represents the states of the different game objects, M is a monoid that represents an input of the players, and F is an action of the monoid M on set S as follows: $F : S \times M \to S$.

Then gamification can be described as a product of two games G_1 and G_2 as follows: $G_1 \times G_2 = (S_1 \times S_2, M_1 \times M_2, F_1 \times F_2)$, where G_1 is a serious (economical) game with tangible external actions and rewards, and G_2 is a non-serious game based on top of the G_1 with virtual actions and rewards.

C. Elements and Rules

According to Salen and Zimmerman [18], a game must have 1) Rules, 2) Players, 3) Struggle (artificial conflict), and 4) Goals (quantifiable outcomes). While the general goal of each game is a win, where can be multiple ways or elements of a game to reflect the player's path towards victory such as badges, which represent player achievements; leader-boards, which allow comparing one's achievements among multiple players; and levels, which reflect the growth of player skill.

Each game element can be described using the Frang [19] scheme as follows: Summary (visualization of an element with a proper description), Purpose, Ability, Motivation, Radoff's type(s) of fun (such as competition or exploration) [20], Dependencies with other game elements, and Importance.

More abstractly, game elements can be specified using a XML-based Gamification Modelling Language (GaML) [21], which provides a mechanism for precise definition of gamification concepts that is suitable for exchange on game mechanics. Finally, game rules connect game elements into a game layer. Such game rules can be modeled using a Petri Net based Machinations visual modeling notation [22].

D. Models and patterns

Several efforts exist at classifying and codifying recurring gamification practices and common techniques such as 1) Mechanics-Dynamics-Aesthetics (MDA) framework [20], a conceptual model of game elements; 2) game design atoms [23]; 3) Game design patterns [24], commonly reoccurring parts of game design; 4) game mechanics [25]; and 5) Game interface design patterns, common successful game design components and solutions such as badges, levels, or leader boards [26].

E. Architectural design

Gamification can be implemented using several architectural design methods:

1) As a service: a separate gamification system is developed, which provides elements of gamification to other systems as a service (e.g., *Mozilla Foundation OpenBadges* [27]);

2) As a module: a separate gamification module is developed that is integrated into a target system at a later stage of design (e.g., *EcoDriving* [28]);

3) As a plugin: a full implementation of gamification is developed that is later added to a target system without any additional effort (e.g., *Jira* [29]);

4) As a separate system: a gamification system and a target system are implemented separately and communicate with each other using messages (e.g., *TaskVille* [30]);

5) As an integrated system: an integrated system is developed which combines both target functionality as well as game behavior/mechanics (e.g., *RedCritter Tracker* [7]).

F. Integration with base system

According to Neeli [25], gamification of a business IS can be performed at different levels with respect to business activities: 1) at superficial level, the game mechanics are used independent of business activity of being performed, 2) at integrated level, the game mechanics are integrated into the business activity being performed, and 3) at embedded level, the business activity is designed based on game mechanics.

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III. GAMIFICATION OF A PROJECT MANAGEMENT SYSTEM

A. Base system

We analyze gamification of a Project Management System (PMS) Trogon (see Figure 1), as an example of a business IS (Information System).

B. Formal description

Following Bista *et al.* [31], gamification of a Project Management System is a tuple:

$$G =< J, B, R, F, P, W, T, I, D > \quad (1)$$

Figure 1. Screenshots of Togon PMS

where J – jobs which were entered into the PMS; B – badges defined in the PMS; R – ratings based on the number of finished jobs; W – registered workers; F – trees which represent jobs in the project forest; P – worker points received; I – month or week time interval; T – time represented in 15 minute time intervals; and D – a function to determine difficulty of jobs.

The value of received points by a worker is a function

$$P(j) = \sum_{n=0}^{count(j)} \begin{pmatrix} T_r(j_n) \cdot b(j_n) \cdot y(j_n, j) - \\ \left(0.1 \cdot \left(T_r(j_n) - T_p(j_n)\right)\right) \end{pmatrix} \cdot D(j_n) \quad (2)$$

Here, $P(j)$ is the number of points received by a worker in time interval, $b(j_n)$ is a badge received by a worker, $y(j_n, j)$ is a function that maps badges to points; $T_r(j_n)$ - time to complete the job j_n, $T_p(j_n)$ - planned time to complete the job, and $D(j_n)$ – difficulty of a job.

The game rules are as follows: (1) Every job can have a badge b and planned work time $T_p(j_n)$. (2) Every worker has real work time $T_r(j_n)$. (3) Every job has its difficulty $D(j_n)$. (4) Badge b is awarded if it is not withdrawn until the job status is „done“. Badge can be withdrawn by a project manager, if job quality is low or it took too long to finish. Quality assurance team members can remove the badge if there are many quality defects.

The player ratings are computed as follows:

1) A set of points is computed containing all employee points for considered time interval.

$$P =< p_1, p_2, \ldots, p_n > \quad (3)$$

2) The set *P* is sorted by descending point count.

$$R = sort\_desc(P) \quad (4)$$

3) Badge board sort order is computed like this:

$$sort\_desc(count(b)) \quad (5)$$

4) Project forests are sorted by total forest size, which represents time it took to complete all jobs.

C. Principles of gamification

To gamify Trogon, a special solution was chosen combining the entire system with a gamification module. For this case study, a simple Project Management System was created with system gamification in mind. Gamification layer of Trogon PMS was encapsulated into a module. This gamification solution was chosen for several reasons: integration to an existing Project Management System is a too complex problem and can affect the quality of gamification; a full system implementation is necessary for the gamification module to be practically useful.

For gamification of a system we used the following steps: 1) Define game rules. 2) Allow players view all employee ratings. 3) Introduce badge system, which consists of several types of badges and a badge board. 4) Badge system was coupled with a level system. Every badge defines a skill and the more of the same type badges are collected the higher skill level received. 5) Special awards and bonuses are presented to most skilled employees as defined by the game rules.

D. Elements and rules of a game

The gamified Trogon PMS has a leaderboard, badge board and the project forest as main elements of gamification. Every element has its purpose. 1) The leaderboard creates competition between individual employees and allows to determine a game winner, which should be additionally awarded. 2) The badge board allows observing the skills of employees. In the badge board the employees are ordered by the total number of badges collected. Each badge (see Figure 2) represents a skill and has its own level. Progress between skill levels is displayed as a progress bar. 3) The project forest provided the element of scalability to represent the size of different projects.

Project forest (see Figure 3) is a visualization of teamwork, which has three distinct areas: unoccupied plot means unfinished tasks, and areas with trees represent finished jobs. Every tree represents a different time interval it took to finish the job, while different type and complexity of a tree (Figure 4) shows that the job required more time to complete it. This creates a forest view where, which a project manager can use to visually evaluate and compare the complexity of jobs performed as well as the skill of the employee.

Figure 2. Game badges and badge levels.

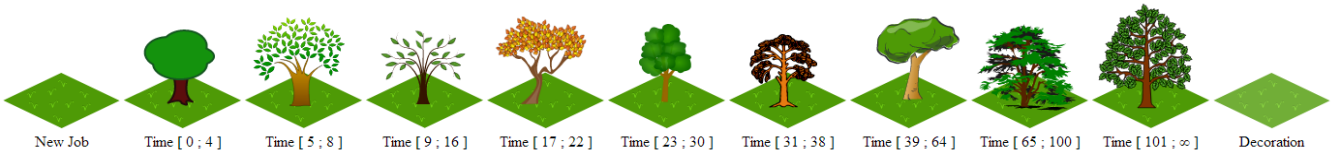

Figure 3. Elements of project forest.

Figure 4. Project forest

E. *Architecture of implementation*

The abstract architecture of Trogon PMS has three layers: 1) Website layer – this layer combines all visual elements into single system. Every website page is composed of one or more solutions from the solution layer. 2) Solution layer – contains business level logic consolidated into specific solutions. Every solution targets a specific problem. 3) Database layer – this layer is the shared by all solutions. Database maps data objects to specific tables in the relational database schema.

Gamification is one specific solution in the solution layer, and elements of gamification are used under multiple website pages. The class diagram (Figure 5) shows the division of solution into visual and logical parts. Visual and logical parts are connected by *IGamificationDC* (gamification data contract) and data object infterfaces (*IUser*, *IProject*, *IUnit* and *IBadge).* Gamification data contract allows us to map any system, which implements the gamification data contract. In implementation: *IProject* defines all project descriptive data; *IUser* defines all user descriptive data; *IUnit* defines a unit of work, which connects project, user and badge into a single system; and *IBadge* defines all badge descriptive data. *IProjectExtensions* and *IUserExtensions* introduce computational logic to *IProject* and *IUser* data objects. Computational logic is implemented as described in formal gamification description. *BadgeBoard, LeaderBoard* and *ProjectBoard* are visual elements, which generate the graphical user interface for the end user to interact.

Game rules are formulated as follows. Tasks are registered and rewards for task fulfillment are assigned. Tasks are split into atomic jobs for which project manager can easily assign planned work time. Every job can hold a special skill badge. Employees enter information about their work results. Quality engineer/project manager checks completed jobs for defects, and awards badges. Employee points and badges become visible to all other employees. Every week best employee is selected to be awarded.

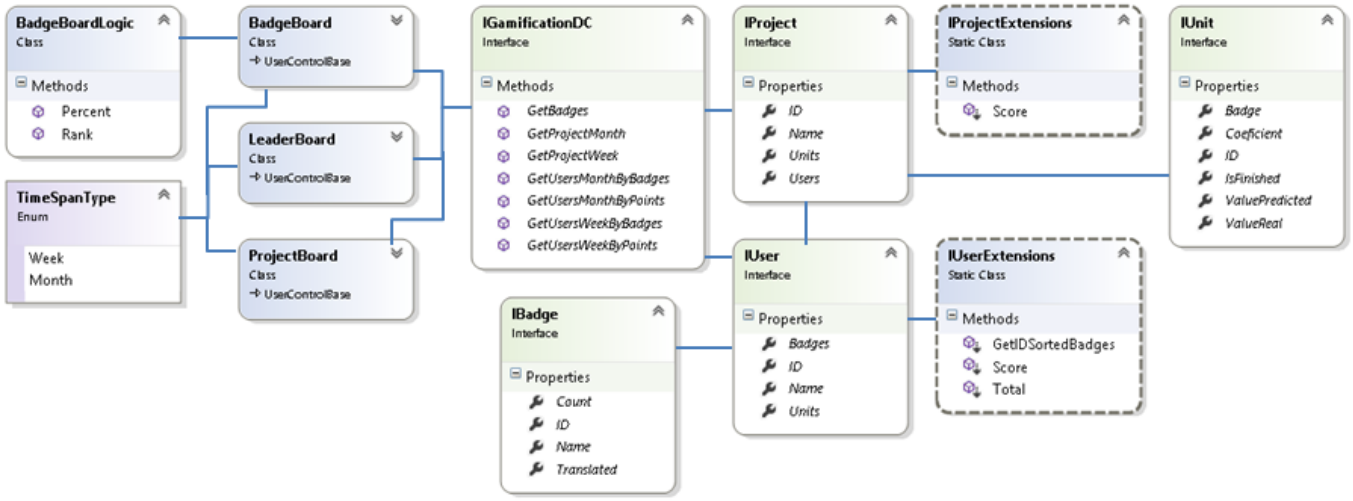

Figure 5. Gamification solution class diagram

IV. EVALUATION OF GAMIFICATION

Here, we describe the evaluation of gamified PMS using adaptation of WCAG 2.0 [8], and adaptation of System Usability Scale (SUS) [7] for gamified interfaces.

A. *Adapatation of WCAG 2.0 to Game Interface*

WCAG 2.0 [8] is a standard method for determining accessibility of a web interface. There are two ratings described in WCAG 2.0: the AA rating is assigned when contrast is >4.5, and AAA is assigned when contrast is >7.

Usually the WCAG 2.0 requirements are used for text only, but in our case most of information is presented in images, therefore we extend these rules on graphical images.

We use the following WCAG 2.0 evaluation scheme:

1) If the number of colors conforming to WCAG 2.0 contrast requirements is larger than the number of non-conforming colors, the interface is WCAG 2.0 compliant.

2) Else if the number of colors conforming to WCAG 2.0 contrast requirements is less than the number of non-conforming colors, but not by more than 50%, then interface has small problems, which, if resolved, would make the interface WCAG 2.0 compliant.

3) Else the interface is considered to be non-compliant with WCAG 2.0.

If interface is compliant with WCAG 2.0 then:

1) If the AAA rating colors dominate then interface is WCAG 2.0 compliant.

2) If the AA rating colors dominate then interface is WCAG 2.0 compliant.

We use the following notation to describe interface compliance:

WCAG 2.0 <X% AAA, Y% AA-, Z% AA> (6)

Here, X, Y and Z are percentage value of the AAA, AA-, and AA rating complying colors.

B. Results of Color Analysis

In the color analysis part of the study, we have analyzed six images of the Trogon PMS interface:

- Dashboard page, which shows all unfinished tasks, system events and inner office communications.
- Tasks page, which displays all tasks registered in the system.
- Employee task page, which displays all tasks assigned to the employee in a Gantt graph.
- Monthly ratings page, which displays the employee's ratings for the current month.
- Monthly badge page, which displays a sorted list of all employees and their badges with skill levels.
- Monthly project forest page, which displays all project forests, which had activity under this month.

We analyze screenshots (JPG images) of the game layer interfaces. For our analysis we use ImageMagick to manipulate images, Lea Verou color contrast tool to compute color contrast and define WCAG 2.0 rating, and custom script to automate the experiment.

Experiment consists of such steps: 1) We register the image of interface. 2) Using ImageMagick we generate image color histogram. 3) Using Lea Verou tool we check contrast of all colors against background color.

The tool returns one possible ratings:

- None is received when color pair is not WCAG 2.0 compatible.
- AA- is received when color pair is WCAG 2.0 AA compatible only for large elements.
- AA is received when color pair is WCAG 2.0 AA compatible.
- AAA is received when color pair is WCAG 2.0 AAA compatible.

The results of WCAG 2.0 evaluations are as follows.

1) Monthly badge board is WCAG 2.0 compliant.

WCAG 2.0 <AAA(48%), AA(23%), AA-(29%)> (7)

2) Monthly project forest is WCAG 2.0 compliant.

WCAG 2.0 <AAA(20%), AA(36%), AA-(44%)> (8)

3) Monthly leaderboard is not WCAG 2.0 compliant but with small changes compliance could be achieved.
4) Employee's task page is not WCAG 2.0.
5) Dashboard page is not WCAG 2.0.
6) Task page is WCAG 2.0 compliant.

WCAG 2.0 <AAA(69%), AA(13%), AA-(19%)> (9)

C. Adaptation of SUS

To rate usability of gamification we use System Usability Scale (SUS) [8] methodology. SUS already could be considered an industry standard for rating system or product usability. The main benefits of using SUS are as follows. 1) A very small number of respondents. Even with small number of respondents accurate results can be achieved. 2) Small number of questions allows a fast and efficient way to gather opinions. 3) Questionnaire can be used for system, product or module usability assessment. Drawback of using SUS is that it focuses on pragmatic quality.

Normally SUS consists of ten questions (statements), which are divided into five question (statement) pairs. In a pair both questions ask the same question, but one from positive side and the other from negative side. The SUS score is computed using such methodology: Every answer scores from 0 to 4 points. Point scale is from 1 to 5. Every question points are computed by subtracting 1 from chosen scale value. Score scale of odd questions 1, 3, 5, 7 and 9 is from 0 to 4. Score scale of even questions 2, 4, 6, 8 and 10 is from 4 to 0. The final score is obtained by multiplying score by 2.5. The total SUS score is from 0 to 100.

For evaluating usability of Trogon PMS, questionnaire consists of evaluation of game elements in Project Management System; data tables; first and second round views (ratings, badges and project forest).

The respondents are asked to respond to such statements.

1. I think what most people easily would learn game rules.
2. For me game rules looked too difficult.
3. For me gameplay elements looked easy to understand.
4. I think what I would need an experts help to fully understand gameplay elements.
5. I would like to have the possibility to always view leaderboard.
6. The leaderboard looked too complex for me.
7. I easily understand the role of badge board in this system.
8. I would need a lot of learning before I fully understand badge board role in this system.
9. I think what project forest is easy to understand.
10. I think what project forest has a lot of imprecisions.

Every pair of questions evaluates part of system gamification and whole questionnaire evaluates usability of entire system. Every pair of questions evaluated different parts of game elements: Statements 1-2 ask for usability evaluation for game rules. Statements 3-4 ask for evaluating gameplay elements. Statements 5-6 ask for evaluating leaderboards. Statements 7-8 ask for evaluating badge board. Statements 9-10 ask for evaluating project forest.

Questionnaire also asks to provide information about the respondent:

1. Your gender.
2. Your age.
3. Do you specialize in IT sector?
4. Comments.

D. Results of SUS survey

60 participants were asked to participate in the survey, and 30 participants have filled the questionnaire form. The main group of respondents was from 18 to 35 years. This age interval is best suited for gamification questionnaire, because their age group is considered to be the largest player group. The questionnaire included 22 men and 8 women participants. 23 of 30 participants work directly with Information Technology (IT) systems.

Every SUS question is evaluated from 0 to 10 points and every element is covered by two questions. Therefore, every gamification element can receive from 0 to 20 points. The

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gamification of entire system can receive from 0 to 100 points. To evaluate gamification qualitatively, we introduce the following intervals:

- 0-30 points – gamification is unusable.
- 31-50 points – gamification usability is poor.
- 51-70 points – gamification usability is average.
- 71-90 points – gamification usability is good.
- 91-100 points – gamification usability is excellent.

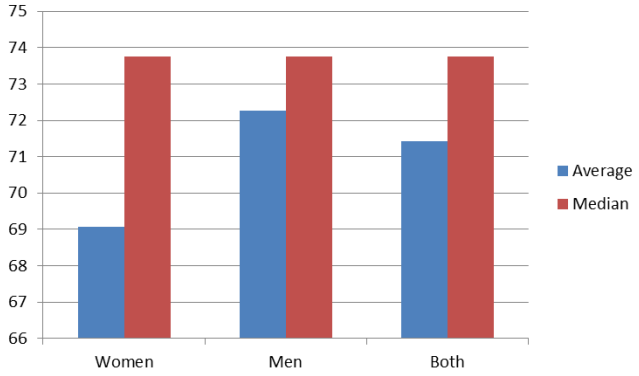

Figure 6. Gamification usability evaluation by user gender

In Figure 6, we present the results of SUS evaluation by gender. Gamification usability by genders has only small difference between women and men. The average difference is 3.5 points. We can assume what gender has almost no effect on gamification usability. Therefore, gamification of Trogon PMS is understood and evaluated pretty much without any differences between women and men.

In Figure 7, we can see large difference between evaluation gamification usability based on the experience of users working with IT systems. The difference in this case is of 17 points. The IT professionals have rated the gamification of Trogon PMS at 75 points, which is 3.9 % higher than the average rating.

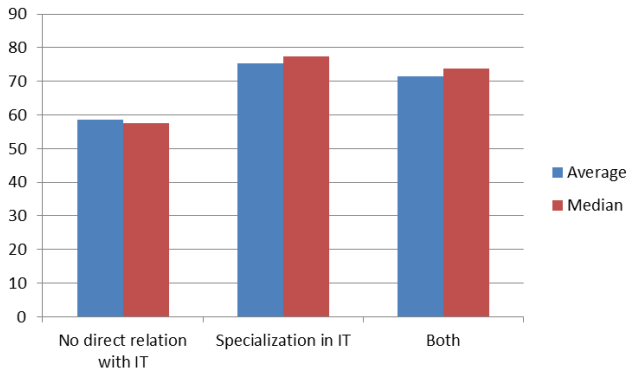

Figure 7. Gamification usability evaluation by user specialization in IT

The entire gamified Trogon PMS has been rated at 71 points from 100 points. Therefore, it has obtained "good" evaluation of gamification usability. When analyzing usability evaluations of specific elements, leaderboards were evaluated as easiest to understand, while game elements were hardest to understand.

V. Discussion and Conclussion

Gamification is a methodology that seriously enhances the systems with game mechanics and game design. In this paper, we have introduced the Trogon Project Management System (PMS) based on the three-layer architecture. Trogon PMS has been gamified by adding the additional game layer to it. The implementation of the gamification solution consists of two parts – data classes and visualization classes. This model of gamification can be applied to any system that implements the gamification data contract.

When gamifying systems there are many possible problems; so it is very important to do risk assessment as soon as possible in order to prevent against problems arising after the release of the gamified product such as user refusal. It is very important before launching gamified Project Management System into company business environment to convince employees to accept such change in companies' policy. Trogon PMS tries to avoid such problem by introducing gamification that would not disrupt normal company workflow.

In gamified systems, the factor of motivation usually decreases over time. Furthermore, over time even the greatest games start losing attraction and pleasure they provided to their users. In Trogon PMS, we leave this problem for project manager to solve, because he is the game master. His goal is to distract from monotony and to retain motivation over time. Project manager has such tools like game prizes and gameplay elements to adjust game scenarios. For example, project manager can award best project team or organize the contest of finest forest. Short intervals of game play in Trogon PMS help to counter monotony, because long running games usually lead to motivation loss. A competition environment, which if not carefully monitored may lead to teamwork problems. This challenge is solved by not showing concrete jobs done by an employee in the team's forest. Forest is the result of the teamwork. To avoid the problem of employees being judged by their contributions because of increased company transparency, we use information hiding to make specific job data more difficult to read.

For example, the leaderboard shows no concrete numbers but only differences between players. It allows to see only the best worker. The project forest does not actually show any concrete results for judging employees. Information is displayed only in short periods, so again you cannot judge employees. To solve a problem like tasks being not adequate, we split tasks into small concrete jobs, which are more adequate.

The experimental validation of gamification was made using quantitative and qualitative evaluation of game layer interfaces. Quantitative evaluation was made using color analysis of interfaces and its evaluation using WCAG 2.0 contrast ratio requirements for accessibility, which were

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transferred from web page domain to game interface domain. We have proposed a new method for evaluating color contrast ratio requirements of gamification interfaces using screenshot images. The method allows to identify interfaces that are designed poorly in terms of color contrast and therefore, may not be acceptable to their users.

Qualitative assessment of gamification usability was done based on using System Usability Scale (SUS), which has been extended and adapted for evaluation of gamification usability. Our study shows that the developed system is evaluated as having good usability (71 out of 100 points). There were no usability differences between men and women. However, there were differences in evaluation of gamification usability results based on user knowledge and experience in working with Information Technologies (IT). The study has found that consumers, which were not specializing in the IT sector, have assigned a lower usability score for the Project Management System.

Future work will deal with solving the problem of integration between business logic rules and game rules, and modeling the relationship and mechanics of game elements.

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