# Designing Game Strategies: An Analysis from Knowledge Management in Software Development Contexts

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**Abstract.** This document describes a model for the design of game strategies. This proposal is based on related works in the field of gamification and its applications. The proposed model is composed of three components: A game environment process, a game environment and a component for measurement and evaluation. This proposition seeks to offer a methodological tool for the design of game strategies in the field of gamification, applied to knowledge management. This document makes an analysis between gamification and knowledge management, with the goal of determining motivation's relationship with properties such as participation, collaboration and contribution, in the implementation of knowledge management processes, particularly in academic software development scenarios. The aforementioned properties are used for the evaluation of three validation scenarios.

**Keywords:** Gamification · Knowledge management · Organizational process · Motivational process

## 1 Introduction

In the field of organizational processes, knowledge is a vital element, which provides the bases for all kinds of entrepreneurial decisions, in aspects such as: infrastructure, processes, and roles, among others, taken from [1]. Considering the importance of knowledge at an organizational level, and particularly considering software engineering as a field of interest, knowledge management KM has been determined as a discipline that offers effective methods and methodologies for software process improvement, as cited by [2, 3]. Considering the definition of [4] about KM in software processes, which defined as an effective alternative for providing the organization with processes for the creation, modification and sharing of their knowledge assets, facilitating their internal relationships, for an optimal development of their software products.


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The aforementioned allows us to support considerations like those exposed in [7], where a variety of challenges in the implementation of KM, associated with software development processes, have been analyzed. Some of the identified problems consist in: mishandling of priorities when aligning KM with organizational needs; indiscriminate and disorganized storage of organizational information; lack of understanding when individually implementing KM processes; low participation in the creation of new knowledge assets; issues in the development of knowledge assets in a collaborative way; lack of diversification and retention of lessons learned during development projects; lack of interest by the development team, when it comes to knowledge contribution; among many others, exposed in [4].

Taking the aforementioned problems into consideration, along with works such as [5, 6], where another set of problems associated to the implementation of knowledge management is listed; we identify, among many of the factors that affect human capital and its involvement with KM processes, the concept of motivation. Considering that motivation influences people's behavior, their performance, drive to continue, work satisfaction, and even life satisfaction, according to [5]. We take the concept of motivation, in order to analyze its impact in the mitigation of problems associated to KM. Gamification is known for its efficient motivation enhancing techniques, both in groups and individually, which generate benefits such as knowledge retention, increased productivity, improved project delivery times, improved usage of budgets and reduced absenteeism. The aforementioned benefits are considered to be within the context of software engineering, according to [6]. For this reason, the analysis presented in this document is focused in proposing a method that allows for the design of game strategies, which support problem solving, in the context of software development organizations which implement knowledge management activities.

This document is structured as follows: Sect. 2 depicts an analysis of the use and impact of gamification in knowledge management processes, particularly in software development contexts. The next section presents a description of the proposed method, as well as its components. Additionally a section is presented, in which a set of properties related to the evaluation of KM processes is proposed. Properties such as participation, collaboration and contribution, are analyzed from the perspective of gamification, considering the application mechanics for each aspect. Finally, conclusions are presented, as well as a preview of future works.

## 2 Gamification and Knowledge Management in Software Development

The relationship between gamification and knowledge management is a field of study still in development, therefore, finding common elements and conditions between these approaches, requires a methodological process. Initially, a literature review was made, in which we identified works that related KM propositions within software development contexts. Interesting works were found, which allow us to identify propositions on methodologies, applications and approaches of KM associated to software development processes. For example the model proposed in [7] where the authors describe eight KM procedures (identification, creation, acquisition, storage, application, sharing,

protection and evaluation), in software development contexts. Products associated with these processes are also identified, and it is interesting to see the relationships between products and some of the less favorable conditions found in their application, as it discussed in [14].

Works such as [4, 5] describe common activities associated with common problems found in KM. The results of the literature review were analyzed with referential works, such as [7], where a very extensive review of KM processes, in software contexts, is made. This analysis allowed us to conclude the relationship between software development processes and the different approaches of knowledge management. Also, it allowed us to identify frequent conditions that could generate problems associated to the development of KM in software engineering processes. These conditions highlight the importance of estimating the impact of properties such as *participation*, *collaboration*, and *contribution*, during the execution of KM procedures; therefore, it will be important to analyze these 3 properties, as well as their evaluation, in the context of gamification.

Considering the described relationship between KM and software development, which was established in the previous paragraph, the results of this analysis allowed us to identify a set of issues associated to the interaction of development groups when it comes to the application of knowledge management processes. Particularly, we have identified a common factor mentioned in each of the related works: *motivation*. Therefore, several definitions and interpretations have been considered, regarding the importance of a proper management of motivation in organizational processes. Some of these are taken from [4], where motivation is considered to be an influential factor in human capital, which requires continuous motivation in order to function properly. Another definition to consider is suggested in [8], where it is stated that lack of motivation can derive in a considerable amount of problems, which are not foreign to knowledge management processes, and particularly not to software development organizations. Therefore, all these works share considerations where they suggest the use of agile alternatives that are captivating to the users, regarding strategies that help mitigate problems related to motivation.

Considering the previous analysis and the relationship between motivation and KM processes, some of the problems identified are: A direct relationship between low motivation within the development team, with a potential decline in knowledge sharing and transferring, with other members of the organization, taken from [6]; Low motivation in new members of the development team makes the acquisition of tacit knowledge more difficult, which needs to be expressed as explicit in their developments and future projects, exposed in [5]; Lack of will by the employees to share knowledge is the main obstacle in knowledge transfer into organization, taken from [3]. All related works in this analysis suggest that organizations require both technological and methodological tools, which support the motivation to identify, create, share, transfer and use knowledge, suggesting gamification as a method to achieve intrinsic motivation and obtain a massive extrinsic motivation that generates specific benefits for the organization, exposed in [11].

Taking all of the above into consideration, we have made an initial analysis based on motivation and the use of alternatives such as gamification, which can be taken from its definition in [4], as a potential tool for the improvement of various aspects within the

software industry. Also, works such as [12] suggest a set of benefits related to the implementation of gamification in software process improvement; these consist in the improvement of: communication between roles, feeling of advancement, competition, altruism, commitment and participation. Considering what's been exposed in this section, along with works like [8, 9], where they share the initiative of developing game strategies, as propositions for the improvement of motivational management in work groups; and considering the work of [12], where they propose a process to guide the design of applications that use Gamification; the current work looks to propose a method based on gamification principles that allow us to design agile strategies for the improvement of knowledge management processes. It is also necessary to propose a set of evaluation properties (collaboration, participation and contribution), that allows us to estimate, measure and control problems associated to knowledge management. These topics will be exposed in later sections.

## 3 Proposed Model for the Design of Game Strategies

The proposed model considers the work of [12] as a fundamental concept, amplifying the initial proposition with game elements that allow us to cyclically measure and evaluate the mechanics and dynamics of designed game elements. In this sense, this method is composed of three phases: A game environment analysis procedure; the game environment, and the measurement and evaluation. Figure 1 shows a conceptual representation of this method, and the three components of each phase. Next, we describe the three phases and their respective components.

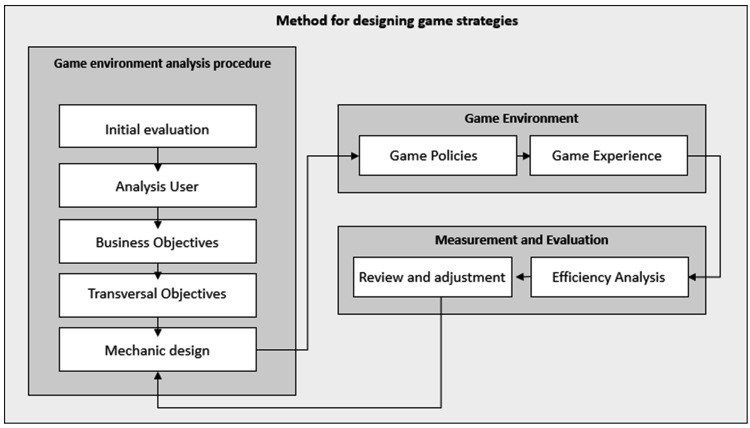


**Fig. 1.** Conceptual model for the design of game strategies.

### 3.1 Game Environment Analysis Procedure

This is composed of 5 steps, which are as follows

1. *Initial evaluation:* Allows for the definition of a set of problems, identified within the organizational interactions. This component suggests considering information such as affected population, estimated time to finish the strategy, involved technologies, artifacts (documents and such).
2. *User analysis:* Users are considered as players according to [13]. The result of this phase will be a characterization of players based on their game experience, this approach is based on works such as [11], where players are analyzed according to their interactions and play style. This phase suggests an analysis among experts and the organization, in order to define the types of players that will be involved in the game strategy.
3. *Business objectives:* Business objectives are of interest to the high management. They establish the organization's extrinsic motivations according to [12]. Goals to be reached with the implementation of the game strategy are defined. The business objective must be measurable and verifiable. This allows for the investments of time and money to be returned.
4. *Transversal objectives:* These establish the initial conditions for the execution of the business objectives. They're specific goals of the player's interest. Transversal objectives allow us to define a way to estimate and measure a player's intrinsic motivation in their game experience. It is suggested to establish short, medium and long term goals, in order to be developed by the player.
5. *Mechanic design:* A mechanic in gamification, according to [13], is the design and configuration of different game elements, grouped for a common goal. A game mechanic allows the player's intrinsic motivation to be fulfilled; it also represents the way to reach extrinsic motivation in business objectives. Among the most common mechanics are those proposed in works such as [13] (autonomy, competence and relation). Other works such as [8, 9], propose mechanics in aspects related to collaboration and participation, in knowledge management processes. The selection and design of game mechanics allows us to model transversal objectives, represented as game dynamics and game elements.

### 3.2 Game Environment

The main purpose is to define the way in which the proposed game strategy will be executed. It establishes the game conditions and rules for the selected mechanics. It includes 3 aspects:

1. *Game policies:* A game policy determines the rules and conditions of the game strategy according to [12]. Game policies are designed with the purpose of generating and sustaining entertainment over time, as well as motivating the player during their game experience. This way, game policies define conditions and restrictions for the manipulation and configuration of the game dynamics, and the way these are used during the game experience. In this component, the player's

levels of experience and adaptability are analyzed and adjusted accordingly with the game strategy. Levels such as: onboarding, habit-building and mastery, mentioned in several works such as [11], have been considered, where activity cycles, as described by [10] are proposed as well.
2. *Game experience:* This component allows us to establish the way game mechanics and dynamics affect the player's perception. Game experience evolves over time, during the use of the gamified application, which utilizes all of the proposed game mechanics. On the other hand, experiences such as the improvement of game knowledge, ability and skill, are experienced by the player.

### 3.3 Measurement and Evaluation

1. *Efficiency analysis:* It is proposed to use metrics, based on gamification principles such as the propositions in [9], where they define metrics with a specific purpose in knowledge management processes. These metrics use elements defined in the game mechanic, and they establish proper indicators, in order to measure the advancement of transversal objectives.
2. *Review and adjustment:* Reviewing is a task that allows us to analyze if transversal objectives have been fulfilled. In the opposite case, the designed mechanic is adjusted. The review compares data obtained by indicators, with the purpose of the transversal objectives. If at least one transversal objective doesn't fulfill its purpose, the process must return to the mechanic design, in order to make an adjustment, either in the selected elements for the game mechanic, or the selection of the mechanic.

## 4 Evaluation Properties Associated with Knowledge Management

The purpose of this section is to present 3 properties (collaboration, participation and contribution), which have been considered for the evaluation of game strategies. Particularly, the proposal is focused on knowledge management processes. These properties have been taken from recommendations and contributions by works such as [8, 9], where they expose the need of considering variables related to collaboration and participation, in a qualitative and quantitative measurement of motivation. On the other hand, the contribution aspect exposed in [6, 10], is adopted as another variable to consider for the evaluation of motivation in KM processes. The proposed definition for the 3 evaluation approaches is as follows.

### 4.1 Collaboration

This aspect allows us to analyze, estimate and measure effective interactions between the work group and the processes associated with KM. An interaction is measured by conditions in which an activity or set of activities is carried collaboratively [15].

### 4.2 Participation

Estimating the effective participation of a work group in KM, allows for the analysis of situations related to motivation and commitment in an organization [14].

### 4.3 Contribution

It isn't enough to determine the quality and quantity of participants in a KM process. This aspect has the goal quantifying the degree of contribution from each participation and its relationship with the work team, which is vital for determining profiles, roles, responsibilities and competences, which are specific for an organization [15].

The relationship between evaluation properties and game mechanics is established based on the theory of game elements by self-determination, proposed by [12]. This theory produces an association between game mechanics and the 3 dynamics of the self-determination theory (autonomy, competence and relation). The proposition of these properties establishes a relationship between each game mechanic and elements based on gamification principles, taken from [13]. This way, Table 1 shows a summary of the association between evaluation properties and a set of game mechanics. In order to evaluate the effectiveness of the proposed properties, we intend to measure the dynamics that take place within the game environment, in order to estimate the level of encouragement for these properties. Considering the elements that have been proposed for such dynamics, and their use by the players, the increase/decrease of participation, collaboration, and contribution rates, can be measured in knowledge management projects.

**Table 1.** Association of evaluation properties with game mechanics and game elements.

| Properties | Dynamics | Proposed elements |
|---|---|---|
| Participation | Autonomy | Profiles, avatars, macros, configurable interfaces, alternative activities, privacy control and notification control |
| | Relation | Groups, social networks and teams |
| | Competence | Badges and leaderboards |
| Collaboration | Relation | Groups, messages, blogs, teams, friending, connection to social networks and chats. |
| | Autonomy | Avatars, profiles and virtual trade. |
| | Competence | Positive feedback and reputation points |
| Contribution | Competence | Positive feedback, optimal challenge, progressive information, intuitive controls, points, reputation points, badges, levels and leaderboards. |
| | Autonomy | Profiles and avatars. |
| | Relation | Group tasks |

## 5 Validation of the Proposed Method

The method proposed in this document has been used to validate properties of collaboration, participation and contribution. The selected scenarios are a group of five companies located in the southern region of Colombia, among a potential of 250. All of the companies that participated in the experimentation are dedicated to software development. The validation was developed throughout a period of 3 months, in which every experimentation was carried during real projects. Results have been satisfying, regarding mitigation and management of the impact of problems associated to knowledge management, in software development processes. Quantifiable data, analysis and details of the implemented case studies will be exposed in extended versions

**Table 2.** Data sheet of the experiments conducted using the proposed method.

| Case study | Evaluated properties | Implemented dynamics | Results' analysis |
|---|---|---|---|
| **Description:** 2 scenarios with similar application conditions were defined. In the first case, a repository (wiki) was used for the publication of good practices. In the second case, the proposed method was applied, and a support application was developed.<br>**Implemented software:** Web application that promotes the voluntary publication of good software development practices, within a software development company. The designed strategy offers bonuses (points), and awards (badges), when employees post good software development practices, both individually and in groups.<br>**Required time:** 3 months<br>**Participants:** 45 employees | Participation | 3 types of badge are defined (professional, junior and amateur). Each badge provides points. These points are bonuses for the quality of the practices.<br>There is also a leaderboard, which validates the best scores within the established categories. | **Scenario 1:** 5 out of 45 employees posted new practices. 11% participation.<br>**Scenario 2:** 40 out of 45 employees posted new practices. 88.9% participation.<br>Effective participation reached 75%. Out of 40 active participants, 30 obtained professional badges, 8 obtained junior, and only 2 remained as amateur. |
| | Collaboration | There are 2 special badges (senior and master), which are obtained by the employees with the highest score in the professional category, who must also post good practices, developed by a team with tasks and roles. | **Scenario 1:** 4 out of 45 employees engaged in teamwork, in order to post new collaborative practices. 8.9% participation.<br>**Scenario 2:** 28 out of 45 employees developed new practices, which were posted. 62.2% collaboration.<br>Effective collaboration reached 89.2%. Out of the 28 participants who developed collaborative practices, 25 obtained senior badges, whereas 3 got master badges. |

of this document. An example of the experiments conducted with the group of selected companies, is summarized in Table 2. This table shows one case study that implemented the method proposed in this document. The data sheet show the properties evaluated, the dynamics implemented and the results obtained.

## 6 Conclusions and Future Work

Knowledge management, due to its complexity when it comes to comprehension and implementation, invites the proposition of alternatives that help generate more agile, motivating and flexible comprehension spaces. An alternative to consider is gamification, due to its emerging field of study and flexibility of application, as well as its easy adaptability to a variety of contexts. In this case, we found that gamification is an agile and viable alternative for the mitigation of problems associated to motivation in knowledge management processes, in software development contexts.

The method presented in this document, is a proposition designed based on the contributions made in several works, which propose processes in the design of game strategies, and proper usage of game mechanics. The key differences with other articles consist in the proposition of: Designing game strategies that part from a specific problem, in order to design measurable and controlled objectives during the execution of the strategy. Offering ways to measure a game strategy and control complex variables such as: reach and impact of the business objective. Another distinctive element is counting with an exclusive component, for the estimation and evaluation of the game mechanic.

Several propositions and studies support the interests of the current work; in which the applicability and efficiency of using gamification in several contexts, with a particular interest in KM, are praised. We make special emphasis in the advantage of game mechanics and the correct application of their elements, in the management and mitigation of problems related to motivation in KM. This work praises gamification characteristics for the evaluation of processes and activities such as autonomy, relation and competence, and their relationship with properties such as participation, collaboration and contribution.

The evaluation properties describes in this document can be applied not only in knowledge management contexts. Its initial analysis allowed us to define a method of application, although it doesn't imply they can't be used and analyzed in different contexts. Right now, the project is developing new validation prototypes, which will be applied in academic contexts and will be used, in order to analyze problems associated to motivation and commitment within specific groups.

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