Knowledge Transfer in Software Development Teams: a Gamification Strategy to Encourage Collaboration*

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ABSTRACT

Software development projects are knowledge-intensive because they involve rigorous management processes that must articulate with good knowledge and management practices. This integration is closely related to knowledge transfer, which is necessary for these projects. However, lack of collaboration, poor communication, lack of motivation to share knowledge, and the inability to make it available are some of the difficulties of knowledge management in software development projects. On the other hand, gamification influences people's behavior, promoting motivation, commitment, and collaboration in work teams. In this sense, gamification can be a potential strategy to transform these difficulties. It is adopted in this research in the design of GamifiK, an approach to encourage knowledge transfer in software development teams by promoting collaboration. GamifiK integrates good knowledge management practices, gamification elements, and collaboration as a soft skill for knowledge creation and transfer. A pilot study was conducted in an academic context to evaluate the preliminary performance of the strategy and its possibility of being validated and implemented in

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a software industry context. The results show that GamifiK can share knowledge and contribute to knowledge transfer in development teams and can be feasibility implemented in a real context.

Keywords: knowledge management; knowledge transfer; software development teams; gamification; collaboration in software development.

Transferencia de conocimiento en equipos de desarrollo de software: una estrategia de gamificación para fomentar la colaboración

RESUMEN

Los proyectos de desarrollo de software son demandantes en conocimiento porque implican procesos de gestión rigurosos que deben articularse con buenas prácticas de conocimiento y gestión. Esta integración está estrechamente relacionada con la transferencia de conocimiento, indispensable en estos proyectos. Sin embargo, la falta de colaboración, la escasa comunicación, la falta de motivación para compartir el conocimiento y la incapacidad de ponerlo a disposición son algunas de las dificultades de la gestión del conocimiento en los proyectos de desarrollo de software. Por otro lado, la gamificación influye en el comportamiento de las personas, promoviendo la motivación, el compromiso y la colaboración en los equipos de trabajo. En este sentido, la gamificación puede ser una estrategia potencial para transformar estas dificultades. En esta investigación se adopta en el diseño de GamifiK, un enfoque para fomentar la transferencia de conocimientos en los equipos de desarrollo de software promoviendo la colaboración. GamifiK integra buenas prácticas de gestión del conocimiento, elementos de gamificación y la colaboración como habilidad blanda para la creación y la transferencia de conocimientos. Se realizó un estudio piloto en un contexto académico para evaluar el rendimiento preliminar de la estrategia y su posibilidad de ser validada e implementada en un contexto de la industria del software. Los resultados muestran que GamifiK puede compartir el conocimiento y contribuir a la transferencia de conocimiento en los equipos de desarrollo y es una viabilidad para ser implementado en un contexto real.

Palabras clave: gestión del conocimiento; transferencia de conocimiento; equipos de desarrollo de software; gamificación; colaboración en el desarrollo de software.

INTRODUCTION

Knowledge Management (KM) is applying a systematic approach to capturing, structuring, managing, and disseminating knowledge throughout the organization to make it more competitive [1]. There are two fundamental classifications of recognized knowledge: tacit and explicit knowledge [2]. Explicit knowledge refers to the knowledge that can be articulated, codified, and communicated symbolically and with natural language. In contrast, tacit knowledge is a personal knowledge that is not easy to express through formal language, making it difficult to transmit and share with others [3]. This knowledge is rooted in individual actions and experiences and each person's ideals, values, emotions, intuition, ideas, and subjective aspects [4].

KM is a systematic process that includes the transfer of knowledge to stimulate social interaction and collaborative work among team members, share tacit knowledge informally, and help maintain explicit knowledge [5][6][7].

KM for software development is considered a key success factor [8] since important factors for software projects such as new knowledge construction, integration, and collaboration are involved during knowledge transfer.

In this sense, collaboration allows knowledge to be socialized, improving the participation of team members [7].

KM maintains a direct association with software development activities associated with the relationship and communication between the customer/user, the development team, and other actors in the process. In addition, KM in software development is related to activities where it is necessary to share experiences, capture knowledge and information, and require techniques that foster organizational knowledge [9].

Software development teams often migrate to work with methodological approaches promoting KM and knowledge transfer characteristics. These approaches are characterized by their ability to promote collaborative work [10], communication, motivation in the distribution, and team collaboration with the knowledge necessary for developing a project. However, there is interest in seeking strategies to facilitate the adoption of such methodologies and to improve key success factors such as communication [9], the ease of making knowledge available [8], and the motivation to distribute and share the knowledge necessary for the achievement of project objectives [11]. This interest can be framed directly with the transfer of knowledge in a software development team [12- 13], as common factors have been identified.

In addition, the new software development frameworks challenge team members to demonstrate skills associated with knowledge transfer and collaborative work [8]. For

example, being a collaborative team, being willing to put at the service of others the knowledge and experience acquired [9]. The knowledge transfer process facilitates social interaction among team members to share tacit knowledge [9]. It is considered a key factor in meeting the challenges of such methodological approaches to software development.

However, the interest in developing strategies that, in turn, facilitate the promotion of knowledge transfer as a good practice for software development motivates the study of gamification as a catalyst for KM in software development [14]. Gamification promotes motivation, commitment, performance, and collaboration in the participants of a development team [15]. Gamification intends to use game elements to influence a change in a user's behavior [16]. One of the main reasons why gamification has become so popular in recent years is that games have an engagement factor. Games affect positive emotions, relieve stress, create stronger social relationships, give a sense of accomplishment, and improve cognitive skills [17].

This paper proposes the design of a gamification-based strategy called, GamifiK to foster collaboration as a key success factor of knowledge transfer in software development teams. For the design of the strategy, we used the model based on gamification and social and human factors (SHF) that influence the productivity of software development teams proposed by Machuca and Gasca [18].

GamifiK integrates KM best practices, gamification elements, and collaboration as knowledge creation and transfer facilitators. The strategy aims to motivate the members of a software development team from an academic or industrial context to share their knowledge and contribute to the success of effective knowledge transfer. This strategy promotes KM in the specific context of software development. Specifically, GamifiK was designed for agile software development environments with the Scrum framework. The GitHub [19] platform is proposed to manage project issues and Assembly [20] to facilitate knowledge transfer between team members and to recognize them as active actors in this transfer.

The rest of the article is structured as follows: Section 1 presents the materials used in this research and shows the background on the practical use of KM and gamification in software development teams. Then, in section 2, the methodology used for this work and the method selected for the strategy design are described. Then, in section 3, the results describing the proposed strategy are shown. Then, in section 4, the results are discussed, and the limitations and recommendations are described. Finally, in section 5, the proposal is concluded, and future work is presented.

1. MATERIALS

1.1 Literature review

This section describes work related to proposals that address KM, gamification, and gamification strategies in the context of knowledge transfer in software development teams.

Zieris and Prechelt [21] studied how knowledge transfer works during pair programming. They qualitatively analyzed several recordings of live pair programming sessions of professional software developers. The results showed that pair programming is not productive without a knowledge transfer technique and that knowledge transfer skills do not automatically arise from good software development skills but can probably be learned.

On the other hand, Kao [22] proposes a collaborative framework to support software developers perform development and maintenance tasks on software projects much faster based on Q&A sites. The framework manages and uses valuable information from sites like Stack Overflow, Quora, and Reddit through annotation, traceability, and team/user management.

Moser *et al.* [23] analyzed the impact of a software quality assurance strategy with gamification and continuous feedback techniques. Delivering high-quality code is a critical success factor for any software project. The results suggest that gamification can serve as a strong motivational driver for developers in addressing software quality issues and facilitating knowledge transfer.

In their research, Friedrich *et al.* [24] analyze the effects of game mechanics on motivation and knowledge-sharing behavior. Therefore, they identify that motivation is key in assuring high content quality within a KM system.

Moldon *et al.* [25] analyzed how gamification directs behavior and participation among software developers. Gamification is especially prevalent in platforms software developers use for collaborative work, such as GitHub [19], and GitHub is an online platform for collaborative programming and software development. The results of this research demonstrate the significant impact of gamification on developers' behavior on large programming platforms and collaboration among them.

Gasca *et al.* [26] designed a web platform called "Planetary Exploration System" which allows team members to explore different worlds and execute missions. In a pilot test of this tool, greater adherence to the new process was evidenced by the actors involved in tasks. This pilot test was carried out for a software development

company's incident management process for one month. The task involved was registering the incident and its solution in the system provided for this purpose.

In addition, a gamification-based strategy was found to promote knowledge transfer in a software development team in [27] and [28]. The strategy was implemented in the code review task of the development phase of the software life cycle, seeking to influence collaboration among team members. In this strategy, points were used as gamification elements assigned to participants (programmers or reviewers) for sharing knowledge with team members.

In general, KM strategies identified in the literature are oriented toward technical approaches or structural aspects of knowledge storage and less attention is paid to the different aspects of human motivation and individual willingness to share knowledge [24]. However, the trend of gamified strategies is oriented toward improving software development activities. Some of the identified strategies allow knowledge building in a development team and motivate team members to share knowledge. However, a lack of solutions to mitigate the challenges of generating knowledge transfer capabilities in software development teams. Some challenges related to collaboration in software development teams.

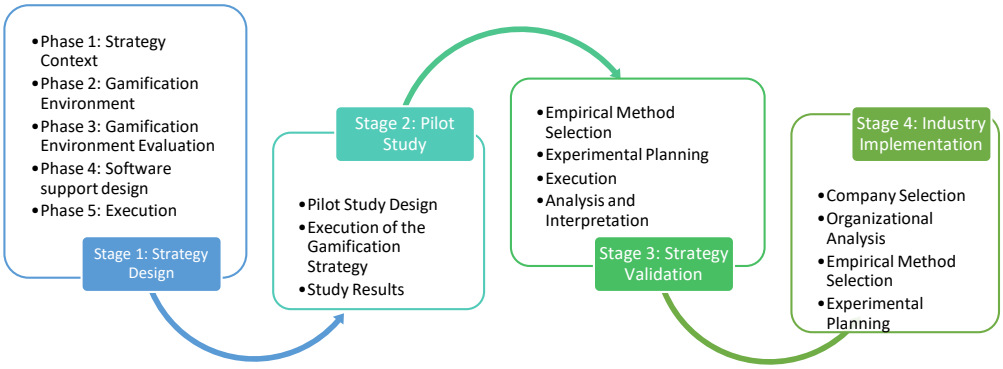
1.2 Research Proposal

This proposal aims reduce the identified difficulties, specifically those related to knowledge management in software development projects, such as lack of collaboration, poor communication, demotivation in activities associated with knowledge sharing, and the inability to make it available. Therefore, this proposal is based on a gamification strategy called "GamifiK", which integrates good practices of knowledge management, gamification elements, and collaboration as a facilitator for the creation and transfer of knowledge in software development teams.

2. METHODOLOGY

Four stages have been proposed for the development of this work, as follows. Stage 1: Strategy Design; Stage 2: Pilot Study; Stage 3: Strategy Validation, and Stage 4: Industry Implementation (Figure 1).

Figure 1. Methodology



Source: own elaboration.

2.1 Stage 1. Strategy Design

The method proposed by Machuca and Gasca was used to design the strategy [18]. It aims to guide the design and execution of strategies based on gamification, in which SHFs of influence on the software development team's productivity is involved.

Figure 2 presents a summary of the method for the design of gamification strategies that favor the productivity of a software development team. This method is developed in five phases: 1) Strategy Context, 2) Gamification Environment Design, 3) Gamification Environment Evaluation Design, 4) Technology Support Design, and 5) Execution.

Figure 2. Method summary

Source: own elaboration based on [29].

2.1.1 Phase 1: Strategy Context

Identify the context where the gamification strategy is to be applied. Then, the SHF to be worked on in the strategy is selected. The method provides an SHF catalog with its description to make the selection.

2.1.2 Phase 2: Gamification Environment Design

Develop three activities to define the design of the gamification environment of the strategy. First, determine the objectives expected to be achieved with the gamification strategy related to the selected SHFs and aligned with the business goals, achieving them within the identified work context.

Secondly, participants are identified with their motivations, and their roles and behaviors are described. To identify the type of participants with their motivations, the method is based on the proposal of types of players suggested by Amy Jo Kim in "Social Engagement Verbs" [30]. Next, depending on the proposed strategy and its context, the roles of the strategy participants will be described. The roles must be related to the participant's role and their behavior since they are associated with the actions they will perform. The behaviors should be concrete and specific and promote the objectives defined in the first activity.

Finally, the gamification elements and the description of how they will be used are included. The model recommends 24 gamification elements according to the level of relationship with the SHF. These elements are classified into dynamics, mechanics, and components [31].

2.1.3 Phase 3: Gamification Environment Evaluation Design

In this phase, software development productivity measures are selected to analyze whether the strategy's favorable implementation influenced productivity. In addition, success metrics are established to measure the strategy's performance regarding the participants' behaviors. These metrics are related to the quantifiable results expected from the strategy participants' behaviors. Finally, a questionnaire is defined to evaluate participants' satisfaction with the strategy experience.

2.1.4 Phase 4: Technology Support Design

In this last phase, the rules or instructions that will guide the development of the strategy are defined. Also, a story is created that integrates participant behaviors and gamification elements while promoting the objectives and SHF that have been previously determined. The story describes the ideas that articulate details defined in the previous phases. Finally, the type of tool proposed for the implementation of the strategy is indicated; this can be a web or mobile application, a board game, or the adaptation of an existing platform.

2.1.5 Phase 5: Execution

This part is described in stage 2 of the pilot study.

2.2 Stage 2: Pilot Study

In this stage, the pilot study is designed to evaluate the behavior of the strategy. Also, the selected tools are designed according to the objective and specifications of such a strategy. Moreover, the objective of the study, the subjects involved, the instruments to be used, and the way in which it will be executed are defined.

Furthermore, fundamental aspects for the execution of the strategy are established, such as the location, the development team, the development project and methodology, and the execution dates.

2.3 Stage 3: Strategy Validation

At this stage, an empirical method defines and supports the strategy validation approach. Validation will allow the strategy to be evaluated with scientific rigor and follow the measures established during strategy design.

2.4 Stage 4: Industry Implementation

In the final phase of the methodology, it is planned how the strategy will be implemented in the industry based on the characteristics of the company and the software development team. An empirical approach may also be used to test the existence of a causal relationship between two or more variables to obtain accurate and generalizable information. This information provides statistical significance based on the measures established in the design of the strategy [32].

3. RESULTS

This section comprises the results of this research's first and second stages. The effects associated with the third and fourth stages are proposed as future work.

3.1 GamifiK

A strategy based on gamification was designed to mitigate the difficulties associated with knowledge transfer capabilities in software development teams, such as collaboration [33] and lack of communication. GamifiK is the proposed strategy and results from applying the previously presented method. The following is a description of the design details.

3.1.1 Strategy Context

The context of the execution of the gamification strategy is the KM. Within this context, it is proposed to intervene in the SHF collaboration in knowledge transfer within the software development teams. According to this scenario, the GamifiK strategy is created.

3.1.2 Gamification Environment Design

The objective of GamifiK is to promote collaboration in knowledge transfer in software development teams. In this phase, participants and their behaviors were defined. Table 1 presents the description of each of the defined participant types.

Table 1. Motivations, roles, and behavior of the strategy's participants

Participant type	Motivations	Role	Behavior
Collaborate	They are motivated by working with others toward a greater goal. They love to "win together" and measure success as a collective impact. They enjoy participating in groups and teams, forming partnerships, and playing cooperative games. They value teamwork, shared learning, and building relationships through shared tasks.	Software development team member	Work together on an issue when a colleague asks for help. Sharing ideas and experience on incidents. Sharing information in the Knowledge Book. Provide collaboration on questions asked in the discussion section of the Knowledge Book.
Explore	They are motivated by acquiring knowledge, exploring boundaries, finding gaps, and knowing the rules that govern a space. They love exploring systems and discovering their tricks. They enjoy accumulating and displaying knowledge. They value accurate information, intelligent design, and building relationships through knowledge sharing. They may enjoy exploring with others, but it is often a satisfying solitary effort.	Software development team member	Acquire knowledge from the experiences of others when providing knowledge in the transfer process. Apply knowledge from the experiences of others when using Knowledge Book inputs. Recognize the usefulness of shared knowledge by liking what is shared in the Discussions section of the Knowledge Book
Compete	They are motivated by testing their skills and seeing how they compare. They love to develop their skills, show their prowess, and know where they stand in a group. They value mastery, learning, and building relationships through friendly competition.	Software development team member	Tag teammates who are considered to have the knowledge to help in a blockage. Provide collaboration in the daily meeting to a teammate who shows any blockage. Share the number of trophies acquired Share in ceremonies when trophies are redeemed in the industry or academy.
Express	They are motivated by opportunities for self-expression. They love tools and systems that allow them to personalize their experience, make their mark, and express their uniqueness. They will use all available tools to create things that others admire and emulate. They value original thinking, creativity, hard work, and personal style. They enjoy customizing backgrounds, fonts, and avatars. They seek status, recognition, and influence through their creative ability	The software development team and Moderator	Recognize with trophies the collaboration of a partner in transferring knowledge. Recognize with trophies the contributions in the Knowledge Book during the sprint. Recognize with gold, silver, and bronze medals the collaboration in knowledge transfer in the retrospective.

Source: own elaboration based on [29].

For the design of the gamification environment, it is important to select the gamification elements to be used. Table 2 shows the gamification elements that were included in this strategy according to the category of the elements and the description of how they will be used.

Table 2. Stages of the design method

Category	Element	Description
Dynamics	Restrictions	Players must perform the three steps to make the knowledge transfer: Request, provide, and qualify the knowledge. There must be evidence of the knowledge transferred in the player's incidence comments. The player must assign the trophies to the teammate who assisted in the knowledge transfer. The player must share the knowledge in the Knowledge Book in the discussion section of the GitHub platform and use the "Knowledge Book" tag. The moderator should assign trophies when other players use the knowledge from the Knowledge Book.
Dynamics	Relations - Social interaction	Interaction between different team members when working in groups such as back-end, front-end, and testing.
Mechanics	Cooperation	Team members work together to perform the three steps of knowledge transfer.
Mechanics	Reward	The player can redeem trophies for bonuses in the real world (industry or academy).
Mechanics	Continuous feedback	In the retrospective, the moderator informs the players of the number of trophies won during the sprint.
Components	Avatar	Players will use an avatar to interact with on the platform.
Components	Leaderboard	At the end of the sprint, a ranking of the players who collaborated the most in Knowledge Transfer and Knowledge Book in the sprint is generated.
Components	Badges	Medals for collaborating during the sprint are assigned to the first 3 places. Contributor 1 - Gold Contributor 2 - Silver Contributor 3 - Bronze. The medals are equivalent to trophies to be redeemed in the industry or academy.
Components	Points	Trophies will be used to manage points. Trophies are accumulated for: - collaborating in the transfer of Knowledge in an incidence of a colleague; -exceeding the knowledge in the Knowledge Book; -when other players react to the shared knowledge; -when other players use the knowledge in the Knowledge Book.
Components	Social graphics	Players will be able to identify themselves on the GitHub platform.

Source: own elaboration based on [29].

3.1.3 Gamification Environment Evaluation Design

The following measures were defined:

Measures of software development team productivity are as follows:

1) Number of stories indicating the project's progress based on the number of stories accepted per sprint.

2) Tasks completed per hour that assess project progress or performance considering the difficulty and effort of the task.

3) Influence measures the individual's participation and commitment in the project's progress.

The success metrics of the strategy's performance based on the participants' behaviors defined in Table 1 are as follows:

- The number of trophies awarded for assisting in the transfer of knowledge on incidents to players in a sprint.
- The number of trophies awarded for knowledge sharing in the Knowledge Book in a sprint.
- Amount of market bonuses redeemed per sprint.
- Knowledge transfer collaboration progress: knowledge transferred in a sprint by player/knowledge transferred in a sprint by the team.
- Collaborator productivity: number of story points committed by the player per sprint/average number of story points committed by the team per sprint.
- Knowledge contributions: number of contributions in the contributor's Knowledge Book/number of contributions in the team's Knowledge Book.

A questionnaire to evaluate participants' satisfaction with the gamification strategy experience can be found in [34].

3.1.4 Technology Support Design

A web platform is necessary to implement the strategy. This platform allows collaborative software development, agile project planning, and management, version control, text boxes to add information and knowledge to incidents, and the hosting of wikis with a reaction bar. In addition, a technology tool to enable employee recognition and reward redemption.

The tools proposed for the implementation of GamifiK are as follows:

- GitHub to manage the project's issues (User Stories, bugs, tasks) and share knowledge in the Discussions section.
- Since the players (development team) will have an avatar with which they will interact in the project, we suggest getavataaars.com, creartuavatar.com, makebadg.

es/avatar#, toonme.com, bitmoji.com, voki.com, and the avatoon application, for avatar creation.

- The Assembly platform will be used for trophy management [20].

In GamifiK the players are the members of the software development team who recognize each other for collaborating in the transfer of knowledge in a software development project.

The software project is developed under the agile Scrum framework. It will use the GitHub platform to host the code repository, manage project issues and share knowledge using the discussions section of the same platform. This platform promotes recognition among employees with meaningful messages and rewards.

Each player is assigned an initial score of 0 trophies which increases as the sprints of the project progress. Trophies will accumulate throughout the project and can be carried over from sprint to sprint. Players will have an avatar with which they will interact in the project, and it will be set as their profile picture on both platforms.

The rules are also complemented by the following key principles on which the strategy is based:

- Players can accumulate trophies for collaborating in knowledge transfer. This process is defined in three steps:

  a. Request knowledge: the player who has an assigned issue must request knowledge from his teammates. To request knowledge, the GitHub platform will be used, the "Help Wanted" tag will be placed, and the trophies will be offered with another tag depending on the complexity of the knowledge required (Example "20 trophies"). The following is Table 3 of equivalence to offer trophies depending on the complexity of the knowledge required:

Table 3. Trophies to offer for the complexity of knowledge required

Complexity knowledge required	Trophies to offer
1	10
2	20
3	30
5	40
8	50

Source: own elaboration.

Moreover, a team member that the player feels has the necessary knowledge to make the transfer may be tagged.

b. Provide Knowledge: the peer provides knowledge to the requesting player through activities such as tutorials or pair programming. These activities must be recorded in the requesting player's GitHub issue.

c. Qualify Knowledge: the player receiving the knowledge must qualify the knowledge received. This qualification must be subject to the fact that the requesting player can apply the knowledge in his context.

In Assembly, the player requesting collaboration will acknowledge the partner for the knowledge transfer by assigning the trophies and in the GitHub issue, the "Help Wanted" label will be removed as well as the trophies offered.

- Players can accumulate trophies for sharing their knowledge in the Knowledge Book. The Knowledge Book is a book that covers the related topics in the project. Through externalization (Tacit – Explicit knowledge transfer) players earn additional trophies when they organize and communicate knowledge in a new Discussion (GitHub using the Tag: Knowledge Book).

In the Book of Knowledge, trophies are obtained in the following way:

a. The player who shares knowledge in a Discussion gets 50 trophies.

b. If a teammate reacts positively with a "like" to the shared knowledge, the player who posted gets 10 trophies.

c. The player who collaborates on a question asked by a teammate in a discussion receives 150 trophies.

At the end of the sprint, a ranking table will be generated for the first three positions: 1) Gold Collaborator, 2) Silver Collaborator and 3) Bronze Collaborator. In addition, medals will be assigned according to the positions in the ranking table. These medals are equivalent to trophies for redemption (See Table 4).

Table 4. Equivalence Badge for trophies

Badge	Trophies
Gold Collaborator	2,000
Silver Collaborator	1,500
Bronze Collaborator	1,000

Source: own elaboration.

Players can redeem trophies for badges according to the trophy redemption table in the industry and the academy (see table 5). The moderator oversees managing the redemptions, and the trophy redemption table can be parameterized according to the organization's interests.

Table 5. Trophy redemption table

Trophies	Industry redemption	Academy redemption
200	1 espresso coffee	
300	1 coffee and 1 *almojábana*	
400	1 coffee and 1 croissant	
500	1 *Frappuccino*	0.5 points in grade
1000	1 *Frappuccino* and 1 almojábana	0.7 points in grade
1500	1 *Frappuccino* and 1 *arepa*	1 point in grade
2000	1 homemade lunch	1.5 points in grade

Source: own elaboration.

The implementation story is a set of activities and behaviors that can be in narrative form or as rules that articulate the dynamics of the strategy. In this sense, the story that integrates the behaviors of the participants, gamification elements, and the promotion of the objectives and SHF for the GamifiK strategy is as follows:

The moderator will set up the project on the GitHub and Assembly platform (manual setup link) and invite team members (players) to collaborate on the project. Players will be able to establish an avatar with which they will interact in the project. Then, when the sprint starts, each player will be assigned an initial score of 0 trophies that increases as the sprint progresses. Players can earn trophies for collaborating in knowledge transfer:

- Request Knowledge: in an incident, players use the tag "Help Wanted" to request collaboration, then with another tag, offer trophies (e.g., "20 trophies") for the collaboration depending on the complexity of the knowledge required according to table 5.
- Provide knowledge: when the players perform the knowledge transfer, they must include evidence of the transfer process (written code, video, etc.) in the incident.
- Qualifying Knowledge: the player who requested the knowledge assigns the trophies offered in the Assembly.

Also, players can earn trophies for sharing knowledge in the Knowledge Book (discussions on GitHub). The player who shares knowledge gets 50 trophies. In addition, if a player reacts positively with a "like" to the shared knowledge, the player who posted

gets 10 trophies. In addition, if a player collaborates on a question in the publication of knowledge, they receive 150 trophies.

Then, at the end of the sprint, a table will be generated with the first three positions of the players who obtained the most trophies for collaborating in the transfer of knowledge, and the moderator will assign the trophies to the players in the Assembly according to table 4.

Finally, players can ask the modeler to redeem trophies for bonuses in the real world. The redemption will be through badges configured in Assembly according to Table 5 of trophy redemption.

3.2 Pilot Study

The pilot study seeks to evaluate the strategy's performance in conjunction with the technological tools that implement it. For this purpose, it is necessary to consider the objective and specifications of GamifiK and the work team where it will be executed.

3.2.1 Pilot study design

Objective

The objective of the pilot study was to implement GamifiK in an academic context and observe that its performance was following its specifications. In executing the strategy, we sought to:

- Identify that the team members understood the strategy.
- The technology platforms will be aligned with the activities proposed in the strategy.
- The team will be motivated to collaborate in knowledge transfer.

Subjects

The subjects of the pilot study were 4 students of the Computer Project Management course of the Systems Engineering academic program of a Higher Educational Institution in Colombia. They assumed the role of software development team members and were provided with a document with the conditions and rules of the strategy. In addition, the participants had knowledge and professional experience in the software development industry under the Scrum framework.

Instruments

A work scenario where a software product is developed was necessary to implement the strategy. For this purpose, the Product Backlog of the project is documented, and

the incidents were assigned for a sprint. The participants were trained in knowledge management and a document was shared where the conditions of the GamifiK strategy were established.

Study preparation

For the preparation of the pilot study, meetings were held before the implementation of GamifiK. Students and the teacher in charge of the course participated in the meetings. In these meetings, the strategy was presented and the meetings for the Scrum ceremonies were scheduled. Also, the documents where the data for the gamification metrics, satisfaction questionnaire, and productivity measures would be recorded were shared.

The project was set up on the GitHub platform. Milestones were used to mark the sprint and tags were used to define the story points and provide trophies for knowledge transfer, and team members were added to the project so they could upload their issue code to the repository. Also, in the Assembly platform, rewards were configured so that participants could be recognized for knowledge sharing and knowledge transfer collaboration. Table 6 details the basic data of the pilot case study.

Table 6. Pilot case study fact sheet

Career or academic program	Systems Engineering
Course name	IT Project Management
Academic level	9 semesters
Course objective	To provide necessary and basic knowledge to apply project management techniques and understand IT project development management problems.
Subject units	1. Software project management. 2. Integration and stakeholders of the software project. 2. Scope and schedule of the software project. 3. Software project execution, monitoring, control, and Knowledge Management. 4. Software project communications and risks. 5. Software project closure.
Strategy execution period	2021-1
Number of sprints	1

Source: own elaboration.

3.2.2 Execution of Gamification Strategy

Validation in an academic environment can be carried out with students as subjects to capture any evident flaws in the proposed strategy and identify improvements to ensure that the best possible solution is available when taken to the industry [35].

In this sense, the pilot study was conducted in an academic context to evaluate the strategy. The period of this implementation was from January 11th to January 25th, 2021.

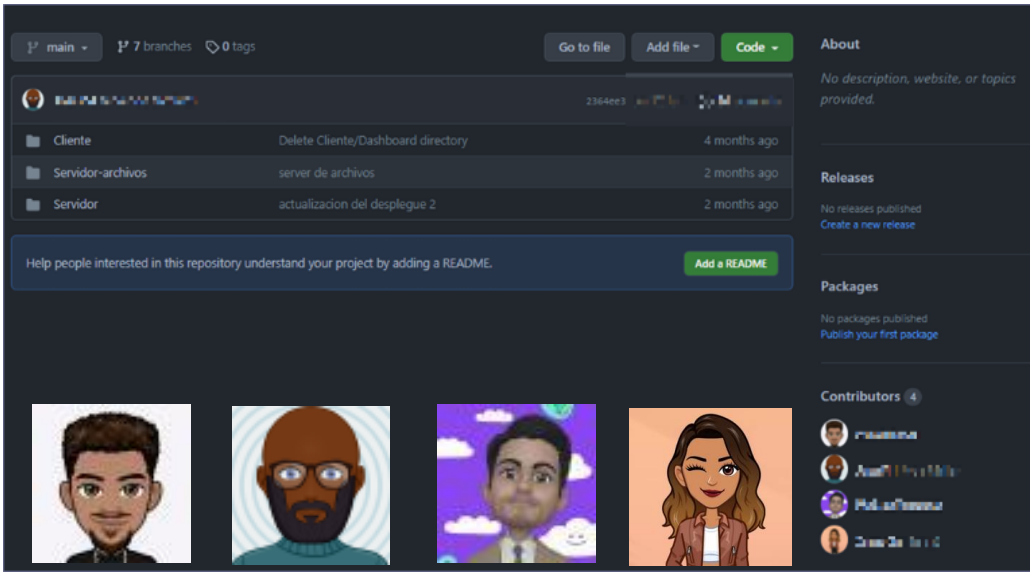
During this implementation, a software project sprint was developed under the Scrum agile framework.

Once the test scenario was configured, the participants started with executing the project sprint working with 7 user stories. During this process, some incidents encouraged requests for help on a specific topic of the project, this caused the other members to share their experience and in turn the knowledge within the team. In this way, the resources provided for the implementation and evaluation of GamifiK were used.

3.2.3 Pilot Study Results

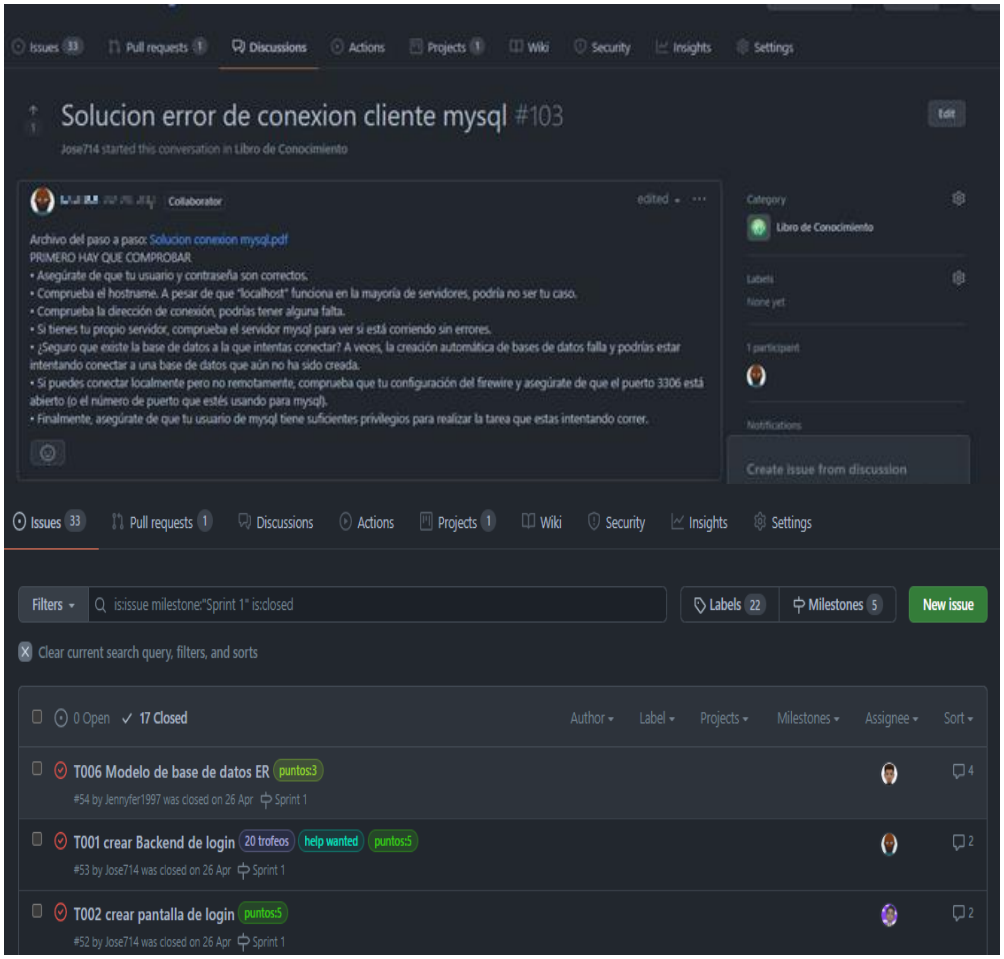
The results of the pilot study showed that each participant designed their avatar to establish it as their user profile (figure 3) and that they managed the project issues to foster the knowledge transfer process and the Knowledge Book (Discussions section) to share knowledge (figure 4). With the support of the Assembly platform, rewards were given to each participant for their collaboration in the knowledge transfer. Also, participants redeemed bonuses and were recognized as active actors in the transfer with trophies. Figure 5 shows the rewards that defined.

Figure 3. Avatars established on GitHub



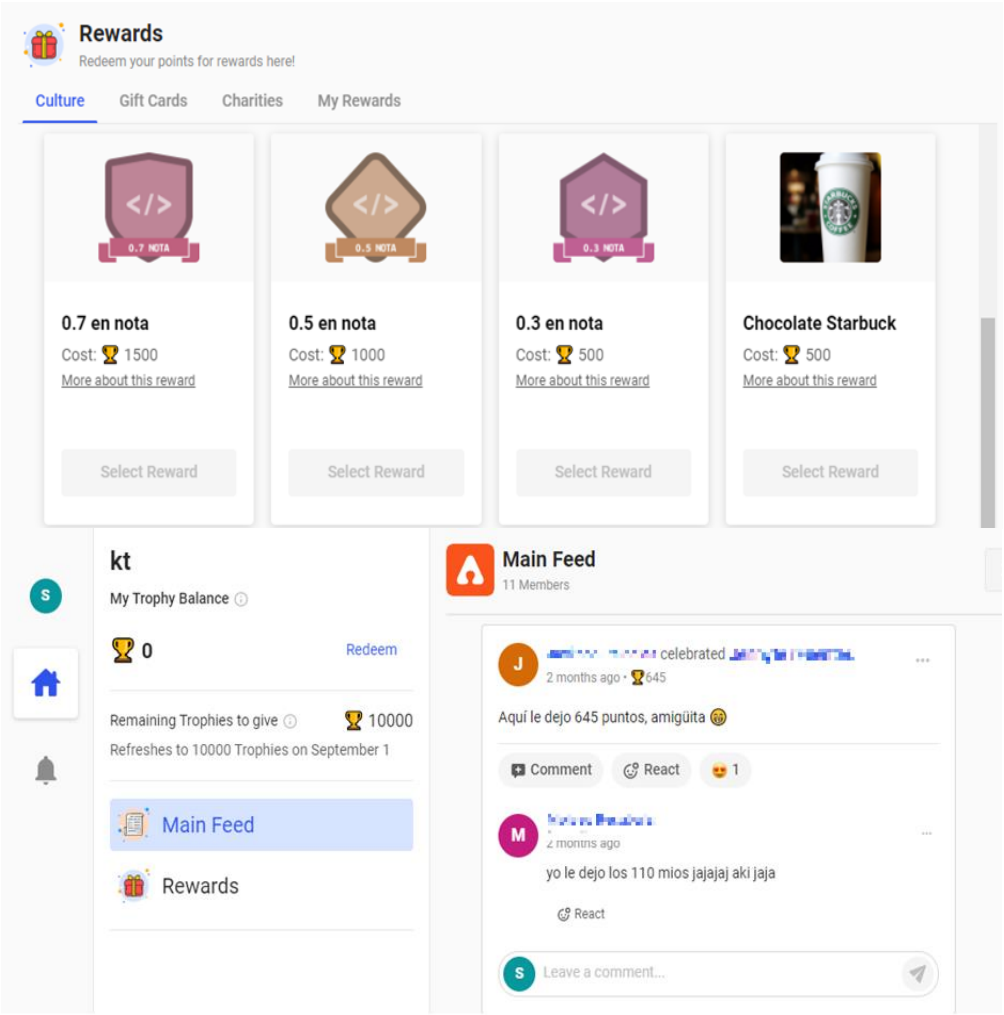
Source: own elaboration.

Figure 4. Project repository and Knowledge Book on GitHub



Source: own elaboration.

Figure 5. Reward settings defined in Assembly



Source: own elaboration.

During this test, it was observed that the platforms used for the implementation of the strategy are adequate and easy to adapt to their needs. In addition, it was perceived that participants expressed their acceptance of the working style proposed by the strategy to foster collaboration in knowledge transfer.

With these preliminary results, GamifiK shows important capabilities and ease of use for software development teams to promote knowledge transfer.

4. DISCUSSION

The literature review revealed the importance of creating strategies to identify, capture and leverage the knowledge of the members of a development team to help them be more productive [33]. However, although gamification-based strategies were found that motivate team members to build, refine and share knowledge, there is no evidence of a concrete solution that confirms that the person receiving the knowledge can use it in his or her context. This is because knowledge cannot be completely transferred during the conversation [36].

The pilot study results show that GamifiK is a potential strategy to foster collaboration when knowledge transfer from one context to another is required. Moreover, this strategy is easy to implement since it is supported by technological tools (GitHub and Assembly) that are easy to use and popular in software development companies.

During the sprint execution, there were requests for knowledge transfer collaboration in the incidents assigned to the players. In this sense, it was observed that the pilot study participants were motivated to use gamification elements such as points (trophies), leaderboards, and badges to share useful information and experience among team members.

Nevertheless, it was noted that participants understood and differentiated the importance of sharing knowledge (Knowledge Book), its usefulness (reactions and questions in discussions), and collaborating in the knowledge transfer on the assigned issues. These skills allowed team members to work together to solve the issues assigned to them for the project sprint.

Based on the key principles of the game's rules in the strategy: 1. Knowledge Transfer y 2. Knowledge Book, it was observed for the first principle that the strategy helps develop knowledge transfer skills through the definition of the steps: a) requesting knowledge, b) providing knowledge, and c) qualifying knowledge. These steps allowed participants to identify the difference between knowledge sharing and knowledge transfer. In this way, the strategy contributed to developing knowledge transfer skills and provided useful information and experience from one context to another. Trophies for knowledge transfer were awarded by the person receiving the knowledge to the subject who had made the transfer, thus validating that the person receiving the knowledge was able to use it in his or her context. Additionally, the Knowledge Book principle allows the development of the team member's skills to share knowledge useful for the project through the trophies awarded for the "Like" reaction to a publication.

4.1 Study's Limitations

The execution of the strategy in a single sprint was a limitation of this research as it made it difficult to have enough data to judge statistically significant results for gamification metrics, the satisfaction questionnaire, and productivity measures. However, with the preliminary data, it was possible to analyze the feasibility of GamifiK to continue with the next stages of this research such as its validation process and implementation in the industry.

At the same time, the context of the execution of the pilot study and the size of the sample are also considered a limitation of this research since it is not possible to generalize the results from this experience. However, the results serve as a reference for future implementations of GamifiK, required for its proper functioning and implementation in other contexts.

4.2 Recommendations

Based on the results of this study, the following recommendations are made to researchers, teachers, software project managers, and the community interested in improving collaboration in the transfer of knowledge in software development teams:

- Research teachers:
  - Replicate the experience with a larger number of subjects and runs per sprint to contrast the results and determine the effect of using the strategy in fostering collaboration in knowledge transfer.
  - Create a software development team that simulates those of the industry, where a project's incidents (User Stories, bugs, tasks) are assigned to the developers and productivity measures are taken.
  - Adjust the trophy redemption table according to the interests of the members of the development team and the course.
- Software development project managers:
  - Implement the strategy in your software development team according to your needs. Consider having a team control that facilitates analyzing the influence of GamifiK on your team's knowledge transfer and productivity.
  - Adjust the trophy redemption table according to the organization's interests and the development team members.

- Set up tags in the Knowledge Book to mark the subject of the knowledge being shared.

5. CONCLUSIONS

A strategy called GamifiK is presented that fosters collaborative knowledge transfer in software development teams. Players as members of the software development team, recognize each other in knowledge transfer in a software development project.

The strategy is designed to be executed in a software development project under the agile Scrum framework with the technological support of GitHub to manage the project's issues (User Stories, bugs, tasks) and support the transfer of tacit-to-tacit and tacit-to-explicit knowledge. It also has support from Assembly for players to recognize each other for knowledge transfer and assign trophies.

GamifiK's technology support facilitates the articulation of management resources commonly used by development teams, avoiding complex software development for its implementation.

The pilot test and its preliminary results show that GamifiK can be implemented in software development teams and can be a practical tool to promote knowledge transfer.

The novelty of this proposal lies in its ability to integrate KM best practices, gamification elements, and leverage collaboration as an SHF to facilitate the creation and transfer of knowledge. GamifiK allows tacit knowledge to be codified through a context such as a project's established incidences to facilitate its implementation.

In future work, a quasi-experiment will be carried out in which hypothesis tests can be applied to evaluate whether there is a statistically significant difference in the results obtained. Finally, it is planned to improve the technological support of the strategy to allow the integration of project management software such as Jira.

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