An Application of a Gamified Approach to Learning of Knowledge Management: Evaluation of an Experience Report

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Abstract—In the current scenario, knowledge has become a valuable and indispensable organizational asset for the decision-making process in different types of organizations. Doing Knowledge Management, managing this business asset correctly, is a competitive advantage and an extremely important task. In this context, studies report that although knowledge has become an important asset, many organizations are unaware of or have difficulty managing this asset effectively. Therefore, it is necessary to explore the process of socialization and collaboration among the members of the organization, in order to stimulate the exchange of knowledge and the maintenance of existing knowledge in the organization, given the volatility of these assets. Thus, the objective of this work is to discuss and analyze the results obtained in an Experience Report that consisted the application of a gamification as a tool to support the teaching and learning of the knowledge management assets and process in the context of a Software Quality Laboratory, at a federal public university in Brazil. The data collected during the experiment were analyzed quantitatively. For this, Criteria, Research Questions, Metrics and Indicators were developed that guided this evaluation process in a quantitative way. At the end of the analysis of these data, the effectiveness and efficiency of this gamification proposal was proven in order to stimulate the teaching and learning process of knowledge management in Information Technology (IT).

Keywords—knowledge management, gamification, teaching and learning

1 Introduction

Knowledge is one of the main elements of the production process in the current context. The need to manage knowledge effectively in order to meet the needs of organizations is notorious, constituting one of the main indicators of organizational performance [1].

According to Silva [2], both organizational performance and innovation within the organization are influenced by the correct application of Knowledge Management. In this way, the relationship between knowledge and the decisions and strategies adopted in the organizational environment is perceptible. Thus, knowledge stands out as a competitive advantage for organizations that apply knowledge management [1].

According to Barbosa [3], the process of knowledge transfer, which usually occurs through social interactions, can be stimulated by creating activities or situations that favor and stimulate informal interactions between individuals.

Thus, according to Lopes et al. [4], the need arises to identify and define strategies and methodologies that stimulate interactions between individuals in the organization, with the gamification methodology being quite promising for stimulating and motivating individuals to a more active participation.

Gamification, in the definition of Deterding et al. [5], is the use of game elements in a non-game context. In addition, Despeisse [6] states that gamification is an approach increasingly adopted in education, given the ability to stimulate students and promote greater involvement in the teaching and learning process.

According to Silva [2], the use of pedagogical practices and the adoption of knowledge management tools is of paramount importance within organizations. In this way, it is possible to guarantee access to the knowledge produced, stimulating the capture of new knowledge through collaborative learning.

Thus, this work aims to answer the main Research Question: Is the gamified approach effective and efficient in supporting the teaching and learning of the knowledge management process in a playful way in the Information Technology?. Based on this Research Question, the objective is to evaluate the adequacy of the gamification proposal as a tool to support the teaching and learning process of knowledge management in the IT. For this, the basic hypothesis is: The gamified approach positively influences the participants' performance and the effectiveness of the Knowledge Management teaching process.

As a way to answer this question, we present the evaluation of the data collected in an Experience Report that consisted the application of a gamification to support the teaching and learning of the knowledge management assets and process. This evaluation took place at the end of the experiment and was based on different criteria, metrics and indicators that were developed to evaluate different aspects of gamification, where the effectiveness of the proposal was verified based on the analyzed data.

In addition to this introductory section, this article is structured as follows: Section II presents the theoretical foundation, Section III details the research methodology, Section IV presents the related works, Section V presents the application of gamification, Section VI presents the data analysis, Section VII presents the discussion, Section VIII presents the threats to validity and, finally, Section IX presents the conclusions.

2 Background

In the definition by Tabares et al. [7], knowledge management is the way in which human resources or machine learning share and acquire experiences from different sources.

Braquehais et al. [8] define knowledge management as the process created to facilitate the creation, storage, transfer and application of knowledge within the organization.

According to Aires et al. [9], knowledge management is understood as the management process from the identification of the organization's strategic objectives, and the elaborated practices, aiming to identify, develop, capture and disseminate the different types of knowledge.

There are several concepts about knowledge management from different authors. However, the existence of processes of creation, capture, storage and socialization of knowledge is common to all definitions. To become an important asset in the organization, it is necessary that knowledge is submitted to a management process that encompasses the phases of capture, storage, transformation, transfer and distribution [7].

Therefore, several authors suggest the use of gamification, which is the thinking process guided by game mechanics to engage users and solve problems [10].

According to Vieira et al. [10], gamification is more used in the business and industrial scope with the aim of engaging employees. However, according to Despeisse [6], the use of gamification is increasingly frequent in the education, due to its ability to stimulate and create an immersive system promoting better student learning.

According to Limantara et al. [11], gamification provides dynamism and aesthetics to a task that is not necessarily attractive. This approach has great potential to involve the student in the process of solving everyday problems, helping them to apply the knowledge studied in a practical way. Therefore, it is necessary for the teacher to prepare a planning of teaching strategies more focused on the student's reality, using a language and visual form similar to those found in games, making the teaching process more attractive to the student [10].

According to Freitas et al. [12], the use of gamification in education has been adopted at different levels of schooling, ranging from early grades to postgraduate courses, as it is an active approach to teaching and learning, motivating participants to commit to activities and in the teaching and learning process. This methodology becomes important as traditional teaching approaches are not attractive to the new generation of students, who are connected to many technological innovations, such as tablets, electronic devices, computers, cell phones, video games, etc [13].

According to Alhalafawy and Tawfiq Zaki [14], the use of gamification in the digital context is a way to achieve goals and improve educational performance. In addition, remote learning has the potential to transform the teaching process, with the use of new digital tools and technologies that favor student learning and performance [15].

The growing interest in the use of gamification is justified by its ability to influence, aggregate and stimulate students. However, it is necessary a detailed planning the application of gamification that considers the desired objectives, the contents to be worked, as well as the expected results with the application of this approach in the educational context [13].

3 Research methodology

This work was developed following the steps described in Figure 1, which were designed to achieve the previously defined objectives. The steps are: 1 – Identify

problems in IT courses, 2 – Analysis and Selection of Features and Characteristics of Pedagogical Approaches, 3 – Adaptation of Gamification from the use of Pedagogical Approaches to the New Approach, 4 – Elaboration of New Approach Instruments, 5 – Assessment of the Adapted Approach, 6 – Planning the Experience Report, 7 – Execution of the Experience Report and 8 – Evaluation of the Experience Report.

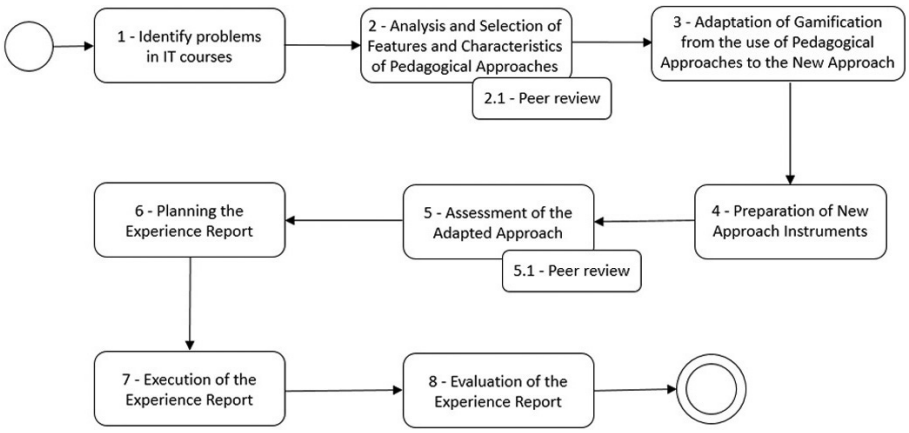


Fig. 1. Work execution steps

3.1 Step 1: Identify problems in IT courses

In this stage, bibliographic research was carried out on the problems present in the IT courses. The objective was to identify the problems with the greatest impact on the Knowledge Management process in the IT, and from there, develop a solution with the objective of solving these problems, contributing to the teaching and learning process.

Thus, the following problems were selected, based on [16] and [17]: (P1) disconnection between theory and practice in teaching, (P2) technical, general and content teaching, not focused on problem solving, (P3) lack of interdisciplinarity, (P4) outdated content, teaching methods and tools, (P5) lack of training in human skills, (P6) most students prefer to process information with activities, speeches and participation active with the content, (P7) students prefer to learn linearly and show a strong preference for logically sequenced steps, and (P8) most students prefer the visual dimension, however teachers adapt to the oral dimension.

3.2 Step 2: Analysis and selection of features and characteristics of pedagogical approaches

At this stage, based on [18], five pedagogical approaches were selected, whose main characteristics served as a pedagogical basis for the adaptation of a gamification to support the teaching and learning of the knowledge management assets and process. These approaches were: (i) Traditional, which is characterized by the transmission of knowledge in the context of the classroom, with the teacher being designated such a task, leaving the teaching centered on the figure of the teacher, (ii) Behaviorist, which

is characterized by the focus on object, that is, in knowledge, using behavioral and social engineering in order to develop the desired social behaviors, (iii) Humanist, which is characterized by emphasizing the role of the subject as the main developer of human knowledge, centered on personality development and capacity of the individual, with the teacher having the role of facilitator of learning, and the content comes from the student's own experiences, (iv) Cognitive, which is characterized by scientifically studying learning as being more than a product of the environment, people or factors that are external to the student, but the construction from the subject's interaction with the object of study, resulting in knowledge and production of their own knowledge, and (v) Socio-Cultural, which is characterized as an interactionist approach between the subject and the object of knowledge, although focusing on the subject as a elaborator and creator of knowledge.

At the end of selection the characteristics of the pedagogical approaches, the analysis of the results was carried out through the technique of peer review, which consists of submitting the results obtained to the scrutiny of an expert in the area studied. After the peer review process, the need to correct some conflicting characteristics was identified. Thus, all the points highlighted by the expert were reviewed and considered in the development of this work. Details of the selection of the characteristics of the pedagogical approaches, the justification for adopting each of these items, and the description of how they were increased in the knowledge management gamification can be found in [19].

3.3 Step 3: Adaptation of gamification from the use of pedagogical approaches to the new approach

At this stage, the adaptation of the knowledge management gamification, proposed in [20], was carried out, based on the results obtained in the previous step. Thus, the new flow of gamification, as can be seen in Figure 2, was designed to meet the demands arising from the adoption of several characteristics present in pedagogical approaches. As a result, new stages appeared in the flow, and others that already existed underwent necessary adaptations to achieve the objective of the dynamics.

One of the new steps that emerged was the Knowledge Factory, which resulted from the union of three stages (Generate Knowledge and/or Comment Cards, Evaluate Cards and Identify the Target Audience), which became part of an internal sequential flow of this new step created. A time loop was also stipulated where only after the end of this time it is possible to advance in the flow of gamification. These changes were made to focus and stimulate the processes of: (i) externalization of knowledge, through the creation of a knowledge card, (ii) internalization of knowledge, through the evaluation of the cards created, requiring a more careful reading, and (iii) targeting knowledge, which is carried out through the process of identifying the target audience where the different knowledge is best applied.

Another new step that emerged was the Self-Evaluation, which was designed with the objective of stimulating the student in the process of perceiving their performance, also leading them to commit to their learning process, through the goals to be achieved in the next round, which he defines at the end of each iteration.

Fig. 2. Flow of knowledge management gamification [21]

The Knowledge Repository step was adapted in order to value the process of socialization of knowledge through social interactions. Thus, a new activity was developed, in addition to the existing ones, which consists of the presentation and debates about the approved knowledge cards, allowing the authors to present their respective knowledge and obtain feedback from the other participants. In addition, new ideas for knowledge cards arise from these interactions, through doubts and explanations, stimulating the group's performance in the next rounds.

Another change occurred in the activities present in the steps of the gamification flow, which began to have a more student-centered focus, enabling greater development throughout the dynamics. In addition, new activities were developed, in addition to the existing ones, and the scoring system was readapted to cover the demands arising from the changes made in the dynamics. Details of the complete flow can be found in [21].

3.4 Step 4: Preparation of new approach instruments

At this stage, new instruments were developed and others adapted to better meet the demands of pedagogical approaches. The new instrument developed was the Self-Evaluation Worksheet, which is a form used by the participant in the Self-evaluation

step, where he can report on his performance throughout the gamification iteration, in addition to verifying and stipulating goals to be achieved in the next interaction.

The instruments that were adapted are: (i) Knowledge Card, which was improved with the "Expert Tip" functionality, where the expert, when evaluating the card, can suggest tips so that participants can improve their knowledge items, or even create new cards based on the information given by the expert, and (ii) the Gamification Worksheet, which was readjusted with the new steps that emerged from the adoption of the characteristics of the pedagogical approaches, the new activities that were designed to each step of the gamification flow, and the new scores that were defined based on the new steps, activities and goals.

The details of each instrument, both in terms of elaboration and use, and the objectives of the application of each instrument, as well as their respective justifications, can be consulted in [22].

3.5 Step 5: Assessment of the adapted approach

At this stage, the evaluation of the adapted gamified approach was carried out based on the characteristics of the pedagogical approaches. This evaluation aimed mainly to verify if all the pedagogical demands were met, and also to evaluate the new adaptations in contrast with the objective of making gamification a tool to support the teaching and learning of the knowledge management assets and process.

Thus, an evaluation was carried out again using the peer review technique, where the expert evaluated: (i) the adaptation of gamification, based on the characteristics of pedagogical approaches, where the different aspects of these approaches were implemented through activities and game elements, with the aim of making the student's experience with the contents worked during gamification more enriching and motivating, (ii) the flow of gamification, in order to maintain a logical sequence based on the knowledge life cycle so that participants have the opportunity to interact with knowledge throughout all stages of this cycle, (iii) the main activities of each stage of the flow, if they were aligned with the respective objectives of each stage, since each one of them addresses a phase of the knowledge life cycle, and (iv) the instruments used throughout the dynamics, which are essential for the follow-up by the participant of the realization of the main activities present in the different stages of the gamification flow, to carry out the activities of externalization, evaluation and direction of knowledge, to carry out the evaluation of their own performance at the end of each round, to expose the approved knowledge and promote the socialization of the knowledge among the participants and for recording the scores and preparing the ranking in order to enable individual and collective monitoring throughout the dynamics.

At the end of the evaluation, all identified problems were corrected based on the expert's suggestions, and all observations were considered for the improvement of the gamification proposal. The adaptations made in the knowledge management gamification, as well as their respective justifications, and the peer review process can be consulted in [21].

3.6 Step 6: Planning the experience report

At this stage, the planning of the experience report was elaborated, which consisted in the elaboration of an application plan of the new knowledge management gamification in the context of a software quality laboratory of a Brazilian public university.

In this planning, the following were defined: (i) the research objectives and their respective indicators, (ii) the target audience, where the members of a software quality laboratory chosen as the context of application of this proposal were selected, (iii) the analysis the profile of the participants in the dynamics, through the collection of information, such as gender, academic level, line of research, professional activity and time of professional activity, (iv) the application model, where the remote modality was chosen, given the health restrictions in force in the period, imposed due to the COVID-19 pandemic, (v) the adequacy of the environment and instruments used for the virtual model, where the adaptation of all the instruments used during the gamification to the virtual modality was carried out and were adopted collaborative tools that would enable both online meetings and the sharing of the many work products used and generated throughout the gamification, (vi) the evaluation methods, which was chosen both the quantitative method, for the analysis of objective data, and the qualitative method, for the analysis of subjective data, and (vii) the forms of data collection, which were defined both for the collection of quantitative data as for the subjective data.

3.7 Step 7: Execution of the experience report

At this stage, the application of knowledge management gamification was carried out in the context indicated above. This stage was carried out over five weekly meetings lasting two hours each. The necessary adjustments identified during this stage were carried out in the interval between each meeting.

3.8 Step 8: Evaluation of the experience report

Finally, at this stage, the analyzes of the data collected in the previous step were carried out, and the results were measured and analyzed based on the indicators defined in the planning of the experience report. This analysis took place in two ways, as defined in the planning: (i) quantitative, which focused on the analysis of measures and indicators, and (ii) qualitative (see more details in [23]), which was carried out using the technique of Affective Computing, which focused on the textual analysis of the evaluative reports in the Self-Evaluation stage aiming to identify the feelings described by the participants, and through the use of SWOT Analysis, which was adopted in the evaluation and feedback meeting that took place at the end of the experience report, where participants were able to highlight strengths, weaknesses, opportunities and threats, based on their experience.

4 Related works

Elm et al. [24] present the CLEVER software, which proposes a trivia (questions) and RPG game for the dissemination of business knowledge. This game uses game elements and each battle is won with correct answers. The authors report a short thirty-minute experiment with three teams competing against each other. However, the planning of the application of this experiment is not detailed, nor the form of evaluation of the obtained results.

One of the weaknesses is that the game does not include knowledge generators, an important character in knowledge management that produces new knowledge (assets) for the organization, and also does not define the experts to validate the knowledge, since all knowledge generated must be analyzed by an expert in order to determine the efficiency and usefulness of a given piece of knowledge.

A point of improvement proposed as future work is an evaluation with a large number of participants to validate this game, design a knowledge repository to store and maintain the management of all the knowledge generated and useful for the organization, and integrate the game with this knowledge repository.

Yin et al. [25] present the Light Quest, which proposes a game to increase motivation in the generation, dissemination and evaluation of knowledge. It is a game that stimulates the ability to produce, disseminate and absorb knowledge in the organizational environment, using Cards, where knowledge is recorded and subsequently evaluated and scored by another team. This score is used to level up the character of the user who recorded the knowledge.

The authors also detail an experiment that took place over four weeks, excluding weekends, with twenty participants. At the end of the experiment, the participants had to answer a set of questions, with a Likert scale between –2 and 2. These answers were qualitatively analyzed and the results used to investigate the participants' motivation in relation to knowledge sharing using the tool developed.

One of the weaknesses is that the Cards are evaluated by people who may not be experts in the knowledge to be evaluated. One of the points of improvement is to add an expert to reassess the Knowledge Cards and do an experiment for a long period with many users.

These academic works present experiences of building gamified approaches, and present relevant topics on knowledge management. They served as a basis for building the proposal for a gamified approach to support the teaching and learning of the knowledge management assets and process and for defining the next steps in the research.

In this context, the present article stands out for presenting the analysis of the application of a gamified proposal, adapted based on the characteristics present in the pedagogical approaches, which was elaborated based on the knowledge life cycle, allowing the user to interact with the knowledge of actively in all its phases. It is worth noting that the analyzes of the data collected occurred both quantitatively and qualitatively.

5 Application of gamification

This section presents the application of knowledge management gamification.

5.1 Planning

This subsection describes the roadmap used for planning the application of gamification.

I: Description of the Context. This work aimed to support a dynamic that aimed to implement the Customer and Market (CM) dimension, included in the MOSE model (Model Guiding for the Success of Public and Private Entities) [26], in the context of the SPIDER laboratory (Software Process Improvement: DEvelopment and Research), from a federal public university in Brazil.

The SPIDER laboratory includes: (i) professors/researchers from UFPA (Federal University of Pará), UFPE (Federal University of Pernambuco), UFLA (Federal University of Lavras) and UNIFAP (Federal University of Amapá), (ii) Master's and Doctoral students/researchers from the PPGCC (Postgraduate Program in Computer Science) and undergraduate researchers from FACOMP (Faculty of Computing), both from UFPA, who work in the research line of Software Engineering (ES) and Education.

The team works in the development of software-oriented projects to help the implementation of MPS.BR (Brazilian Software Process Improvement), CMMI (Capability Maturity Model Integration), MOSE and others models in organizations. The customization of software to meet specific demands of organizations is a differential of this work, since it minimizes the need to acquire proprietary software.

The education has been encouraging the use of new practices and methods that contribute to the teaching-learning process. There is a need to innovate teaching processes, aiming to encourage students to participate more actively [27].

In this way, we suggest the application of the Knowledge Management Framework as a tool to support the achievement of the desired objectives in the dynamics of implementing the CM dimension, of the MOSE model, since it was designed based on the main pedagogical teaching approaches (traditional, behavioral, humanistic, cognitive and socio-cultural), aiming to overcome the challenges of the current teaching model described in [16] and [17].

In addition, the specific objectives of the implementation dynamics of the CM dimension are aligned and served through this gamification. In this way, it was possible to identify the following needs, which were met through the application of knowledge management gamification: (i) Stimulate the engagement and participation of the members of the dynamics, aiming to build a joint improvement for the SPIDER laboratory, (ii) Awaken the voluntary interest of the participants, (iii) Awaken the motivation in the members to participate in the dynamics, (iv) Maintain constant feedback, (v) Present the benefits of the improvements (expected results), of the CM dimension, (vi) Stimulate the socialization of participants, (vii) Presentation of content related to the selected models, (viii) Definition of problems perceived within the SPIDER laboratory, (ix) Conduct training on the content presented regarding the CM competence dimension of the MOSE model, (x) Provide students with autonomy to develop, (xi) Holistic view of the CM competence dimension, (xii) Enable participants before recognizing the performance of the other colleague, (xiii) Conducting the dynamic evaluation, and (xiv) Carrying out the performance evaluation of the participants.

It is worth noting that some of the characteristics of knowledge management gamification that favor its application in this context are: (i) it does not require the participant

to have prior knowledge about the subject studied, since it can be presented in a fractional way over the iterations, (ii) uses rewards as a form of stimulus, (iii) uses a system of individual points and points per team, valuing cooperation and socialization, and (iv) establishes an average to be achieved in each stage, through medals, being a indicator both individually and collectively.

Thus, because it is a laboratory with a diversity of researchers in different areas of Software Engineering, it is necessary to apply a methodology that stimulates the knowledge management process at the end of the experiment, so that it can direct all the information that is cataloged and learned and made available to its target audience.

The labor market has undergone major transformations that drive companies to adapt their organizational structures and production processes [28]. Thus, it is necessary to evaluate, over time, the knowledge items in order to evaluate their application, usefulness and compliance with what was initially proposed. Based on this, it is necessary to apply knowledge management too in order to catalog, identify, reevaluate and make knowledge items available to their respective target audiences and, later, enable the management of these assets in terms of application, validity and fulfillment of objectives in the context of the SPIDER laboratory.

As it is a research group, where there is a high turnover of members, at different levels of research (undergraduate, masters, and doctoral students, as well as professors), it is interesting to maintain a repository of knowledge of the solutions that will be developed and the lessons learned by the group. Thus, both future and current participants will be able to consult this knowledge that will be produced, whenever necessary.

Another factor that corroborates the need to use knowledge management gamification is the need to classify future solutions and knowledge that are produced in order to maintain a database ordered by type of knowledge and classified by target audience. This facilitates not only consultation, but also the assignment of tasks and responsibilities.

Furthermore, the SPIDER laboratory is made up of participants with different profiles and levels of responsibilities, thus making it necessary to identify knowledge based on the responsibilities and attributions of each member.

It is also necessary to give laboratory members a perception of their attributions and responsibilities within the SPIDER group. The activities "evaluate card" and "identify target audience" encourage participants to evaluate knowledge based on their responsibilities. They also enable a holistic view of the group where knowledge from other departments is evaluated and the public to which this item refers, generating an expectation regarding the expert's evaluation. Thus, the participant knows the functions of each department in the group, and has the opportunity to interact with diverse knowledge outside the scope of their department, and to perceive the relationships between the many research areas active in the context of the laboratory.

II: The participants. The participants in the experience report were nine members of the software quality laboratory, who participated in the dynamic, making it possible to catalog and promote the socialization of ideas and solutions developed throughout the experiment.

Of these participants, five are doctoral students and four are masters students, all of whom work in the Software Engineering and have professional experience in the

Information Technology. It is also noteworthy that among the participants, only one is female and the others are male. Table 1 presents the profile of the participants.

Table 1. Core drivers and their corresponding game elements

ID	Academic Formation	Research Line	Professional Activity	Activity Time
P01	PhD Student	Software Engineering	Researcher	4 years
P02	PhD Student	Software Engineering Education	Researcher	6 years
P03	PhD Student	Software Engineering	Researcher	5 years
P04	PhD Student	Software Engineering	Systems Analyst	4 years
P05	Master's Student	Software Engineering	Researcher	1,5 years
P06	Master's Student	Software Engineering	Researcher	3 years
P07	PhD Student	Software Engineering	Professor	10 years
P08	Master's Student	Software Engineering	Technician	2 years
P09	Master's Student	Software Engineering	Researcher	5 years

The participants were allocated in the existing roles in the gamification after analysis carried out based on the history of each member. The existing roles in knowledge management gamification are: Master, Judge, Expert and Player.

Among the participants, a doctoral student acted in the Master profile, being responsible for timing the times in each activity and signaling when to proceed to the next stage of the flow. This participant was selected for this role because he was one of the researchers who created this gamified approach, being also responsible for solving any doubts about the dynamics and also providing any necessary adjustments for the good application of the experience report.

In the Judge profile, a doctoral student was allocated, being responsible for the Gamification Worksheet, cataloging the generated work products and recording the scores obtained by each Player throughout the stages. This participant was selected for this role because he had carried out several similar experiments, having extensive experience and mastery in conducting and recording scores in dynamics using the gamification technique. In addition, he acted as a Judge of the dynamics that aimed to carry out the implementation of the CM dimension of the MOSE model, in the context of that laboratory.

In the Expert profile, a doctoral student was allocated, as she was an expert in the area of knowledge being studied. It is the attribution of this function to help resolve doubts, evaluate and score the Cards created by the Players, suggest challenges, and indicate the Cards that will be stored in the knowledge repository and disseminated in the group. This participant was selected because she was the researcher who planned and led the application of the dynamics that aimed to implement the CM dimension of the MOSE model, in the context of the aforementioned laboratory, having a great domain of the studied topic.

Finally, two doctoral students and four master's students acted in the Player profile, who assumed the roles of main actors in the knowledge creation process. These participants were selected for having actively participated in the proposition of solutions and ideas during the dynamics of implementation of the CM dimension of the

MOSE model, having, therefore, a great potential of knowledge to be cataloged and shared.

III: The application period. The application of knowledge management gamification took place between 09/09/2021 and 10/7/2021, as can be seen in Table 2. The meetings always took place on Thursdays, from 4:00 pm to 6:00 pm, totaling five meetings.

Table 2. Gamification application schedule

Date	Activities	Duration
09/09/21	Presentation of Dynamics	4:00 pm to 5:20 pm
	Simulated Round	5:20 pm to 6:00 pm
09/16/21	Iteration1	4:00 pm to 6:00 pm
09/23/21	Iteration2	4:00 pm to 6:00 pm
09/30/21	Iteration3	4:00 pm to 6:00 pm
10/07/21	Evaluation and Feedback	4:00 pm to 6:00 pm

At the first meeting, on September 9, 2021, the presentation of the dynamics and the Simulated Round were held so that the participants became familiar with the dynamics, its instruments, the rules, and the activities to be carried out at each stage of the gamification flow.

On September 16, 23 and 30, 2021, the first, second and third iteration of gamification took place, respectively. In these meetings, the participants carried out all the activities proposed in the stages of the gamification flow, always based on the goals stipulated in the previous rounds.

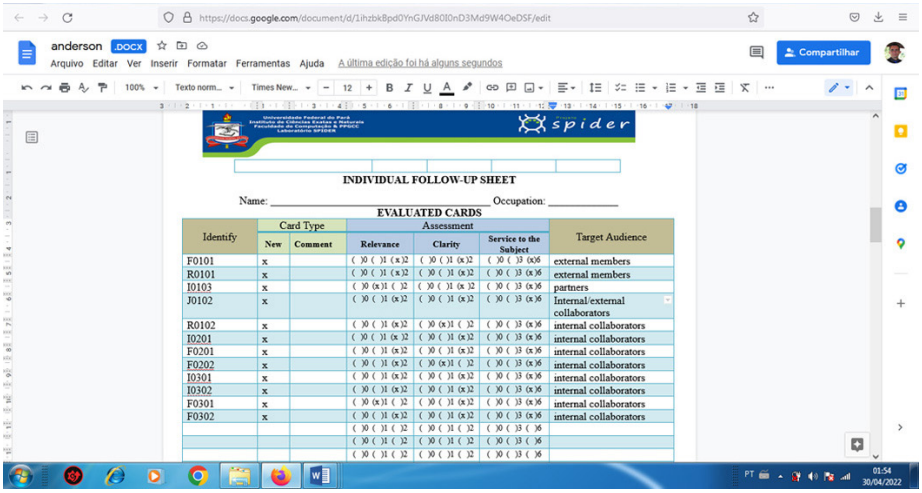
Finally, on October 7, 2021, the last meeting took place, where the dynamics evaluation and participant feedback meeting was held. Here it was possible to collect qualitative data, using the SWOT matrix, from a focus group meeting with all the participants of the experience report.

IV: Gamification instruments and support tools. Due to the impossibility of meeting in person, due to the COVID-19 pandemic, the application of gamification took place remotely. With this, it was necessary to adopt different collaborative tools so that the physical instruments used in gamification, which were originally designed for face-to-face modality, could be adapted for remote use.

Thus, the following tools were selected: (i) Google Meet, used to organize rooms for remote meetings, (ii) Google Calendar, used to organize meeting dates and times, (iii) Google Drive, which was the repository adopted to organize all files, work products and instruments throughout the application of gamification in a collaborative way, and (iv) Email, for exchanging messages and scheduling meetings.

Within the Google Drive virtual environment, it was necessary to use different tools in the process of adapting the instruments present in the gamification, as described below.

The Google Docs tool was used to adapt the Individual Monitoring Worksheet and the Self-Evaluation Sheet, allowing participants to edit the different fields and fill in the information collaboratively, as can be seen in Figure 3.



INDIVIDUAL FOLLOW-UP SHEET

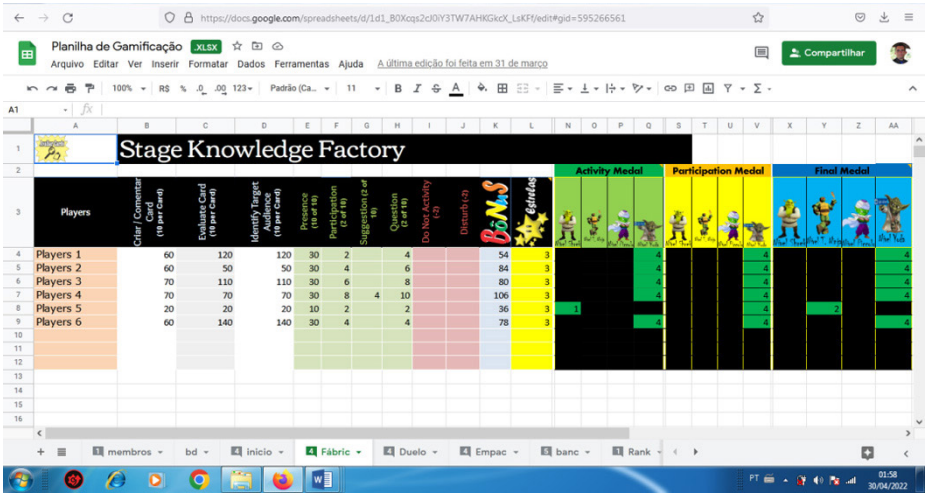
Name: _____ Occupation: _____

EVALUATED CARDS

Identify	Card Type		Assessment			Target Audience
	New	Comment	Relevance	Clarity	Service to the Subject	
F0101	x		( )0 ( )1 (x)2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	external members
R0101	x		( )0 ( )1 (x)2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	external members
I0103	x		( )0 (x)1 ( )2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	partners
J0102	x		( )0 ( )1 (x)2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	Internal/external collaborators
R0102	x		( )0 ( )1 (x)2	( )0 (x)1 ( )2	( )0 ( )1 ( )2 (x)3	internal collaborators
I0201	x		( )0 ( )1 (x)2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	internal collaborators
F0201	x		( )0 ( )1 (x)2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	internal collaborators
F0202	x		( )0 ( )1 (x)2	( )0 (x)1 ( )2	( )0 ( )1 ( )2 (x)3	internal collaborators
I0301	x		( )0 ( )1 (x)2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	internal collaborators
I0302	x		( )0 ( )1 (x)2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	internal collaborators
F0301	x		( )0 (x)1 ( )2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	internal collaborators
F0302	x		( )0 ( )1 (x)2	( )0 ( )1 (x)2	( )0 ( )1 ( )2 (x)3	internal collaborators
			( )0 ( )1 ( )2	( )0 ( )1 ( )2	( )0 ( )1 ( )2 ( )3	
			( )0 ( )1 ( )2	( )0 ( )1 ( )2	( )0 ( )1 ( )2 ( )3	
			( )0 ( )1 ( )2	( )0 ( )1 ( )2	( )0 ( )1 ( )2 ( )3	

Fig. 3. Individual monitoring form in Google Docs tool

The Google Sheets tool was used to adapt the Gamification Worksheet for remote use, as can be seen in Figure 4. This tool allowed only the Judge to have permission to enter data, leaving the other participants only able to view the worksheet.



Stage Knowledge Factory

Players	Criar / Comentar Card (10 por Card)	Evaluate Card (10 por Card)	Identify Target Audience (10 por Card)	Presence (10 of 10)	Participation (2 of 10)	Suggestion (2 of 10)	Question (2 of 10)	Do Not Activity (-2)	Disturb (-2)	BONUS	Estrelas	Activity Medal	Participation Medal	Final Medal
Players 1	60	120	120	30	2		4			54	3	4	4	4
Players 2	60	50	50	30	4		6			84	3	4	4	4
Players 3	70	110	110	30	6		8			80	3	4	4	4
Players 4	70	70	70	30	8	4	10			106	3	4	4	4
Players 5	20	20	20	10	2		2			36	3	1	4	2
Players 6	60	140	140	30	4		4			78	3	4	4	4

Fig. 4. Gamification worksheet in Google Sheets tool

To adapt the knowledge cards, the Google Drawings tool was used. This tool made it possible to insert editable text boxes into an image. Thus, it was possible to keep the original design of the card as it had been designed, as shown in Figure 5.

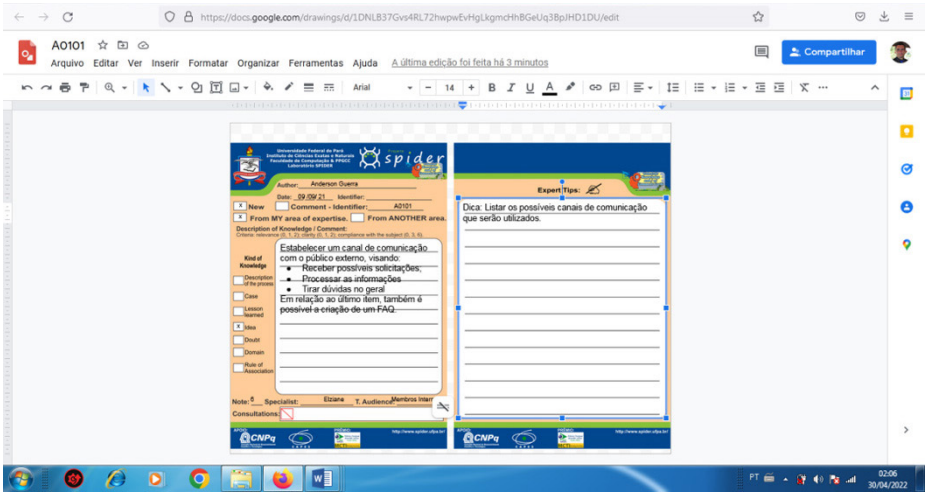


Fig. 5. Knowledge card in the Google Drawings tool

Finally, in the adaptation of the Knowledge Framework, the Google Jamboard tool was used, which allows the creation of different frames and the insertion of images, as can be seen in Figure 6. Thus, seven frames were created that correspond to the seven types of knowledge (Process Description , Case, Lesson Learned, Idea, Doubt, Domain, and Association Rule), and in each frame the approved cards were inserted, organized by type of knowledge.

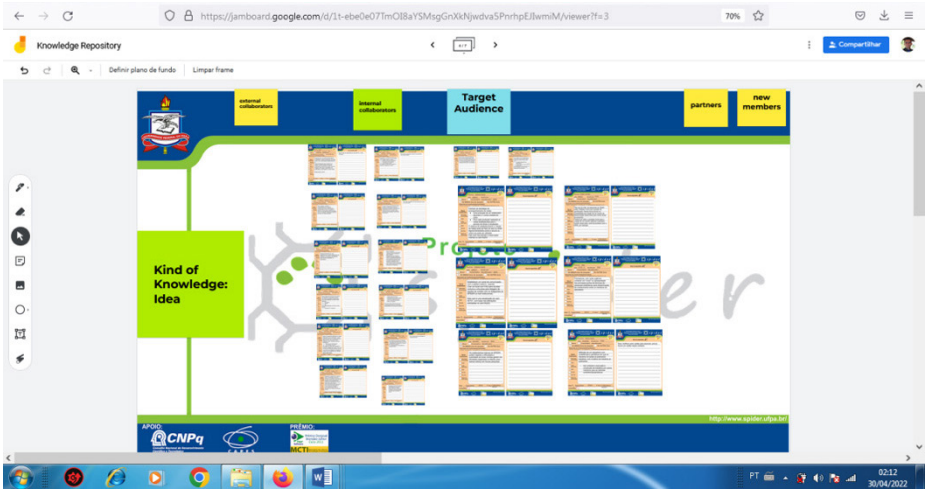


Fig. 6. Knowledge board in the Google Jamboard tool

These tools were selected because they are free, generating no burden for the user, and because they are available within the Google Drive environment, facilitating use and navigability between the different instruments.

V: Adopted evaluation criteria. After the conclusion of the gamification, the necessary information was collected to carry out the evaluation of the results, using the Framework for gamification evaluation by Monteiro et al. [29]. For the evaluation, it was necessary to define the evaluation criteria, questions and indicators. The defined evaluation criteria were: C01) Performance, linked to the participant's evolution throughout the dynamic, C02) Motivation, related to the impact of the approach on the participant for the production of knowledge, C03) Engagement, ability to involve participants in activities, C04) Awareness, participants' perception of the importance of the knowledge generated, C05) Communication, ability to provide situations to stimulate socialization and exchange of knowledge, C06) Efficiency, linked to the fluidity of dynamic activities, C07) Satisfaction, related to positive emotion resulting from the experience of participation, C08) Adequacy, alignment of the dynamics with the objectives proposed in the planning, and C09) Perception, linked to the participant's observation regarding the objective of the dynamics and the socialization process.

To this end, some Research Questions (RQ) were defined, with their respective indicators that serve as a guide in the process of evaluating the results, as shown below:

- *RQ1 – What is the list of knowledge items produced and approved within the SPIDER research group?* This question is related to performance and aims to analyze the relationship between the knowledge generated and the knowledge effectively approved,
- *RQ2 – Did the gamified approach increase participants' motivation in the habit of producing and evaluating knowledge?* Through this question, the objective is to evaluate how gamification impacts the participant's extrinsic motivation,
- *RQ3 – Did the dynamic participants engage in knowledge production and evaluation activities?* This question helps in the process of evaluating the engagement of participants in the knowledge management gamification,
- *RQ4 – Did the participants perceive that the knowledge produced by themselves, and by others, is important and has an impact on SPIDER's business?* This question aims to evaluate participants' awareness of the importance of knowledge management for their group,
- *RQ5 – Did the participants communicate during the dynamics? Did communication favor the production of knowledge?* Through these questions, the objective is to evaluate how the adapted gamified approach impacts the communication and socialization process among the participants,
- *RQ6 – Were the dynamics applied during the gamification fluid, that is, did they occur without delays, without problems, without impediments? If not, why did these delays occur? What problems arose? Do they impact the production of knowledge? What are the most common problems?* These questions help in evaluating the adapted approach regarding the new organization of flow stages and activities and its efficiency,

- *RQ7 – How do participants perceive their own performance during the experiment?* This question helps in the evaluation of the participants' performance regarding the perception of their progress in the dynamics,
- *RQ8 – Did the participants show satisfaction after applying the gamified dynamics?* With this question, the objective is to evaluate the satisfaction of the participants at the end of the application of gamification,
- *RQ9 – Do the instruments and activities developed fulfill the purpose of stimulating knowledge management?* The objective of this question is to evaluate the adequacy of gamification as a tool to support the teaching and learning process of knowledge management,
- *RQ10 – Did the participants understand the purpose proposed for the gamified approach?* The purpose of this question is to evaluate the participants' perception of the teaching objectives of the knowledge management assets and process,
- *RQ11 – How did the participants perceive their socialization process within the gamified approach?* Finally, this question helps to evaluate the participants' perception regarding the process of socialization of information and experiences within the dynamics.

5.2 Execution

As mentioned earlier, the meetings took place on Thursdays, lasting two hours. In the first meeting, the participants and their respective roles, the purpose of the dynamics, the knowledge-generating theme that would serve as the basis for the creation of the cards were presented, and then the simulated round of the Beginning step began. After the appropriate presentations were made, the dynamic flow was briefly presented, followed by the presentation of the work products used to carry out each task (knowledge cards, individual follow-up sheet, self-evaluation sheet, knowledge board and gamification worksheet).

Thus, the Simulated Round began, under the guidance of the Master, where the participants got to know, in a simulated practical way, the activities to be performed and the rules in each step. The doubts that arose were answered by the Master. It is worth mentioning that this step occurred only in this first meeting, with the Knowledge Factory step being the starting point in the other meetings. The minimum score defined in the planning was 10 points, which can be earned by participating in the Simulated Round activity.

In the following meetings, the iterations started from the Knowledge Factory step, where the participants had the opportunity to interact actively in the knowledge creation process, enabling the creation, evaluation and identification of organizational knowledge, in addition to promoting the process of socialization of the knowledge.

The dynamics occurred according to the times and activities defined in the steps of the gamification flow. Minimum scores were defined to unlock activity badges at each stage and the gamification execution took place as detailed below.

Thus, in the Knowledge Factory step, the Players started in the internal flow by the Generate Knowledge and/or Comment Cards sub-step. The main activities of this step are: "Create Knowledge Card", which is the construction of a knowledge item based on the knowledge acquired from the participant, and "Comment Knowledge Card", which

is the construction of a knowledge item based on a Knowledge Card already approved in the Knowledge Repository.

To create a Knowledge Card, it is necessary to fill in some identification data on the Card, such as: (i) Author, which is filled in with the name of the participant or team, (ii) Date, indicating when the Card was created, (iii) Identifier, which is a sequence composed of numerical numbers where the first 2 digits represent the author's registration, the third and fourth digits represent the number of the iteration that the card is being created, and the remaining digits represent the sequential number of creation of cards created by Player, (iv) New, if the knowledge to be described is a new item, (v) Comment, if the knowledge to be described is related to a Card from the "Knowledge Bank", and it is also necessary to indicate the ID of the card to be commented, (vi) From MY Area of Expertise, if the matter reported is related to his area of expertise or activity, otherwise he must check the option From ANOTHER Area, (vii) Description of Knowledge/Comment, which is the field where the author describes a single knowledge or comment. After creating the Knowledge Card, the Player records it on his Individual Tracking Sheet, in the "created cards" table.

Following the internal flow of the Knowledge Factory step, participants were directed to the Evaluate Cards step, whose main activity is "Evaluate Card". Thus, the Players and the Expert evaluated the cards created by the participants in the Generate Knowledge and/or Comment Cards step, and it was forbidden to evaluate the cards created by them. This activity was developed based on the criteria: (i) Relevance, which represents the degree of importance of this knowledge, with a score of zero, one or two, (ii) Clarity, which represents the way in which this knowledge is described, with a score of zero, one or two, and (iii) Subject Compliance, which represents alignment, compliance, and the potential to resolve a given issue or subject, with a score of zero, three or six.

When evaluating a particular Knowledge Card, the expert could write down in the Expert Tip field one or more tips referring to this knowledge item, which could be an idea, a question or a problem based on this item, so that the students can develop a solution.

Every evaluation performed was recorded on the Individual Monitoring Form, in the "Rated Cards" table, so that the student could monitor his/her development.

Finally, in the last step of the internal flow, the participants performed the main activity "Identify Target Audience", which aimed to identify the audience to which the Knowledge Cards would best suit. In this activity, the Player was prohibited from analyzing the cards of his own authorship, and at the end of each identification, the evaluation was recorded in the Individual Monitoring Form, in the "Rated Cards" table in the "Target Audience" column.

The internal flow activities, when performed, had a reward of 10 points, and could be performed repeatedly until the 20-minute time defined for the Knowledge Factory step had expired. The minimum score required to unlock the medals in this step was 60 points. Once the time conditional of the step was over, the gamification flow was followed, otherwise, it re-entered the internal flow of the step.

In the Duel step, each player's individual follow-up form was checked, comparing the scores assigned with the expert's evaluation for the same card. If the score was accurate, the Judge recorded the score for that Player in the gamification worksheet.

At the end of checking all the individual follow-up sheets, the Judge announced the partial ranking and the winners of the duel.

For this step, a time of 20 minutes was defined, and a minimum of 100 points to unlock the activity medals. The main activity, if performed, had a reward of 50 points.

In the Pack Card and Communicate Target Audience step, cards with a score equal to or greater than 6 were cataloged, taking into account the types of knowledge and the target audience. At the end of the organization, the approved cards were organized in the Knowledge Board, and the Judge filled out the gamification worksheet with the corresponding score, then proceeded to notify the respective target audience about the existence of this new knowledge item to be consulted.

At this step, a time of 15 minutes was defined, and a minimum of 40 points to unlock the activity medals. For each approved Knowledge Card, there was a reward of 20 points.

In the Knowledge Repository step, time was made available for the Players to consult the cards in the knowledge board, and they could request an explanation of the card by its respective author. All requests were directed to the Master who organized the presentations, without prejudice to the authors in the consultation process. In addition, participants could score: if they managed to approve their comment card, which was related to an already approved card, with a reward of 2 points, and also when their knowledge card is commented on by another participant, generating a reward of 1 point. These activities aim to stimulate the student's socialization and verbal, mental and intellectual development.

A time of 20 minutes was defined for this step, and a minimum of 4 points to unlock the activity medals.

In the Ranking step, the individual performance of each participant was presented in an orderly manner. This information was important for the self-evaluation process, in the next step. A time of 5 minutes was defined for this step, with no activity medals because it is a feedback step.

Finally, in the Self-Evaluation step, the participants evaluated their performance throughout the dynamics and filled out an evaluation form, where they indicated the step that had the lowest performance and defined improvement goals to be achieved at the end of the next interaction. After filling in the header of the form, and recording the current iteration, the score achieved in each of the steps of the flow was also recorded. Then, it was recorded whether the previously stipulated goal was reached, if any. Finally, the student reported the evaluation of his participation in this iteration, keeping a written record of his analysis, and set goals to be achieved in the next iteration.

For this, a time of 20 minutes was defined, with no activity medals because it is an individual evaluation step.

5.3 Evaluation

There were 2 types of evaluation: the qualitative, which took place from the use of affective computing, the use of SWOT analysis and the analysis of medals won, and the quantitative, which took place from the analysis of the Gamification Worksheet and the Post Gamification Questionnaire.

I: Qualitative analysis – affective computing. The qualitative analysis, through the application of affective computing, was carried out from the evaluative reports of the participants about the personal performance of each one at the end of each iteration. Therefore, the Affective Analysis of the Texts was carried out in order to identify the emotions perceived from the words used in the report and the variations in the frequencies felt throughout the dynamics.

Activities were carried out: (i) reading and treatment of the text, where non-essential words or characters were identified and removed, making the text clearer and more objective, (ii) assignment of classes, which consisted of defining weights for each type of sentiment (positive, negative and neutral), (iii) pre-processing, where the identification of sentiments took place, from the analysis of the answers, and the cataloging based on the weights, and (iv) transformation, where the data were allocated based on the classification of weights for further analysis.

In the process of analyzing the feelings identified, the iterations were considered individually, allowing the perception of the predominant feelings in each round, contrasting with the context of application of the dynamics. At the end, the evaluation of feelings was carried out in the general context of the dynamics, where the degree of feelings aroused in the participants during the application of gamification was perceived. A word cloud chart was also prepared, according to the degree of occurrence, where it is possible to perceive the most cited feelings in the evaluative reports. Planning and data analysis using Affective Computing can be found in [23].

II: Qualitative analysis – SWOT analysis. Using the SWOT analysis, during the feedback and evaluation meeting, it was possible to evaluate the dynamics from the perspective of the participants. Thus, it was possible to identify strengths that differentiate the dynamics, weaknesses to be corrected, opportunities for improvement and threats to the functioning of the proposal.

As strengths the participants highlighted: the opportunity to get acquainted with the dynamics, mutual respect, collaboration, responsibility with colleagues and with the knowledge generated, competitiveness in the dynamics, the participation of the expert, the reward system, debates, the opportunity to ask questions with the authors of the knowledge, the socialization of knowledge among the participants, the possibility of monitoring individual performance, the awareness of personal performance, and the self-evaluation process.

Participants highlighted as opportunities: making the rules of the steps and scores available in a file accessible to all participants, creating a tutorial detailing each step, scores and instruments, creating a system for automating gamification, applying gamification in person, and automating the scores, speeding up the completion of the self-evaluation form, leaving the participant designated to develop their opinions and goals.

They also pointed out, as weaknesses, the following items: need to customize each folder according to each participating profile in the remote modality, delay in disclosing scores, lack of detailing of scores for mapping in the self-evaluation form, lack of automation in filling of points in each step, and difficulty in filling in the scores.

Finally, as a threat, the participants mentioned the need for evaluation in each application context in order to define the appropriate target audience in each experiment.

Further details using SWOT Analysis can be found in [23].

III: Qualitative analysis – analysis of medals. The analysis of the Medals from the gamification worksheet, filled with the participants' performance data, took place at the end of the three programmed iterations, whose scores were cumulatively recorded. The following data contained in the gamification worksheet were analyzed: Participation Medal, Activity Medal, Final Medal and General Medal. Table 3 presents the result of the analysis of the gamification worksheet.

Table 3. Summary of the medal table analysis

Step	Medal	Medal Type				
		No Medal	Shrek	Ninja Turtle	Piccolo	Yoda
Beginning	Participation					100%
	Activity					100%
	Final					100%
Knowledge Factory	Participation					100%
	Activity		16.7%			83.3%
	Final		16.7%			83.3%
Duel	Participation					100%
	Activity	16.7%		33.3%	50%	
	Final	16.7%			83.3%	
Pack Card and Communicate Target Audience	Participation					100%
	Activity		16.7%	83.3%		
	Final			16.7%	83.3%	
Knowledge Repository	Participation					100%
	Activity	16.6%	50%	16.7%	16.7%	
	Final	16.7%		50%	33.3%	
Ranking	General			16.7%		83.3%

The Participation Medal represents the Player's level of involvement and participation in the gamification. This medal is obtained through the Bonuses that are earned whenever the participant gets involved in gamification, answering or asking questions, or even giving suggestions.

The Activity Medal represents the participant's performance level in carrying out the main activities present in each step of the dynamic flow. When performing these activities, the participant is rewarded with the respective score, defined in the dynamics planning, and these points are added to the total score for each step. So, as the scores accumulate and reach specific point ranges, the different activity badges are unlocked, in ascending order of value. Table 4 presents the scores defined for unlocking activity badges at each step.

The Final Medal represents the combination of participation in the dynamics and performance in activities, enabling the analysis of the participant's general performance at the end of each step. For this, the participation medal and the activity medal are combined, resulting in the final medal.

Table 4. Ranges of points for unlocking activity medals

Medal	Steps of Gamification Flow				
	Beginning	**Knowledge Factory**	**Duel**	**Pack Card and Communicate Target Audience**	**Knowledge Repository**
Yoda	10	From 150	From 400	From 220	From 13
Piccolo	–	120 to 140	300 to 350	160 to 200	10 to 12
Ninja Turtle	–	90 to 110	200 to 250	100 to 140	7 to 9
Shrek	–	60 to 80	100 to 150	40 to 80	4 to 6
No Medal	0	0 to 50	0 to 50	0 to 20	0 to 3

Finally, we have the General Medal that represents the participant's global performance in gamification. Unlike the final medal, which focuses on overall performance at a specific step of the flow, this medal aims to emphasize the participant's overall performance, enabling a holistic view. Therefore, it is necessary to calculate the arithmetic mean of the final medals based on the weights assigned to each medal. Based on the result of this calculation, the General medal is awarded according to the defined intervals, namely: Shrek medal if the average is between 0 and 1 point, Ninja Turtle medal if the average is between 1.1 and 2, Piccolo medal if the average is between 2.1 and 3, and, finally, Yoda Medal if the average is between 3.1 and 4.

The planning and analysis of the Medals' qualitative data can be consulted in [23].

IV: Quantitative analysis. At the end of the application of knowledge management gamification, a quantitative analysis of the data collected during the experiment was performed. To this end, evaluation criteria, research questions, metrics and indicators were defined.

For the quantitative evaluation, the criteria presented above were adopted. Considering the evaluation criteria, some Research Questions (RQ) were defined, also presented above, with the respective metrics and indicators that served as a guide in the process of evaluating the results. The metrics were classified into: Objective Metrics (OM), being those that can be measured numerically, and Subjective Metrics (SM), where it is not possible to measure numerically directly. The answers to these questions served to answer the Main Question of this study: "Is the gamified approach effective and efficient in supporting the teaching and learning of the knowledge management process in a playful way in the Information Technology?". The list of metrics and research questions is presented in Table 5.

For the subjective metrics, measurements were adopted through: (i) Likert scale (1 to 5, where the higher the number, the greater the degree of importance), and the arithmetic mean system was also adopted, and (ii) Evidence, which is the existence of reports or facts observed by both the researcher and the participants.

Table 5. List of metrics and research questions

Metrics	Research Questions										
	RQ1	**RQ2**	**RQ3**	**RQ4**	**RQ5**	**RQ6**	**RQ7**	**RQ8**	**RQ9**	**RQ10**	**RQ11**
SM01 – Clarity	X										
SM02 – Attendance to the Subject	X										
SM03 – Relevance	X										
SM04 – Feasibility	X										
OM05 – Total Generated Items	X										
OM06 – Total Approved Items	X										
OM07 – Ratio of Approved Cards x Generated Cards	X										
SM08 – Existence of Reports		X									
OM09 – Goal Setting			X								
SM10 – Extrinsic Motivation			X								
OM11 – Goal Achievement				X							
SM12 – Existence of Reports				X							
OM13 – Presence				X							
SM14 – Participants' Awareness					X						
SM15 – Communication of Participants						X					
OM16 – Total of Related Cards						X					
SM17 – Efficiency of Participants							X				
SM18 – Existence of Reports							X				
SM19 – Satisfaction								X			
SM20 – Existence of Reports								X			
SM21 – Adequacy									X		
SM22 – Existence of Reports									X		
SM23 – Perception										X	
SM24 – Existence of Reports										X	
SM25 – Perception of socialization											X

For each metric, the indicators were defined, with the respective attendance conditions, as well as the instruments that would be analyzed in the process of evaluating these indicators. The relationship between metrics, indicators and instruments is presented in Table 6.

Table 6. List of metrics, indicators and instruments

Metrics	Indicators	Instruments
SM01 – Clarity	There is no ambiguity in the text, as it may impair the understanding of the information.	Individual Monitoring Form – Evaluate Card
SM02 – Attendance to the Subject	The Knowledge Card must be aligned with the context of the experiment.	Individual Monitoring Form – Evaluate Card
SM03 – Relevance	The proposed knowledge is important in the context of the experiment and within the theme adopted for the generation of knowledge.	Individual Monitoring Form – Evaluate Card
SM04 – Feasibility	The proposed knowledge is applicable in the context of the experiment or within the proposal being studied.	Individual Monitoring Form – Evaluate Card
OM05 – Total Generated Items	Existence of knowledge generated in the participant's repository.	Gamification Worksheet
OM06 – Total Approved Items	Existence of an approved knowledge card.	Gamification Worksheet
OM07 – Ratio of Approved Cards x Generated Cards	Existence of approved knowledge resulting from the subtraction of the total approved from the total generated.	Gamification Worksheet
SM08 – Existence of Reports	Existence of complementary reports about the perception of their progress in the Post Experiment Questionnaire and/or Self-Evaluation Sheet.	Self-Evaluation Sheet and Post-Experiment Questionnaire
OM09 – Goal Setting	Participant define the goals to be achieved in the previous round.	Self-Evaluation Sheet
SM10 – Extrinsic Motivation	Existence of established goals and confirmation of motivation by the participant.	Self-Evaluation Sheet and Post-Experiment Questionnaire
OM11 – Goal Achievement	Participants achieved some goal set in the previous round.	Self-Evaluation Sheet
SM12 – Existence of Reports	Existence of complementary reports that show engagement in the Post Experiment Questionnaire and/or Self-Evaluation Sheet.	Self-Evaluation Sheet and Post-Experiment Questionnaire
OM13 – Presence	Participants must be present at all rounds.	Gamification Worksheet
SM14 – Participants' Awareness	Answers to Consciousness-related questions from the Post-Experiment Questionnaire were between 4 and 5 on a likert scale.	Post Experiment Questionnaire
SM15 – Communication of Participants	Answers to questions related to Communication, from the Post-Experiment Questionnaire, being between 4 and 5 on the likert scale.	Post Experiment Questionnaire
OM16 – Total of Related Cards	Existence of related cards that were produced as a result of communication between participants.	Gamification Worksheet
SM17 – Efficiency of Participants	Answers to questions related to Efficiency, from the Post Experiment Questionnaire, are between 4 and 5 on the likert scale.	Post Experiment Questionnaire
SM18 – Existence of Reports	Existence of complementary reports about the efficiency of the proposal in the Post Experiment Questionnaire and/or Self-Evaluation Sheet.	Post Experiment Questionnaire and Self-Evaluation Sheet

(Continued)

Table 6. List of metrics, indicators and instruments *(Continued)*

Metrics	Indicators	Instruments
SM19 – Satisfaction	Answers to questions related to Satisfaction, from the Post-Experiment Questionnaire, were between 4 and 5 on the likert scale.	Post Experiment Questionnaire
SM20 – Existence of Reports	Existence of complementary reports about the satisfaction of the proposal in the Post-Experiment Questionnaire and/or Self-Evaluation Sheet.	Post Experiment Questionnaire and Self-Evaluation Sheet
SM21 – Adequacy	Answers to questions related to Adequacy, from the Post Experiment Questionnaire, being between 4 and 5 on the likert scale.	Post Experiment Questionnaire
SM22 – Existence of Reports	Existence of complementary reports about the Adequacy of the proposal in the Post Experiment Questionnaire and/or Self-Evaluation Sheet.	Post Experiment Questionnaire and Self-Evaluation Sheet
SM23 – Perception	The answers to the questions related to Perception, from the Post-Experiment Questionnaire, were between 4 and 5 on the likert scale.	Post Experiment Questionnaire
SM24 – Existence of Reports	Existence of complementary reports about the Perception of the purpose of Gamification in the Post-Experiment Questionnaire and/or Self-Evaluation Sheet.	Post Experiment Questionnaire and Self-Evaluation Sheet
SM25 – Perception of Socialization	The answers to the questions related to Perception of the socialization process, from the Post Experiment Questionnaire, were between 4 and 5 on the likert scale.	Post Experiment Questionnaire

At the end of the experiment, the participants answered a questionnaire containing 39 questions, which were prepared based on the Criteria adopted in this research. Thus, the answers to this questionnaire contributed to answering the questions described below.

Based on criterion C01 (Performance), two research questions were elaborated: "RQ1 – What is the list of knowledge items produced and approved within the SPIDER research group?", and "RQ2 – How do participants perceive their own performance during the experiment?".

RQ1 is related to performance and aims to analyze the relationship between the knowledge generated and the knowledge effectively approved. To answer this question, seven metrics were created with their respective indicators as described below.

The first metric is SM01 – Clarity, whose service indicator is the absence of ambiguity in the text, since it can impair the understanding of the information. This metric was evaluated based on the analysis of the Individual Monitoring Form instrument on the Evaluate Card tab.

The second metric is SM02 – Attendance to the Subject, whose service indicator requires that the Knowledge Card is aligned with the context of the experiment, that is, it must be within the scope of the subject that was chosen as a knowledge-generating theme. This metric was evaluated based on the analysis of the Individual Monitoring Form instrument on the Evaluate Card tab.

The third metric is SM03 – Relevance, whose service indicator is the relevance of the knowledge item in the context of the experiment and within the theme adopted for

generating knowledge. This metric was evaluated based on the analysis of the Individual Monitoring Form instrument on the Evaluate Card tab.

The fourth metric is SM04 – Feasibility, whose service indicator is whether the proposed knowledge is applicable in the context of the experiment or within the proposal being studied. This metric was evaluated based on the analysis of the Individual Monitoring Form instrument on the Evaluate Card tab.

The fifth metric is OM05 – Total Generated Items, whose service indicator is the existence of knowledge cards generated in the participant's repository. This metric was evaluated from the analysis of the Gamification Worksheet instrument.

The sixth metric is OM06 – Total Approved Items, whose service indicator is the existence of an approved knowledge card. This metric was evaluated from the analysis of the Gamification Worksheet instrument.

The seventh metric is OM07 – Ratio of Approved Cards x Generated Cards, whose service indicator is the existence of approved knowledge resulting from the subtraction of the total approved from the total generated. This metric was evaluated from the analysis of the Gamification Worksheet instrument.

RQ2 (Did the gamified approach increase participants' motivation in the habit of producing and evaluating knowledge?) evaluates the performance of the participants in relation to the perception of their progress in the dynamics. To answer this question, the metric SM08 – Existence of Reports was created, whose service indicator is the existence of complementary reports about the perception of their progress in the Post Experiment Questionnaire and/or Self-Evaluation Sheet. This metric was evaluated from the analysis of the Self-Evaluation Sheet and the Post-Experiment Questionnaire responses.

Based on C02 (Motivation), the research question "RQ3 – Did the gamified approach increase the participants' motivation in the habit of producing and evaluating knowledge?" was elaborated. From this question, the objective is to evaluate how gamification impacts the extrinsic motivation of the participant. To answer this question, two metrics were created with their respective indicators as described below.

The first metric is OM09 – Goal Setting, whose fulfillment indicator is whether the participant defines the goals to be achieved in the next round. This metric was evaluated based on the analysis of the Self-Evaluation Sheet.

The second metric is SM10 – Extrinsic Motivation, whose compliance indicator is the existence of established goals and the confirmation of motivation by the participant. This metric was evaluated from the analysis of the Self-Evaluation Sheet and the Post-Experiment Questionnaire.

Based on C03 (Engagement), the research question "RQ4 – Did the participants in the dynamics engage in knowledge production and assessment activities?" was elaborated. This question will help in the process of evaluating the Engagement of participants in knowledge management gamification. To answer this question, three metrics were created with their respective indicators as described below.

The first metric is OM11 – Goal Achievement, whose fulfillment indicator is whether participants achieved any goals established in the previous round. This metric was evaluated from the analysis of the Self-Evaluation Form instrument.

The second metric is SM12 – Existence of Reports, whose service indicator is the existence of complementary reports that show engagement in the Post Experiment

Questionnaire and/or Self-Evaluation Form. This metric was evaluated from the analysis of the Post-Experiment Questionnaire and Self-Evaluation Sheet.

The third metric is OM13 – Presence, whose service indicator is that participants are present in all rounds. This metric was evaluated from the analysis of the Gamification Worksheet instrument.

Based on C04 (Awareness), the research question "RQ5 – Did the participants perceive that the knowledge produced by themselves, and by others, is important and impact on SPIDER's business?" was elaborated. This question aims to evaluate the participants' awareness of the importance of knowledge management for their group.

To answer this question, the SM14 metric – Participants' Awareness was created, whose service indicator is whether the answers to the questions related to Awareness, from the Post Experiment Questionnaire, are between 4 and 5 on a likert scale. This metric was evaluated from the analysis of the responses to the Post Experiment Questionnaire.

Based on C05 (Communication), the research question "RQ6 – Did the participants communicate during the dynamics? Did communication favor the production of knowledge?" was elaborated. Through these questions, the objective is to evaluate how the adapted gamified approach impacts the communication and socialization process among participants. To answer these questions, two metrics were created with their respective indicators as described below.

The first metric is SM15 – Communication of participants, whose service indicator is whether the answers to the questions related to Communication, from the Post Experiment Questionnaire, are between 4 and 5 on the likert scale. This metric was evaluated from the analysis of the responses to the Post Experiment Questionnaire.

The second metric is OM16 – Total of Related Cards, whose service indicator is the existence of related cards that were produced as a result of communication between participants. This metric was evaluated from the analysis of the Gamification Worksheet instrument.

Based on C06 (Efficiency), the research question "RQ7 – Were the dynamics applied during gamification fluid, that is, did they occur without delays, without problems, without impediments? If not, why did these delays occur? What problems arose? Do they impact the production of knowledge? What are the most common problems?" was elaborated. These questions will help in evaluating the adapted approach regarding the new organization of flow steps and activities and its efficiency. To answer these questions, two metrics were created with their respective indicators as described below.

The first metric is SM17 – Efficiency of Participants, whose service indicator is whether the answers to the questions related to Efficiency, from the Post-Experiment Questionnaire, are between 4 and 5 on the likert scale. This metric was evaluated from the analysis of the responses to the Post Experiment Questionnaire.

The second metric is SM18 – Existence of Reports, whose service indicator is the existence of complementary reports about the efficiency of the proposal in the Post Experiment Questionnaire and/or Self-Evaluation Form. This metric was evaluated from the analysis of the Post-Experiment Questionnaire and Self-Evaluation Sheet.

Based on C07 (Satisfaction), the research question "RQ8 – Did the participants show satisfaction after the application of gamified dynamics?" was elaborated. With this question, the objective is to evaluate the satisfaction of the participants at the end

of the application of gamification. To answer this question, two metrics were created with their respective indicators as described below.

The first metric is SM19 – Satisfaction, whose service indicator is whether the answers to questions related to Satisfaction, from the Post Experiment Questionnaire, are between 4 and 5 on the likert scale. This metric was evaluated from the analysis of the responses to the Post Experiment Questionnaire.

The second metric is SM20 – Existence of Reports, whose service indicator is the existence of complementary reports about the satisfaction of the proposal in the Post Experiment Questionnaire and/or Self-Evaluation Form. This metric was evaluated from the analysis of the Post-Experiment Questionnaire and Self-Evaluation Sheet.

Based on C08 (Adequacy), the research question "RQ9 – Do the instruments and activities developed fulfill the purpose of stimulating knowledge management?" was elaborated. The objective of this question is to evaluate the suitability of gamification as a tool to support the teaching and learning process of knowledge management. To answer this question, two metrics were created with their respective indicators as described below.

The first metric is SM21 – Adequacy, whose compliance indicator is whether the answers to the questions related to Adequacy, from the Post Experiment Questionnaire, are between 4 and 5 on the likert scale. This metric was evaluated from the analysis of the responses to the Post Experiment Questionnaire.

The second metric is SM22 – Existence of Reports, whose service indicator is the existence of complementary reports about the Adequacy of the proposal in the Post Experiment Questionnaire and/or Self-Evaluation Form. This metric was evaluated from the analysis of the Post-Experiment Questionnaire and Self-Evaluation Sheet.

Based on criterion C09 (Perception), two research questions were elaborated, namely: "RQ10 – Did the participants perceive the purpose proposed for the gamified approach?", and "RQ11 – How did the participants perceive their socialization process within the gamified approach?".

RQ10 is related to the Perception criterion and aims to evaluate the participants' perception of the teaching objectives of the assets and the knowledge management process. To answer this question, two metrics were created with their respective indicators as described below.

The first metric is SM23 – Perception, whose service indicator is whether the answers to the questions related to Perception, from the Post Experiment Questionnaire, are between 4 and 5 on the likert scale. This metric was evaluated from the analysis of the responses to the Post Experiment Questionnaire.

The second metric is SM24 – Existence of Reports, whose service indicator is the existence of complementary reports about the Perception of the purpose of Gamification in the Post-Experiment Questionnaire and/or Self-Evaluation Sheet. This metric was evaluated from the analysis of the Post-Experiment Questionnaire and Self-Evaluation Sheet.

RQ11 evaluates the participants' perception regarding the process of socializing information and experiences within the dynamics. To answer this question, the SM25 metric – Perception of Socialization was created, whose service indicator is whether the answers to questions related to Perception of the socialization process, from the

Post Experiment Questionnaire, are between 4 and 5 on the likert scale. This metric was evaluated from the analysis of the responses to the Post Experiment Questionnaire.

6 Data analysis

This section presents the analyzes carried out from the data collected in the application of gamification to support the teaching and learning of the knowledge management assets and process. The data were evaluated from the metrics, defined in the previous section, considering their respective indicators, and from the research questions defined in the planning of the application of the experiment.

6.1 Analysis of metrics

In the process of analyzing the metrics, different instruments were evaluated, namely: Gamification Worksheet, Self-Evaluation Sheet, Individual Monitoring Sheet and Post-Experiment Questionnaire.

One of the ways of collecting qualitative and quantitative data was through the application of the Post-Experiment Questionnaire at the end of the experience report. This questionnaire was organized into blocks that grouped the questions referring to the same criterion. The questions had two response options, being: subjective, where the participant spoke the answer in a textual way, and objective, where the participant should signal one of the 5 alternatives (Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree), organized in the likert system, where the alternatives represented, respectively, scores 1, 2, 3, 4 and 5, with the highest degree of agreement having the highest score.

It is important to inform that Player P05 only participated in the initial iteration. This was due to the impossibility of participating in the other rounds, given that at the time, his work was classified as an essential activity, in the context of the COVID-19 pandemic, his license to participate was revoked and his immediate return decreed.

The analysis performed for metrics SM01, SM02 and SM03 show that the service indicators were achieved. The analyzes were based on the evaluations of the knowledge cards carried out by the participants, focusing on different criteria for each metric, respectively: Clarity with a maximum of 2 points, Service to the Subject with a maximum of 2 points and Relevance with a maximum of 6 points. Thus, three analyzes were performed: Item Arithmetic Average (MAI) which is the arithmetic average of the grades for each card individually, Individual General Average (MGI) which is the arithmetic average of the MAI of each author, and General Class Average (MGT) which is the arithmetic mean of the MGI of all participants.

For the SM01 metric, the lowest MAI found was 1.5, which was achieved in only two knowledge cards authored by participants P01 and P05. The lowest MGI was from participant P05, who reached 1.75. Finally, MGT in this metric was 1.93 for clarity, which means an excellent level of clarity of the developed knowledge.

In SM02, the smallest MAI found was 1, which was reached in only two cards belonging to participants P01 and P03. In MGI, the lowest was from participant P01,

who reached 1.58. In this metric, MGT scored 1.76 in Service to the Subject, which means an excellent level of alignment of the knowledge developed.

For the SM03 metric, considering all knowledge cards, the lowest MAI received was 3.75. This average was achieved in only one card authored by participant P01. In MGI, the lowest was from participant P01, who reached an average of 5.21. The MGT in the dynamics was 5.64, which means an excellent level of relevance of the knowledge developed.

The analysis performed for the SM04 metric shows that the service indicators were satisfied. The following were calculated: the individual average, which is the average of the scores of the cards of each participant, given by the Expert in the evaluation process, and the general average of the class, which is the average of the general scores of the cards of all the participants.

Thus, in the SM04 metric, the lowest individual average of the cards' scores was that of participant P03, which was 8.8 (the maximum average being 10). The general average of the class in the dynamics was 9.4, which represents an excellent quality of the cards generated. It is noteworthy that all the knowledge generated by the participants was approved in the expert's evaluation process.

The analysis performed for the OM05 metric demonstrates that the service indicators were achieved. This metric is about total knowledge items. In all, 32 knowledge cards were created, and the participant with the lowest number of cards created was P05 with a total of 2 cards, and the participants with the highest number of cards created were participants P03 and P04, both with 7 cards created each. These data demonstrate the participation in the dynamics of all those involved, resulting in generated knowledge items.

The service indicators were also achieved, according to the analysis performed for the OM06 metric. In all, 32 knowledge cards were approved, and the participant with the lowest number of cards approved was P05 with a total of 2 cards, and the participants with the highest number of cards approved were participants P03 and P04, both with 7 cards each. This analysis reveals the quality of the generated items, resulting in the approval of all cards in the expert's evaluation process.

The analysis performed for the OM07 metric shows that the service indicators were achieved. From the analysis of the Gamification Worksheet instrument, it was found that all knowledge cards created were approved. This represents mastery of the content by the participants and the effort to propose ideas and solutions that are aligned with the context of the dynamics.

The service indicators were achieved, according to the analysis performed for the SM08 metric. For this metric, both the Self-Evaluation Sheet and the Post Experiment Questionnaire were analyzed. Several reports were found about individual progress in the dynamics, corroborating the fulfillment of the metric indicators. Participants perceived their own performance, especially in the evaluative report in the Self-Evaluation step, where some reported on the achievement, or not, of the stipulated goals. They also reported on impediments that impacted their performance at the end of each iteration. These data demonstrate the strong involvement of the participants regarding the monitoring of their performance, leading them to identify the strengths and especially the difficulties encountered.

The analysis performed for the OM09 metric shows that the service indicators were satisfied. The analysis was performed using the Self-Evaluation Sheet instrument and it was found that, in the Self-Evaluation step, the participants established goals to be achieved in the next iteration. These data corroborate the affirmation of the participants' commitment and motivation regarding their performance in the dynamics.

The analysis performed for the SM10 metric shows that the service indicators were satisfied. These indicators were analyzed using the Self-Evaluation Sheet instrument and also the Post-Experiment Questionnaire, where two specific questions for this indicator were evaluated.

The first question asked the participants if 10 the dynamics/practices made the learning process enriching and challenging. Participants P01, P03 and P06 indicated yes, giving a maximum score of 5 (strongly agree). The other participants scored 4 (agree).

The second question designed to evaluate this criterion asked the participants whether, throughout the case study, the gamified approaches kept them motivated to participate in the dynamics/practices. Opinions were above average, with a score of 5 given by participants P01, P03 and P06, grade 4 by participant P02, and grade 3 (neutral) by participants P04 and P05. In this way, it was possible to identify the fulfillment of the indicators for this metric since the answers were satisfactory, as perceived in the data analysis.

The service indicators were also achieved, according to the analysis performed for the metric OM11. The Self-Evaluation Sheet instrument was analyzed, where it was found that all participants were involved in the process of creating cards. However, in the first iteration there were still no goals to be achieved.

Thus, in the first iteration the goals were defined without being based on a previous parameter. In the next round (iteration 2), only a few goals were achieved, such as participants P01 and P03 who reached half of their goals. Participants P02, P04 and P06 did not achieve any of the goals. Participant P05 was absent in iteration 2 and 3. In iteration 3, participant P01 was unable to achieve the goals, alleging problems in time management. Participants P02 and P03 were able to reach their goals. Participant P04 partially achieved the goals. And, participant P06 did not perform the last self-evaluation.

Based on these data, it was possible to identify the fulfillment of the indicators for this metric, given the achievement of goals by the participants, as perceived in the data analysis.

The service indicators were also achieved, according to the analysis performed for the SM12 metric. The instruments Self-Evaluation Sheet, Gamification Worksheet, and Post-Experiment Questionnaire were analyzed, where reports and evidence that prove the participants' engagement were identified. It was evidenced that all participants created and evaluated knowledge cards. There was also participation in debates, presentations of cards with questions and suggestions for ideas that enriched learning and dynamics.

The analysis performed for the OM13 metric shows that the service indicators were satisfied. These indicators were analyzed using the Gamification Worksheet instrument, where the participant's presence is recorded. After verification, it was concluded that all participants were present, with the exception of participant P05, who was unable to

participate in iteration 2 and 3 due to an emergency at work during the period of application of the aforementioned iterations, and his absence in the dynamics was justified.

The service indicators were also achieved, according to the analysis performed for the SM14 metric. The Post-Experiment Questionnaire instrument was analyzed, where two specific questions for this indicator were evaluated. The first question asked whether the approach used in the experiment was adequate for the continuous generation of knowledge within the SPIDER group. Participants P01 and P02 signaled with a score of 5. The other participants signaled with a score of 4.

The second question asked about the participants' point of view on the knowledge-generating theme adopted in the experiment (Customer and Market dimension from MOSE), whether it was relevant in the dynamics. Participants P03 and P06 gave a grade of 5. Participants P01, P02 and P05 gave a grade of 4. And, participant P03 assigned a grade of 3.

Based on these data, it was evident that the participants realized the importance of the knowledge generated in the dynamics for the improvement of the research laboratory, satisfying the indicators of this metric.

The analysis performed for the SM15 metric shows that the service indicators were satisfied. These indicators were analyzed using the Post-Experiment Questionnaire instrument, where four specific questions for this indicator were evaluated.

The first question asked the participants if the sub-step of creating knowledge cards, of the Knowledge Factory step, favored the externalization of knowledge. Participants P01 and P06 assigned a grade of 5, the other participants assigned a grade of 4. The second question asked the participants whether the step of creating knowledge cards favored the combination of knowledge. Participant P04 assigned grade 2 and the others assigned grade 4.

The third question asked the participants whether the knowledge card evaluation step favored the internalization of knowledge. Participant P04 assigned a grade of 2, on the other hand participant P06 assigned a grade of 5 and the other participants gave a grade of 4. Finally, the fourth question asked the participants whether the "Knowledge Bank" stage favored the socialization of knowledge. Participants p02 and p05 assigned grade 4. And the others assigned grade 5.

In addition, the constant exchange of information between the participants was observed throughout the dynamics. In the Knowledge Repository step, there were enriching debates about the cards approved with the participation of all the members. These factors, together with the other items analyzed, corroborate the fulfillment of the indicator.

The analysis performed for the OM16 metric shows that the service indicators were satisfied. These indicators were analyzed using the Gamification Worksheet instrument, where it was found that a total of 7 related cards were created, with the authors: P01 created 1 card, P02 created 1 card, P04 created 3 cards, and P06 created 2 cards.

The analysis performed for the SM17 metric shows that the service indicators were partially satisfied. These indicators were analyzed using the Post-Experiment Questionnaire instrument, where 8 specific questions for this indicator were evaluated.

The first question asked the participants if the dynamics/practices were carried out in an adequate time. Participant P04 assigned a grade of 5, P06 gave a grade of 2 and the other participants gave a grade of 4. It was also asked if the experiment would benefit

if it were carried out in person. Participant P05 assigned grade 3 (neutral), P03 and P04 scored 4 (agree), and the others scored 5 (I totally agree).

The second question asked the participants if the dynamics/practices developed did not restrict the participant's creativity to create their own solutions. Participant P04 assigned grade 3 and the other participants assigned grade 5.

The third question asked the participants if the dynamics/practices were harmed because they were done online. Participants P01 and P03 assigned grade 3, P05 and P06 graded 2, and P02 and P04 graded 4.

The fourth question asked the participants whether the experiment would benefit if it were done face-to-face. Participant P05 assigned grade 3, P03 and P04 graded 4 and the others graded 5.

The fifth question asked the participants how they evaluated the items ease of use and ease of reading referring to the instruments for creating knowledge cards. Regarding the evaluation of the item ease of use, P06 gave a grade of 2, P01 and P04 a grade of 3 and the others a grade of 4. As for ease of reading P05 graded 2, P01 graded 5 and the others graded 4.

The sixth question asked the participants how they evaluated the ease of use and ease of reading items regarding the instruments used in the knowledge card evaluation activity. Regarding the item ease of use P04, P05 and P06 scored 2, P01 scored 5 and P02 and P03 scored 4. Regarding the item readability P06 scored 2, P02 and P05 scored 4, and P01, P03 and P04 scored 5.

The seventh question asked the participants how they evaluated the following items related to the knowledge repository: duration, proactivity and socialization. Regarding the item duration, P01 and P02 scored 3, P03 did not respond and the others scored 4. Regarding the item proactivity, P06 scored 5, P03 did not respond and the others scored 4. Finally, regarding socialization, P01 and P06 scored 5, P03 did not respond and the others scored 4.

The eighth question asked the participants how they evaluated the duration of the Experiment. Participants P03 and P05 scored 2, P02 scored 3, and the others scored 4.

Thus, we believe that this point has been partially met. Once there were delays and setbacks that hampered the progress of the dynamics. After the first round, these difficulties were identified and the dynamics and times were readjusted in order to solve the problems. After that, the iterations occurred satisfactorily.

The service indicators were also achieved, according to the analysis carried out for the SM18 metric. The instruments Self-Evaluation Sheet, Gamification Worksheet, and Post-Experiment Questionnaire were analyzed, where participants reported difficulties about the times of the dynamics that impacted their performances. Another factor mentioned by the participants was the adaptation of the instruments to the remote mode, since different software tools were used for the different instruments. This impacted the navigation between the instruments and the adaptive process of the initial round. After the second round, participants reported being more familiar with the tools and with the adaptations made in the gamified approach and in the times of the steps.

The analysis performed for the SM19 metric shows that the service indicators were satisfied. These indicators were analyzed using the Post-Experiment Questionnaire instrument, where two specific questions for this indicator were evaluated.

The first question asked participants whether the experiment was designed in an attractive way. Participants P01 and P04 assigned a grade of 5 and the other participants assigned a grade of 4.

The second question asked the participants how they evaluated the tools presented for use during the experiment in remote mode (Google Drive, Google Meet, etc.). Participants P04 and P05 assigned grade 2, P02 and P03 graded 4 and P01 and P06 graded 5.

The service indicators were also achieved, according to the analysis performed for the SM20 metric. The instruments Self-Evaluation Sheet, Gamification Worksheet, and Post-Experiment Questionnaire were analyzed, where the participants indicated several positive points that made this experience very satisfactory.

The issue of sociability and the fact that the dynamics stimulate creativity in the description of the cards were points highlighted by the participants. The debates created in the Knowledge Repository step were also mentioned, which were quite enriching, allowing the externalization of ideas, opinions, the detailing of knowledge, generating the participants' engagement in the dynamics. These social interactions aligned with the dynamics favored the documentation of improvement ideas in the laboratory context, reported another participant.

The analysis performed for the SM21 metric shows that the service indicators were partially satisfied. These indicators were analyzed using the Post-Experiment Questionnaire instrument, where 13 specific questions for this indicator were evaluated.

The first question asked the participants whether the approach chosen for the experiment had a good integration of theory and practice. Participant P04 scored 3, P02 and P05 scored 4 and P01, P03 and P06 scored 5.

The second question asked the participants if the dynamics/practices had an adequate level of complexity. Participant P05 scored 4 and the others scored 5.

The third question asked the participants if the dynamics/practices developed did not restrict the participant's creativity to create their own solutions. Participant P04 scored 3 and the others scored 5.

The fourth question asked the participants whether the instruments to support gamification (Gamification Worksheet, Knowledge Board, Knowledge Cards, Individual Monitoring Form, Self-Evaluation Sheet) were of good quality. Participant P04 scored 5 and the others scored 4.

The fifth question asked the participants whether the instruments to support gamification (Gamification Worksheet, Knowledge Board, Knowledge Cards, Individual Monitoring Form, Self-Evaluation Sheet) helped with performance, engagement, and communication. Regarding performance, participants P04 and P05 rated 2, P01 and P06 rated 3 and P02 and P03 rated 4. Regarding engagement, participants P01 and P06 rated 5 and the others rated 4. As for communication, participant P05 scored 2, P06 scored 3, P01 scored 5, and the others scored 4.

The sixth question asked the participants which of the steps/practices was (were) the most decisive for the consolidation of knowledge: creating cards, evaluate cards, identify target audience, and knowledge repository. The answers were: (i) as for the step creating cards, participants P02 and P04 gave a grade of 4 and the others gave a grade of 5, (ii) as for the Evaluate Cards step, participants P04 scored 3, P02 scored 4 and the others scored 5, (iii) as for the Identify Target Audience step, participants P01 and P05

scored 4, P02 scored 2, P03 and P06 scored 3, and P04 scored 1, (iv) and regarding the Knowledge Repository step, participants P01 and P05 gave a grade of 4 and the others gave a grade of 5.

The seventh question asked the participants if the approach used in the experiment is adequate for the continuous generation of knowledge within the SPIDER group. Participants P01 and P02 scored 5 and the others scored 4.

The eighth question asked the participants how they evaluated the items related to the creation of knowledge cards in terms of ease of use and ease of reading. In terms of ease of use, participants P01 and P04 gave a grade of 3, P02, P03 and P05 a grade of 4 and P06 a grade of 2. In terms of ease of reading, participant P01 graded 5, P05 graded 2 and the others rated 4.

The ninth question asked the participants how they evaluated the items referring to the knowledge card evaluation form in terms of ease of use and ease of reading. As for the ease of use, participant P01 gave a grade of 5, P02 and P03 gave a grade of 4, P04 a grade of 3, and P05 and P06 a grade of 2. As for ease of reading, participants P01, P03 and P04 graded 5, P02 and P05 scored 4, and P06 scored 2.

The tenth question asked the participants how they evaluated the items referring to the knowledge repository in terms of: duration, proactivity and, socialization. The answers were: (i) in terms of duration, participants P01 and P02 scored 3 and the others scored 4, (ii) as for the proactivity item, all participants gave a grade of 4, (iii) and regarding the item socialization, participants P01, P03 and P06 gave a grade of 5 and the others gave a grade of 4.

The eleventh question asked the participants how they evaluated the scope of activity item, referring to the experiment. Participants P01, P04 and P06 scored 5 and the others scored 4.

The twelfth question asked the participants how they evaluated the item degree of difficulty, referring to the experiment. Participants P03 and P06 rated 5 and the others rated 4.

The thirteenth question asked the participants how they evaluated the tools presented for use, referring to the experiment. Participants P01 and P06 scored 5, P02 and P03 scored 4, and P04 and P05 scored 2.

Thus, in the general evaluation, the instruments and activities fulfill the purpose of stimulating knowledge management, promoting the externalization of ideas and the socialization of knowledge, with the criteria meeting indicators being satisfied.

The service indicators were also achieved, according to the analysis performed for the SM22 metric. The instruments Self-Evaluation Sheet, Gamification Worksheet, and Post-Experiment Questionnaire were analyzed, where participants reported that the instruments and activities created the possibility of exchanging knowledge, debates, and maturation of ideas. They also highlighted that the debate stimulated creativity for the elaboration of other cards in the following rounds. Another highlight was the possibility of participant development during the dynamic, encouraging their engagement. Finally, the figure of the Expert was cited by the participants as very important within the dynamics, serving as a quality parameter for the knowledge developed.

The analysis performed for the SM23 metric shows that the service indicators were satisfied. These indicators were analyzed using the Post-Experiment Questionnaire instrument, where three specific questions for this indicator were evaluated.

The first question asked the participants if they perceived the externalization of knowledge in the step of creating knowledge cards. Participant P06 assigned grade 5 and the others graded 4.

The second question asked the participants if they perceived the internalization of knowledge in the knowledge card evaluation step. Participant P04 scored 2, P06 scored 5 and the others scored 4.

The third question asked the participants if they perceived the steps of the knowledge cycle (externalization, combination, internalization and socialization) within the experiment. Participants P01 and P03 scored 5, P02, P04 and P06 scored 4 and P05 scored 3.

Based on the data, it was possible to confirm compliance with the indicators for this criterion. The participants realized the purpose proposed for the gamification and had a satisfactory involvement in the dynamics. All participants got involved in the dynamic activities and contributed with suggestions, ideas and debates, making the knowledge sharing experience a positive one.

The service indicators were also achieved, according to the analysis carried out for the SM24 metric. The instruments Self-Evaluation Sheet, Gamification Worksheet, and Post-Experiment Questionnaire were analyzed, where participants reported, at the end of the experiment, the positive points that contributed to the perception of the purpose of gamification. The socialization of knowledge was also highlighted as an important factor during the process, enabling a holistic view of the participants' ideas for improving the laboratory.

Participants also mentioned that it was also possible to understand the importance of ideas and opinions of other participants in the process of building solutions to improve the laboratory. Another point mentioned was that the experiment took place in an evolutionary way, where the practice became easier to perform and flowed in a simpler way. Also, it was highlighted that the updates that were made worked properly.

Finally, the analysis performed for the SM25 metric shows that the service indicators were satisfied. These indicators were analyzed using the Post-Experiment Questionnaire instrument, where four specific questions for this indicator were evaluated.

The first question asked the participants if they perceived the externalization of knowledge in the step of creating knowledge cards. Participant P06 assigned grade 5 and the others graded 4.

The second question asked the participants if they perceived the internalization of knowledge in the knowledge card evaluation step. Participant P06 assigned grade 5, P04 graded 2 and the other participants graded 4.

The third question asked the participants if they perceived their performance when following the evolution of the knowledge sheet. Participants P02 and P03 scored 5, and the others scored 4.

The fourth question asked the participants how their socialization process took place in the knowledge repository step, where the following interactions were presented: I presented ideas, I suggested improvements, I presented doubts, I participated in debates, and I discussed experiences.

Participant P05 did not answer this question. The answers of the other participants were: (i) in the item "I presented ideas", participants P02 and P06 gave a grade of 5 and the others gave a grade of 4, (ii) in the item "I suggested improvements", participants

P02 and P06 gave a grade of 5, P04 a grade of 1, and P01 and P03 a grade of 4, (iii) in the item "I presented doubts", participants P02 and P06 gave a grade of 5, P01 and P04 a grade of 4, and P03 a grade of 2, (iv) in terms of "I participated in debates", participants P02 and P04 gave a grade of 5, P03 and P06 a grade of 4, and P01 a grade of 3, (v) and in the item "I discussed experiences", participants P02, P03 and P04 gave a grade of 5, and P01 and P06 gave a grade of 4.

The participants were very participative and communicative during the dynamic, which made the experience a positive one. It was noticed that some participants socialized more when the subject was directly aligned with their area of expertise, which allowed for a vast exchange of experiences and information during the process. In the general evaluation of this item, it was satisfactory because the participants were able to perceive this socialization process and evaluate their performance in this phase.

6.2 Analysis of research questions

The research questions were analyzed based on the results of the criteria defined for their respective questions. For each question, a set of metrics was adopted that corroborated the analysis of the questions.

To answer RQ1, the results of metrics SM01, SM02, SM03, SM04, OM05, OM06 and OM07 were analyzed, which served as a basis for answering the question. Thus, based on the evaluated data, it is concluded that the generated knowledge items showed an above-average quality standard. This was evidenced from the approval of all the knowledge generated and the alignment of the evaluations regarding the adequacy and importance of these knowledge items within the context of the SPIDER laboratory. Through the analysis of the measures, it was noticed that there was a good performance of the group, which delivered quality work products with great added value, which can be implemented within the laboratory and positively impact the resolution of the identified problems.

To answer RQ2, the results of the SM08 metric were analyzed, which served as a basis for the answer to the question. Thus, based on the evaluated data, it is concluded that the participants were able to perceive their performance throughout the dynamics through the ranking and monitoring of the personal goals that were defined. The position in the ranking was highlighted by the participants as a motivator for personal strategies, leading them to diversify their actions and dedicate more effort to activities that scored better. This perception of performance also impacted the definition of personal goals, which were reevaluated by the participants throughout the dynamics in order to make the goals more realistic according to the new personal strategies. Thus, greater achievement of personal goals was perceived, in line with a better evolution in the general ranking.

To answer RQ3, the results of the OM09 and SM10 metrics were analyzed, which served as a basis for the answer to the question. Thus, based on the data evaluated, it is concluded that the gamified approach was effective in motivating participants in the habit of producing and evaluating knowledge. Through the analysis of the indicators, it was noticed that the activities and monitoring instruments (Gamification Worksheet, Ranking, Self-Evaluation Sheet) were factors that contributed to the performance of

the participants. This is because it enabled participants to evaluate their productive potential, leading them to seek to achieve their goals and also to move up in the general ranking. As the task of creating and evaluating knowledge, in addition to scoring in that specific step, also impacted the other steps, which aimed to reward the previous good performance (creating and evaluating knowledge items with quality), the participants sought to employ efforts and quality in the activity of creating and evaluating knowledge to achieve their goals in dynamics.

To answer RQ4, the results of the metrics OM11, SM12 and OM13 were analyzed, which served as a basis for the answer to the question. Thus, based on the data evaluated, it can be concluded that the participants were engaged in the activities of evaluation and creating of knowledge, resulting in knowledge items aligned with the needs found in the context in the research laboratory. It was possible to perceive the involvement of the participants and the effort to deliver knowledge that was applicable and that met the expectations of the subject studied. In addition, in the activity of evaluating knowledge, there was a considerable number of evaluations aligned with the Expert's evaluation, which demonstrates the degree of commitment of the participants in this activity.

To answer RQ5, the results of the SM14 metric were analyzed, which served as a basis for the answer to the question. Thus, based on the data evaluated, the analysis of the indicators, the observation during the application of the dynamics, and the analysis of the recordings, we can conclude that there was a perception of the participants about the importance of the knowledge generated in the impact of the business of the SPIDER laboratory. Thus, the debates, sharing of experiences and ideas were productive since the participants realized that new ideas and solutions could emerge or even be matured among the group through dialogue and, thus later be transformed into a knowledge card.

To answer RQ6, the results of metrics SM15 and OM16 were analyzed, which served as a basis for answering the question. Thus, based on the data evaluated, the observation during the application of the dynamics, and the analysis of the recordings, we can conclude that there was communication between the participants. In addition, communication favored the creating of knowledge, with the creating and approval of 7 knowledge items related to other cards. This represents 21.9% of the total number of cards created and approved, which reinforces the occurrence of communication. It is noteworthy that the approved cards are presented and discussed by the participants in the knowledge repository step, which stimulates the emergence of new related ideas or even the complement of this knowledge, which can be transformed into a knowledge card.

To answer RQ7, the results of metrics SM17 and SM18 were analyzed, which served as a basis for answering the question. Thus, based on the data evaluated, it is concluded that the dynamics and activities applied were fluid, elaborated on the basis of the knowledge life cycle. However, there were delays in the dynamics due to the following factors described below with the respective solutions developed.

The first problem found was hardware, which occurred in the first iteration, where a computer used by the Master presented processing failures due to the excess of screens running (meet meeting screen, recording of the meeting, individual monitoring form of all participants collaboratively open, collaborative knowledge framework, collaborative gamification sheet, collaboratively Google drawings for cards).

This issue was addressed by using a second computer in subsequent rounds, where tasks were split.

The second problem was related to the point accounting routines. This routine was performed by the Master and the Judge, who analyzed the individual sheets of each participant to collect the information for scores, which took longer than expected, given the limitations of internet bandwidth and the different instruments. This problem was solved by adjusting the times for this routine in the following rounds.

Finally, the third problem found was related to navigation between the different instruments present in the gamification, which were adapted using different software tools. This adaptation to the remote modality using different tools caused a problem of navigation between the instruments where the participant had to keep different tabs open in their browser, requiring time and attention to select the desired tab. These problems mainly impacted the performance of participants in activities that required the use of these tools. This problem was alleviated through instructions for use, provided by the Master whenever any participant signaled difficulties with the tools throughout the dynamic.

To answer RQ8, the results of metrics SM19 and SM20 were analyzed, which served as a basis for answering the question. Thus, based on the data evaluated, the observation during the application of the dynamics, and the analysis of the recordings, we can conclude that the participants showed satisfaction at the end of the application of the experiment. A point mentioned, but not definitive for the final opinion, was about the tools used in the adaptation of gamification instruments. Participants signaled the fact that there was more than one tool, which required navigation between the instruments, which is the main negative point in this question. However, in the final evaluation, despite this mentioned negative point, the participants indicated that they were quite satisfied with the dynamics. One of the highlights was the socialization of knowledge generated by the dynamics that favored the cataloging of ideas and solutions for the SPIDER laboratory context.

To answer RQ9, the results of metrics SM21 and SM22 were analyzed, which served as a basis for answering the question. Thus, based on the data evaluated, the observation during the application of the dynamics, and the analysis of the recordings, we can conclude that the instruments and activities fulfill the purpose of stimulating knowledge management. They enable the exchange of information and socialization among the participants, following the knowledge life cycle as a basis. The steps and activities, in the evaluation of the participants, received satisfactory grades, corroborating this analysis.

To answer RQ10, the results of measurements SM23 and SM24 were analyzed, which served as a basis for the answer to the question. Thus, the knowledge was carried out during the analysis of the data of the application process, with the knowledge that the participants realized the purpose of the knowledge proposal. The steps of the knowledge management process were noticeable throughout life, and the socialization process was highlighted as the main point of the participants, who perceived the opportunity to contribute to the improvement of the SPIDER laboratory through their ideas and solutions.

To answer RQ11, the results of the MS25 metric were analyzed, which served as a basis for the answer to the question. Thus, with our knowledge, during the observation

of the analysis the dynamics of application activities, it was noticed that the participants had the perception of the socialization process contained in each step of the activities of the dynamic operation. After inclusion rounds, they suggested inclusion projects as steps, and participated in the other debates they supported, suggesting process improvements and participations. It is worth mentioning that there was a lot of interaction between the participants, a fact that reinforces an idea of socialization within the group.

7 Discussion

In this section, the analyzes carried out on the criteria defined in the planning of the application of knowledge management gamification are presented, as well as an overall evaluation of the experience report.

7.1 Analysis of criteria

The Evaluation Criteria were evaluated based on the Research Questions defined in the planning of the evaluation of the dynamics results, whose results were detailed in previous section. For each question, a set of metrics was adopted, and the result of the evaluation of these questions corroborated for the criteria analysis.

To evaluate C01 (Performance), the results of Research Questions RQ1 and RQ2 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the evaluated data, it is concluded that the dynamics proved to be efficient, as it stimulated those involved to actively participate in the dynamics and achieve good performance, developing quality and effective knowledge items for the context studied. It also proved to make the participants realize their performance in the dynamics and organize strategies, dedicating greater efforts and time to the activities they have more affinity, without neglecting those that give them more difficulties, given that all activities have goals to be achieved. Thus, we conclude that the dynamics meets the Performance criterion.

To evaluate the C02 (Motivation), the results of the Research Question RQ3 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the evaluated data, it is concluded that, in relation to the C02 criterion, the approach proved to be effective, as its instruments, activities and game elements achieved the objective of motivating participants through rewards and points. From the analyzed data, it was noticed throughout the application of the dynamics the motivation of the participants to carry out the activities in the search to achieve their personal goals, and a higher score for growth in the ranking. In addition, the "Expert tip" also served as extrinsic motivation, suggesting ways for the participant to explore knowledge based on their Knowledge Card. Thus, we conclude that the dynamic meets the Extrinsic Motivation criterion.

To evaluate the C03 (Engagement), the results of the Research Question RQ4 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the data evaluated, it is concluded that gamification proved to be efficient in the process of engaging participants in the dynamics. Coordinated activities based on the knowledge

life cycle enabled student interaction with all steps of knowledge creation. In addition, the use of collaboration mechanics supported the socialization process among the participants, facilitating communication and the exchange of ideas, leading them to perceive their importance within the dynamics and, thus, encouraging them to become more involved. Another important factor that we evaluated was the use of the Self-Assessment activity, where participants were able to analyze and reflect on their performance and also set personal goals for the next iteration, thus reinforcing their engagement in the dynamics with a focus on achievement of goals and personal performance. Thus, we conclude that the dynamic meets the Engagement criterion.

To evaluate the C04 (Awareness), the results of the Research Question RQ5 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the data evaluated, it is concluded that gamification proved to be effective in the process of leading the participant to realize the importance of the knowledge generated during the dynamics, since it was planned to support, through knowledge management, a previous dynamics. Thus, during the presentation of the dynamics in the simulated round, the objectives of gamification were presented, as well as the knowledge-generating theme, which everyone should base themselves on to generate knowledge. Also, in the card evaluation step, the knowledge generated was evaluated based on criteria that referred to the main objective, making the participant always in contact with these objectives. In addition, the role of the Expert in the dynamics reinforced the perception of importance among the participants. Thus, we conclude that the dynamics meets the Awareness criterion.

To evaluate the C05 (Communication), the results of the Research Question RQ6 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the data evaluated, it is concluded that the dynamics proved to be efficient, since it stimulated those involved to communicate actively throughout the dynamics. The creation of a specific activity to stimulate socialization among participants in the Knowledge Repository step, where they could expose their knowledge, give explanations of their card or even the context in which it should be used, facilitated dialogue and interaction between participants. Thus, we conclude that the dynamic meets the Communication criterion.

To evaluate C06 (Efficiency), the results of Research Question RQ7 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the data evaluated, it is concluded that, despite the activities being considered satisfactory, even with the problems presented, the efficiency criterion (fluidity of activities in the dynamics) was below expectations, given the unforeseen events. With a view to better adapting the dynamics to the remote modality, the following needs were highlighted: development of a serious collaborative game that includes all stages, rules, activities and instruments and whose minimum hardware and software requirements are defined and accessible. Thus, we conclude that the dynamics partially meets the Efficiency criterion.

To evaluate the C07 (Satisfaction), the results of the Research Question RQ8 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the data evaluated, it is concluded that gamification proved to be effective in terms of satisfaction. The participants signaled that their expectations were met, in addition to having been able to perform their duties and carry out the activities present in the dynamics. The objective of socializing knowledge about the spider laboratory context was

achieved, which reinforces this issue. Thus, we conclude that the dynamic meets the Satisfaction criterion.

To evaluate the C08 (Adequacy), the results of the Research Question RQ9 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the data evaluated, it is concluded that gamification proved to be suitable for the context of the software quality laboratory, serving as a tool to support the teaching and learning of the knowledge management assets and process. The experiences reported and observed were very satisfactory, evidencing the suitability of this approach in the Information Technology. The knowledge items generated and approved were used to compose the database of ideas and solutions generated from the application of this dynamic, and can be implemented to improve the customer-market dimension. Thus, we conclude that the dynamics meets the Adequacy criterion.

To evaluate C09 (Perception), the results of Research Questions RQ10 and RQ11 were analyzed, which served as a basis for the answer to that criterion. Thus, based on the data evaluated, it is concluded that gamification proved to be efficient in terms of perception, presenting the participants with the objectives and means of achieving the expected results. The instruments developed and the flow activities facilitated the socialization process and the perception of the importance of knowledge management for both personal and collective development. The use of collaboration mechanics facilitated the exchange of knowledge between participants, who perceived in other cards the possibility of developing new ideas or even complementing existing knowledge through the creation of related cards. Thus, we conclude that the dynamics meets the Perception criterion.

7.2 General analysis

The general analysis took place based on the results of the evaluation of the Evaluation Criteria defined in the planning of the gamification evaluation. In this way, the result of the evaluation of the criteria corroborated for the general analysis, where the Main Research Question of this experience report was answered: "The gamified approach is effective and efficient in supporting the teaching and learning of the knowledge management process in a playful way in the Information Technology?".

Among the criteria evaluated at the end of this experiment (Performance, Motivation, Engagement, Awareness, Communication, Efficiency, Satisfaction, Adequacy and Perception), all were met, with the exception of the Efficiency criterion, which was partially met.

Regarding the latter, some negative points were identified during the experiment and will be worked on so that the proposal has a greater impact as a tool to support the teaching and learning process, namely: (i) the need to optimize feedback times, necessary to that there are no lapses of unproductive time, given the time required to process the information, hindering the participant's performance and reasoning, (ii) automation of scores, necessary so that the process of consulting scores and ranking is not an expensive task, where as an opportunity for improvement the possibility of making the scores and ranking available in the participant's main window was identified, avoiding changing windows, (iii) readjustment of the instruments in a single

collaborative platform, avoiding the accumulation of tools and open tabs during the dynamic, since this generates confusion and difficulty in the use of these instruments, and (iv) adequacy of hardware and software resources, in order to increase the probability of all participants having access to the minimum resources necessary to perform the dynamics and use the tools equally.

Thus, based on the data evaluated, we concluded that the gamified approach to knowledge management was considered satisfactory as a more effective and efficient way of teaching knowledge management in a playful way, impacting the teaching and learning process of the dynamic participants.

8 Threats to validity

In this section, some threats to validity related to the execution of the experience report will be discussed and how they were dealt with throughout the development of the research.

8.1 Internal validity

According to Lima et al. [30], internal validity defines whether the observed relationship between treatment and outcome is not due to the influence of factors other than those evaluated, resulting in incorrect inferences.

In this study, a threat to internal validity related to the story was identified. This threat occurs due to the possibility that the result of the process is a consequence of an event external to the experiment.

Given that this experiment took place remotely, in a pandemic context, requiring the use of many resources and tools, some of which were known only at the time of application of the dynamics, it was necessary to implement actions to reduce the impacts of this influence.

In this way, the tools were made available on a collaborative platform and the researcher made himself available to clarify doubts and carry out training for participants outside meeting hours.

8.2 External validity

According to Lima et al. [30], external validity defines the conditions that impact the generalization and analysis of the results of an experiment. In this study, a threat was identified to the external validity to which it is related to time. This threat occurs when time constraints are imposed or removed.

To reduce the impacts of the threat related to time, the meetings were organized to take place on a weekly basis, giving the possibility of adapting the application of the dynamics, if necessary, and time to carry out training between each meeting.

8.3 Construction validity

According to Lima et al. [30], construct validity considers the relationship between theory (if the treatment reflects the cause satisfactorily), and observation (if the result reflects the effect satisfactorily), that is, it considers the cause and effect relationship.

A threat to construction validity has been identified which is related to the design of the experiment. This threat generally occurs due to poor definition of the theoretical basis or the definition of the experimentation process.

To reduce the impacts of the threat related to the experiment project, the first meeting was dedicated to the presentation of the objectives and the dynamics process. In addition, a simulated round was adopted for the presentation of rules and training in the use of collaborative tools and work products present in gamification.

8.4 Conclusion validity

According to Lima et al. [30], conclusion validity is related to the ability to analyze and interpret the results in order to reach a correct conclusion. A threat present in the study is in relation to the analysis of the results, since it lacks a comparative evaluation of this proposal with the results of another application in a different organizational context, in order to obtain a generalization of the scope of the proposal.

9 Conclusion

This article presented the results obtained from an Experience Report in the application of a gamification to support the teaching and learning of the knowledge management assets and process, in the context of a software quality laboratory. The results obtained from this experience report will serve as a reference for future applications of dynamics in different contexts. In addition, the opportunities for improvement identified will be used to improve the proposal, in order to make gamification more efficient as a support tool in the teaching and learning process.

Some contributions were obtained in this work: (i) identification of difficulties regarding the planning and application of gamification in the remote modality, as reported in the data analysis, (ii) the need to apply this proposal in a different organizational context, in order to verify the effectiveness and efficiency of gamification, (iii) and the proposal of the teaching methodology, through the application of the gamified framework, using game elements and different pedagogical approaches to support the teaching and learning process of the knowledge management assets and process, was the main contribution of this work, because it is expected that this approach will help researchers and teachers in the use of the highlighted elements as an aid for the teaching and learning process, mainly in the knowledge management process.

As limitations of this work, we highlight the lack of results from applications of this proposal to carry out comparative data analysis, the amount of students participating in the experiment that may not generalize the results obtained for the gamification performed, and this experience report is the first to be carried out with this new proposal.

Thus, a comparative evaluation of these results with the data resulting from future applications of this approach is necessary, for a more substantial comparative evaluation.

Finally, as future works, we highlight: the application of Knowledge Management Gamification in a different organizational context, in order to evaluate the effectiveness and efficiency of this proposal in different contexts and increase the number of students involved, as already mentioned, and adequacy of this gamification proposal, based on the problems identified in the efficiency criterion, reported in the general analysis.

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