The gamification as a tool for developing competencies: A proposal of application for analysis and prevention of failures based on 8D methodology

A gamificação como instrumento para o desenvolvimento de competências: Uma proposta de aplicação para análise e prevenção de falhas com base na metodologia 8D

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ABSTRACT
This article proposes developing an analysis and failure prevention system that uses gamification as a strategy for employee engagement. This approach allows the users involvement with some aspects, such as the game's narrative, continuous reflection, and competition, which is directly linked with the recognition in the industrial organization, that occurs in awards, materials, or not. Beyond that, work contributes to personal motivation regarding fulfilling the goals pre-established by the company's sectors. Therefore, a study was carried out through bibliographical research that allowed the formation of the system and its instructional methods for employees. The design was developed on the Canvas platform and simulates the gamification system through interactive illustrations, using features to hold the employee's attention, such as pastel colors, simple language, and an assistant robot character. Moreover, as an example, the process presented a methodology called TOPS 8D (Team Oriented Problem Solution/8 Disciplines), showing how the evaluation can be elaborated. Finally, the developed model allows a more effective interaction of employees with their leaders and with the tools used in the industry, contributing to improving the level of training, adding value and giving it a qualitative scope, and avoiding wasted time with inadequate training.

Keywords: active learning, gamification, failure analysis, people engagement.

RESUMO
Este artigo propõe o desenvolvimento de um sistema de análise e prevenção de falhas que utiliza a gamificação como estratégia para o envolvimento dos empregados. Esta abordagem permite o envolvimento dos utilizadores em alguns aspectos, tais como a narrativa do jogo, a reflexão contínua, e a competição, que está directamente ligada ao reconhecimento na organização industrial, que ocorre em prémios, materiais, ou não. Além disso, o trabalho contribui para a motivação pessoal em relação ao cumprimento dos objectivos pré-estabelecidos pelos sectores da empresa. Assim, foi realizado um estudo através de pesquisa bibliográfica que permitiu a formação do sistema e dos seus métodos instrucionais para os trabalhadores. O desenho foi desenvolvido na plataforma Canvas e simula o sistema de gamificação através de ilustrações interactivas, utilizando características para prender a atenção do empregado, tais como cores pastel, linguagem simples, e um personagem robô assistente. Além disso, como exemplo, o processo apresentou uma metodologia chamada TOPS 8D (Team Oriented Problem Solution/8 Disciplines), mostrando como a avaliação pode ser elaborada. Finalmente, o modelo desenvolvido permite uma interacção mais eficaz dos empregados com os seus líderes e com as ferramentas utilizadas na indústria, contribuindo para melhorar o nível de formação, acrescentando valor e dando-lhe um âmbito qualitativo, e evitando o desperdício de tempo com formação inadequada.

Palavras-chave: aprendizagem activa, gamificação, análise de falhas, envolvimento das pessoas.

1 INTRODUCTION

The global workforce is slowly changing and giving room to the new generation. By 2030, about 75% of our global workforce is expected to be represented by generation Y (born between 1980 and 1997) (MONTES, 2017).

Thus, the current market must adapt to the new workforce that seeks independence, transparency, immediate gratification, and social connection.

In this way, organizations have attempted to improve the technological functions in supporting knowledge sharing among employees, identifying domain experts to facilitate access to specialization (YUAN *et al.*, 2007), and incorporating corporate social networks (LEONARDI, 2014).

Despite significant advances in knowledge management in the last decades, organizations are still struggling to improve the involvement of their employees in creating and maintaining it (HEISIG *et al.*, 2016; WANG *et al.*, 2014).

In an attempt to gain employee engagement, gamification emerged as a label fabricated for the intersection of the game with non-game-related elements and activities. A general definition of gamification is "The process of adding game mechanics to processes, programs, and platforms that would not traditionally use such concepts" (SWAN, 2012, p. 13).

The use of gamification to encourage people to participate in targeted activities is gaining the attention of academics and industry (DETERDING, 2011; SUH *et al.*, 2015).

Sarangi and Shah (2015) said that they are the elements rooted in the gamified process - a sense of shared purpose, challenge, and reward - that make it attractive and engaging, decoding the mechanics do the gamification work (RYAN *et al.*, 2013).

In this way, gamification creates significant scenarios to engage and reach the full potential of this new generation that is entering the market. It allows employees to feel involved by recognizing the same within the industrial organization.

It takes the way of awards and the immediate social recognition that the game has, with transparency prevailing and providing real-time feedback from employees and the team as a whole in meeting pre-set goals by the company's sectors. Thus, quantifying employee contributions, gamification helps to identify "who knows what" and "who contributes to what" (MASHHADI *et al.*, 2016).

Besides that, the new era of digitalization helps the employees see the methodological training changes as non-radical changes. It happens because, as said by Gangadharbatla (2016), the gamification of everything (ROLLAND and EASTMAN,

2011) responds to a general shift onto digital natives (BENNET *et al.*, 2008) that not only have grown with the internet and network technologies but that have been born into a world filled with digital games within the context of home and everyday life.

There are several tools available within the corporate environment, such as 5S, Failure Mode and Effect Analysis (FMEA), Root Cause Analyses (RCA), Fault Tree Analysis (FTA), and 8D methodology, which is used for fault investigation and analysis. One of those that stand out is Team Oriented Problem Solving - TOPS 8D or simply 8D, which was developed to be an auxiliary tool for understanding a fault-breaking phenomenon that results in the loss of function of a machine or process (Oliveira, 2017).

As quoted by Oliveira (2017), Tarartuch (2009) defines the methodology 8D (eight Disciplines) as a complementary methodology and simultaneously integrates all the methods that have proven most effective, introducing means that seek to ensure the manufacture of the products and that provide the protection to the client.

According to Rambaud (2011), the methodology helps improve products and processes and establishes a standard practice emphasizing facts that focus on the origin of the problem by determining the root cause.

From this, it is possible to apply gamification concepts in a tool as important as 8D, creating an environment with singular aspects, such as a game narrative, continuous reflection, competitiveness, teamwork, challenges, emotion, rewards, fun, and pleasure, which stem from the interaction between employees through healthy competition to make everyday tasks more exciting.

2 LITERATURE REVIEW

2.1 GAMIFICATION

Gamification is the practice related to the application of game mechanics in several areas of knowledge, such as business, health, social life, education, and, more recently, has been widely used in production processes as part of the generation and propagation of knowledge in organizations (PARAVIZO *et al.*, 2018; HAMMEDI *et al.*, 2017; ROCHA *et al.*, 2021; SUH and WAGNER, 2017; SARANGI and SHAH, 2015; HARMAN *et al.*, 2014; INSLEY and NUNAN, 2014).

Through the pillars associated with creating a game, the proposal to use gamification is related to increasing engagement, arousing people's curiosity, and, through the recommended challenges, achieving results, receiving compensation and recognition for the success achieved. The set of critical elements of gamification tasks,

level of progression, feedback, characters, multimedia elements, goals, objectives, punctuation, and reward are necessary for creating the application.

Burke (2014) defines gamification "is not just about applying technology to old engagement models, but about create new engagement models, targeting new communities of people and motivating them to achieve goals they may not even know they have." An important factor, given that, according to Anitha (2014), engagement can represent better performance and ultimately fulfill a company's goals.

Besides that, Freitas (2015) says that gamification has the power to shape behavior and have a positive influence on people's psychology (HAMARI, 2014; HERZIG, 2014; HERZIG *et al.*, 2012). With this, gamification can be understood as an integral technique in many applications since this approach could help achieve promising results when integrated into any application (KHALEEL et al., 2016).

For this, some authors refer to critical points for effective and engaging gamification; more specifically, to increase de success of implementation of a gamification system, it should consider the user profiles (MARACHE-FRANCISCO *et al.*, 2013).

2.2 LEARNING ORGANIZATION CULTURE

According to Jiménez (2016), if an organization's culture is oriented toward learning, and its structure permits collaborators to impact knowledge, the working force is more inclined to feel entrusted to learn.

Besides that, the author refers to an order to support knowledge creation: organizations have to harvest a learning culture that gives satisfactory conditions for employees to learn. This concept is a point in developing gamification systems, which can be sawn how these conditions.

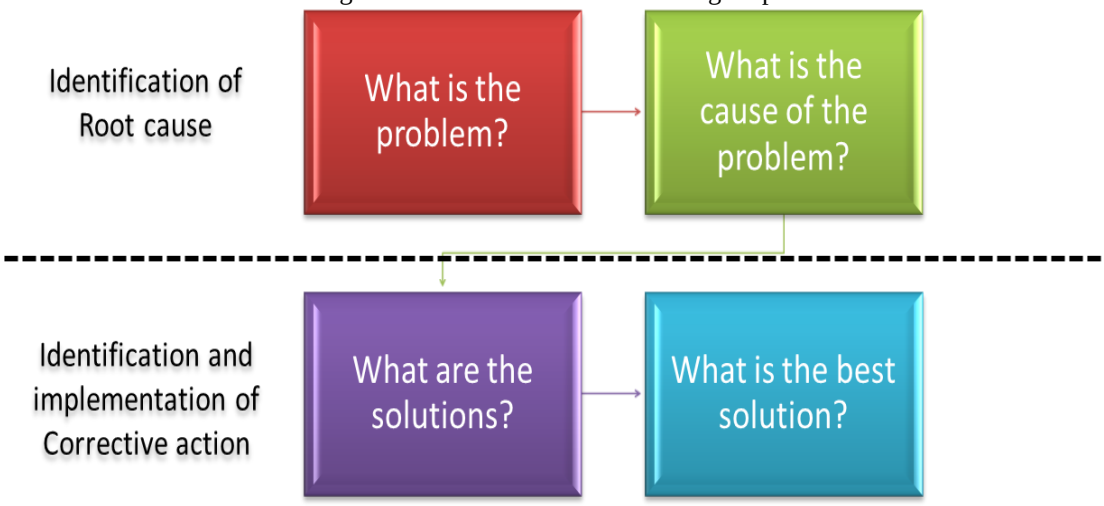
In this way, the learning through gamification allows the user to do things that they commonly do not like. An example from Groh (2012) is solving mathematical equations in the context of games, which is fun for many people, who disagree to denote the identical task as fun in the context of school, where most of the functions seem to be boring and repeating?

Thus, it is essential to confront the user with exciting challenges, which explain that the same conditions can apply to companies in the specific case of formal training.

2.3 METHODOLOGIES AND TOOLS FOR ANALYSIS AND FAULT PREVENTION

To attend to the complexity of production systems and constantly improve, many tools were developed specifically to analyze and prevent failures. These tools are the center of the proposed gamification model because training is supposed to happen to focus on then. However, the process of understanding a problem is related to the comprehension of how failures occur, as show in Figure 1.

Figure 1 – Root Cause Understanding Steps.



Source: Adapted from Oliveira (2017).

Oliveira (2017) indicates five technics (or devices) that can be used how good practices: 5S, Failure Mode and Effect Analysis (FMEA), Root Cause Analyses (RCA), Fault Tree Analysis (FTA), and Team Oriented Problem Solution – 8 Disciplines (TOPS 8D's) Methodology.

- 5S's: A set of practices that seek to reduce waste and improve the performance of people and processes through a simple approach that ensures the maintenance of optimal conditions in the workplace. Application of the senses of organization (*Seiri*), tidiness (*Seiton*), cleanliness (*Seiso*), normalization (*Seiketsu*) and self-discipline (*Shitsuke*). (INDRAWATI *et al.*, 2020; NALLUSAMY, 2016; SINGH *et al.*, 2014).
- RCA: Is the process of discovering the root cause of problems to identify the most appropriate solutions to implement. Root cause analysis can be done with a set of principles, techniques and methodologies that allow identifying the root cause of an event or trend. It is intended to show where processes or systems failed or caused a problem, in order to apply the most appropriate tools and methodologies to develop an

action plan that focuses on eliminating the causes of failures. (CHEN, 2013; GANGIDI, 2019; MAHTO and KUMAR, 2008).

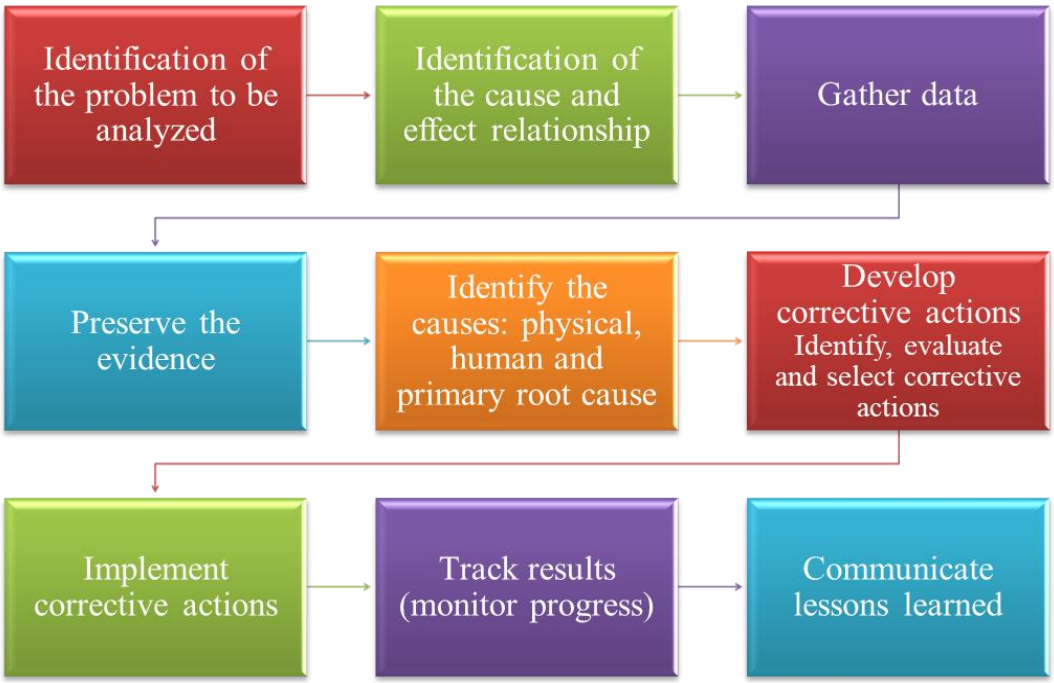
- FMEA: Analysis of failure modes and their effects is a technique used in identifying the modes of a system, product or process to provide guidance for eliminating or reducing the risk related to these failures. The methodology is carried out according to the following steps: 1. For each process input, determine how the process can fail, that is, identify the failure modes; 2. Determine the effect of each identified failure mode; 3. Identify the potential causes of each failure mode; 4. List current controls for each identified cause; 5. Assign severity (S), occurrence (O) and detection (D) degrees; 6. Calculate the number of priority risk (NPR - number of priority risk) through the equation NPR = S x O x D; 7. Determine recommended actions to reduce higher NPRs; 8. Implement appropriate actions and document the results; 9. Recalculate the RPN and start interventions at the highest values. (BRAAKSMA *et al.*, 2012; DOSHI; DESAI, 2017; OLIVEIRA *et al.*, 2019).
- FMECA: Extension of the FMEA study with wide application in terms of improving the reliability and maintainability of equipment and systems. It includes criticality analysis, which is used to assess the probability of failure modes in relation to the severity of their consequences. A methodology similar to FMEA, differing in data analysis. Criticality analysis (CA) can be quantitative or qualitative, depending on the availability of failure support data. The qualitative analysis is equivalent to that performed by the FMEA, culminating with the presentation of the NPR and acting according to its value. Quantitative analysis requires calculating the criticality (Cr) of each potential failure mode: Cr = F(t) x MF(t) x Pp(t). Where: F(t) - Probability of failure of each item; MF(t) - Failure Mode Rate; Pp(t) - Probability of loss. (MARQUES, 2007; SAMOPA *et al.*, 2017).
- FTA: Analytical and deductive technique where an undesired level (TLE - Top Level Event) is specified and analyzed considering all chain events related to system failures. Quantitative assessment provides the probability of occurrence of the top of the tree event, also enabling the precise identification of the root causes that most contribute to the failure of the system. The steps are: 1. System definition; 2. Tree construction; 3. Determination of minimum cuts; 4. Quantitative assessment; 5. Identification of the most important failure modes; 6. Conclusions and recommendations.

(KHAN and HADDARA, 2004; O'CONNOR and MOSLEH, 2016; WOJTASZAK and BIALY, 2016).

- 8 Disciplines: Eight disciplines, also known as team-oriented problem solving - TOPS/8D, aim to eliminate the practice of "putting out fire" that often happens as the product or service life cycle develops. It consists of a sequence of phases that must be followed from the moment the problem becomes evident. The stages of the method are as follows: Step 1: Create a team and work with it; Step 2: Describe the problem; Step 3: Implement and verify the intermediate containment actions; Step 4: Define and verify the root cause(s); Step 5: Choose and verify permanent corrective actions; Step 6: Implement permanent corrective actions; Step 7: Prevent the occurrence; Step 8: Congratulate the team. (BANICA and BELU, 2020; LABOVIC, 2018; SHARMA *et al.*, 2020).

The steps for studying the root cause of a problem are related to the correct identification of the problem, minimizing the effects and the adoption of the most appropriate tools and methodologies for the development of an action plan, as shown in Figure 2 (CINTRA and OLIVEIRA, 2021).

Figure 2 – Steps recommended for Root Cause Analysis Efforts.



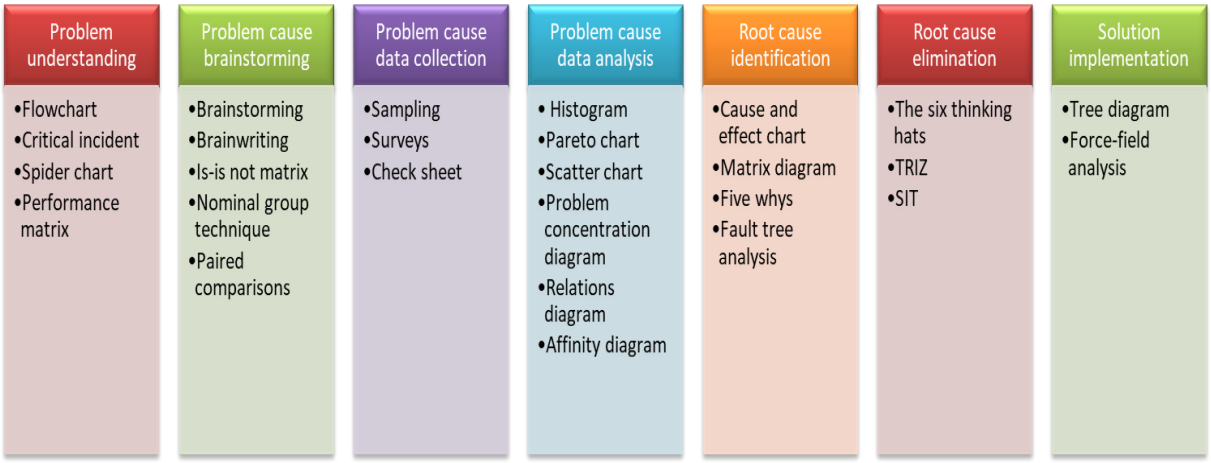
Source: Adapted from Cintra and Oliveira (2021).

Some of the benefits that the application of the RCA methodology brings are listed below:

- Saves time spent repairing failures, allowing time for improvement actions, in addition to improving the ability to solve problems;
- Improves reliability and maintainability, resulting in increased operational availability;
- Improves the quality of processes, products and services;
- Improves safety, occupational health and environment results;
- Prevents recurrence of the same failures in the future;
- Captures and maintains product and process knowledge in the organization;
- Encourages all areas/activities within the organization to continuous improvement;
- Identifies security concerns and increases customer satisfaction.

In general, problem solving should always be a disciplined activity in which Lean actions are only an important contribution in this process. This means that these are not the immediate answers for solving problems, since it is necessary to know which method or tool to use in each phase, and those presented in Figure 3 are just some of the most common tools available for use by the organization in its most different processes.

Figure 3 – Recommended Tools for Root Cause Analysis.



Source: Adapted from Oliveira (2017).

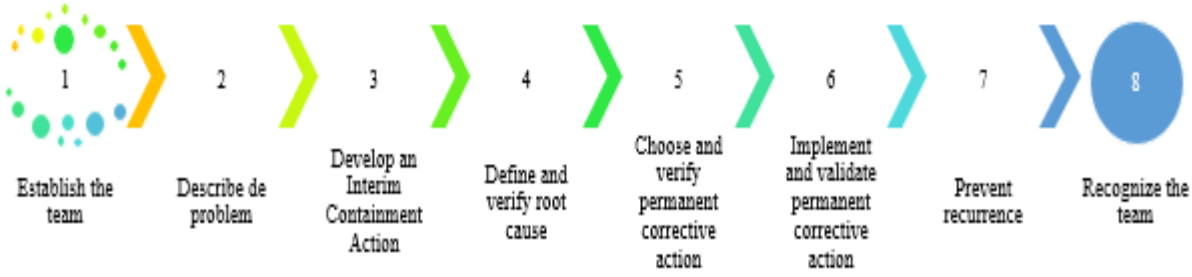
3 METHODOLOGY

The methodological procedure of this research consisted of using eight phases of the 8D methodology from the understanding of each step, through bibliographic research. The gamification process was built following each of the steps of the methodology.

To advance the phases, it is necessary that the previous phase has been completed, not being allowed to advance to the next phase without the conclusion of the previous phase. With this, the gamification process was created for training the engineering, production and maintenance teams of the organization, in order to understand and apply this methodology of analysis and failure prevention. Through the use of Canvas, the screens and other phases of the process were created.

The simulation uses initially, 8D methodology or Team Oriented Problem Solving – TOPS 8D (OLIVEIRA, 2017). The author also refers to 8D's as a tool developed to help the understanding of a phenomenon that results in function loss of a machine or process. Moreover, this method follows an application's sequence that can be sawn in the following Figure 4 and represents the sequence used in the gamification process design.

Figure 4 – TOPS 8D Methodology Sequence.

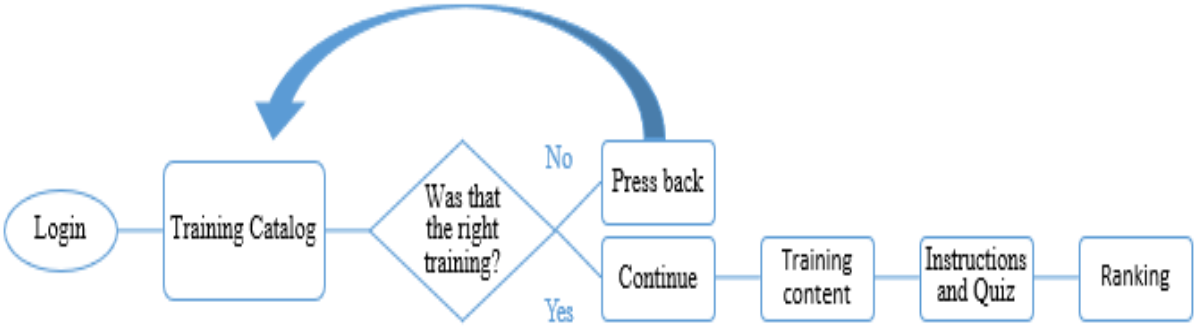


4 MODEL'S DEVELOPMENT AND ANALYSES

The gamification model was developed on the Canvas platform, a web tool used to create designs. This feature allows access to images, graphics, text, and forms models and provides the sharing of the completed designs in two versions: web (.PNG) and print (.PDF).

Beyond that, the system was designed in the "presentation" mode, simulating the actual size used in computers, and, finally, was provided in the formats (.PDF) and (.PNG), following the structure below (see Figure 5).

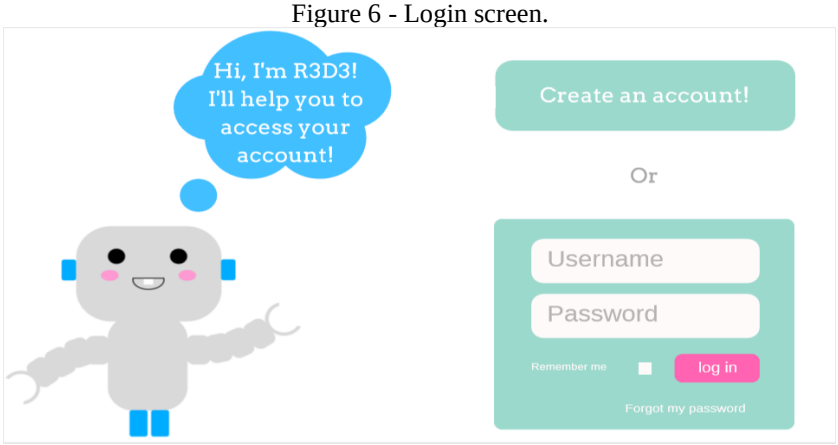
Figure 5 - Model's structure.



4.1 SYSTEM SCREENS

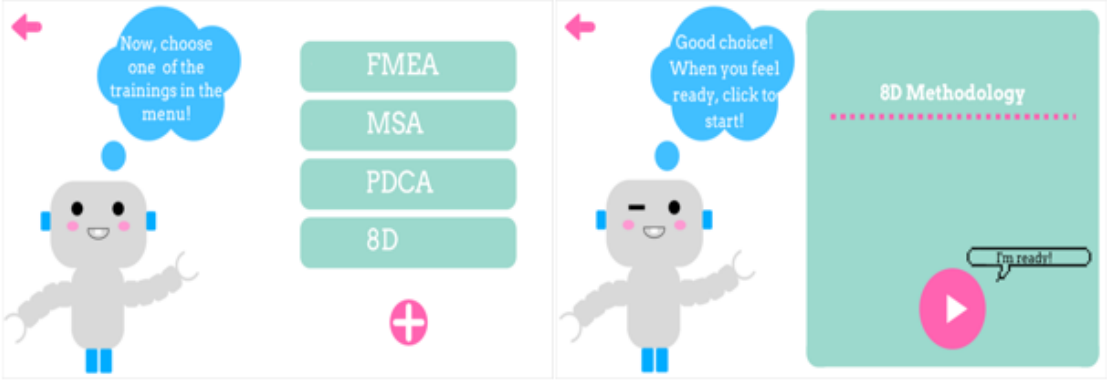
The first system screen represents the Login screen, where the user receives robot support, which indicates the steps that must be followed to access the learning game.

Figure 6 - Login screen.



The next screen shows the process started, where the user must choose what tool wants to learn. From the moment it chooses the application/training methodology, and has access to the confirmation screen (Figure 7).

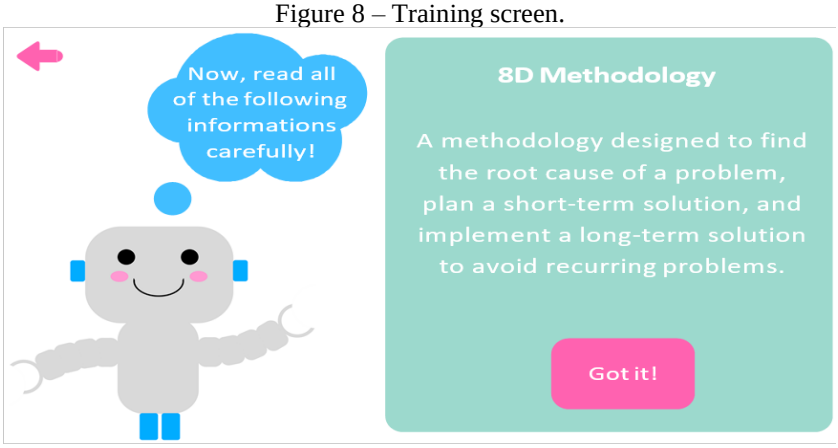
Figure 7 - (a) Initial screen and (b) Confirmation screen.



(a) (b)

Among several tools available for simulation, the user chose the 8D methodology, for instance, a method of analysis and resolution of problems composed of eight structured steps. Thus, the training starts showing the concept of the tool, as can be sawn in the following screen. The “Got it!” button allows the passage to the following concepts (Figure 8).

Figure 8 – Training screen.



The following screens allow the visualization of the eight disciplines studied in this gamification tool. For example, some of the disciplines are shown in the pictures below (Figure 9 to Figure 14).

Figure 9 - D1 step screen.

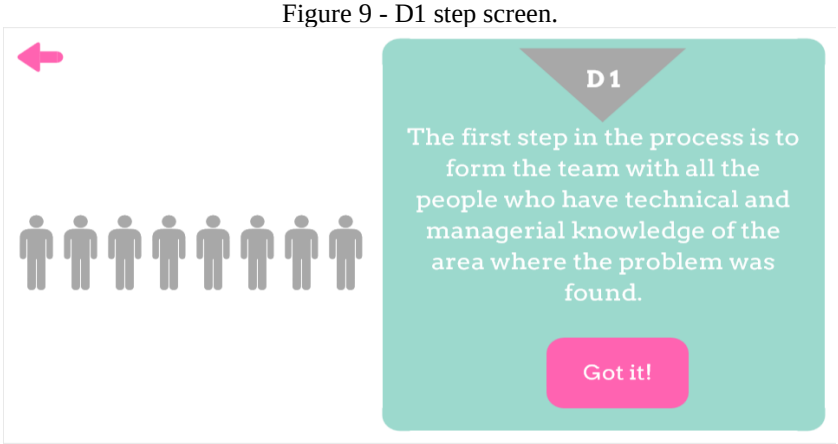


Figure 10 - D2 step screen.

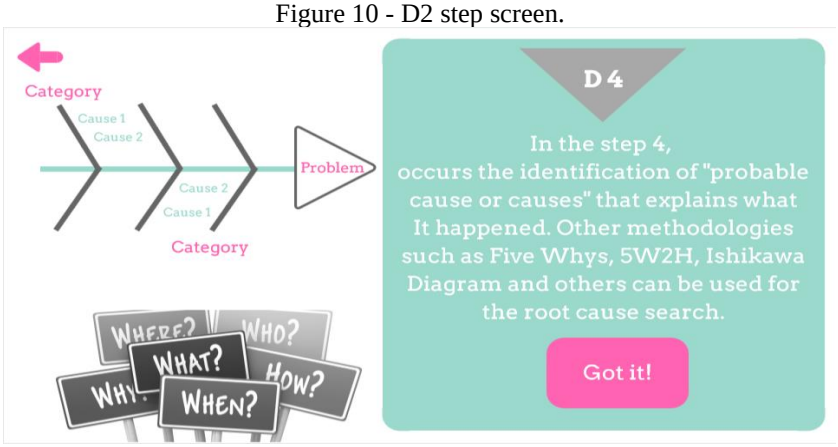
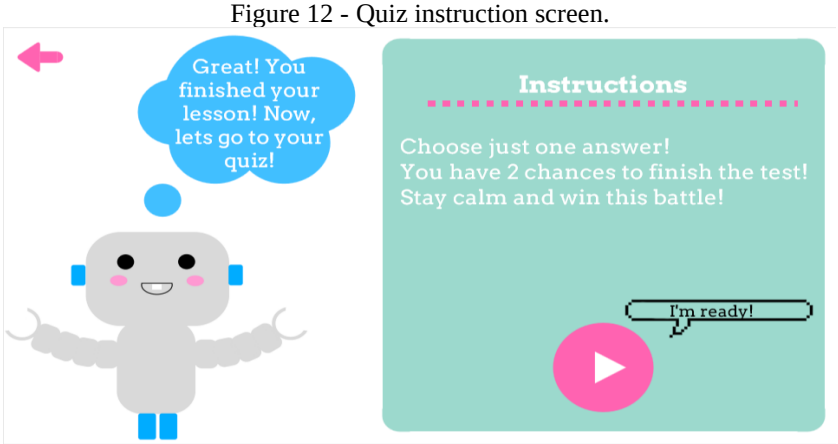


Figure 11 - D8 step screen.

After finalizing the training, the user has access to the Quiz screen to answer questions about the conducted training. The following screen brings basic instructions to complete this step.

Figure 12 - Quiz instruction screen.



At the end of the Quiz, the user has access to the Score screen, where the Quiz punctuation is displayed.

Figure 13 - Score screen.

This score is computed so that the user's Ranking can be fed with this information. When he clicks on the bottom right button (the medal), he can visualize his position among the other company collaborators. The next screen simulates this process.

Figure 14 - Ranking screen.

The presented gamification strategy is based upon establishing a competition among the company employees, which results in greater engagement, especially when coupled with bonuses and recognitions, whether material or not. Thus, the system does not approach gamification as an obligation, establishing rules and use limits, but rather as a way to drive continuous learning, bringing returns to both employees and the company.

In addition, the methodology has a unique approach that can be applied to many other tools, not particularly those focused on fault analysis and prevention, thus allowing the training of employees in several areas, such as ergonomics and human resources.

5 CONCLUSIONS AND FUTURE WORK

Considering the system based on gamification principles to analyze and prevention of failures that were proposed for this study, it was perceived that the structure used involves different mechanisms to improve the employee learning; with this, the engagement of the employees has the resources to be effective and brings back improvements to the organizations that use the created tool.

These mechanisms involve the combination of colors, presenting a continuity and harmony of tones on each screen of the process. The language used is often represented by signs colloquially, which brings the computer system closer to human speech, making communication more interactive.

The formation of a self-explanatory tool, which uses a robotic character to accompany the development through the training together with the employee transmitting security and support in cases of doubts to proceed with the proposed activity. In this way, the developed methodology allows the employee to train regarding the tools that can help him daily practically and interactively since the employee is no longer restricted only to formal training that happens at specific times and demand hours that could be destined for production.

Thus, the system reduces available hours for conventional training and adds interactive and continuous learning to the employees' daily routine, which is also aligned with the benefits destined for the best employees, increasing competitiveness and the consequent engagement of the organization's teams.

Moreover, the developed model has brought illustrations to be used in natural computer systems, which involve computers and physical ergonomic structures that meet the technical norms of safety and allow the employee’s comfort when using them.

It should be applicable to be integrated into a physical unit that is also ergonomically pleasant to the user, bringing privacy and comfort at the learning moment, besides presenting a strategic layout for easy access to the organization spaces.

Therefore, later work has the alternative of exploring the possible structures for the system installation and applying it in web development software such as Visual Studio, which allows the creation of computational platforms through the C # (C sharp) programming language.

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