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DEPARTAMENTO DE ENGENHARIA ELETROTECNICA
E COMPUTADORES (DEEC)

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Licenciado em Engenharia Eletrotécnica e Computadores

BUSINESS SERVICES CO-CREATION SYSTEM

MESTRADO EM ENGENHARIA ELETROTÉCNICA E COMPUTADORES
Universidade NOVA de Lisboa
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To my beloved grandmother.

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After all these years, and with two bachelors in the back, I can say I'm proud to finally reach this point in life and couldn't have done it without the support of the ones that came through my path. Firstly, I would like to express gratitude to the warm welcome that this institution gave me in the first bachelor and the continuation of the feeling of empathy by all the teachers who offered their knowledge and help and the colleagues who became friends along the way. And with the finish of this master, I would like to thank my thesis advisor, Ana Inês Oliveira, for all her help, time and knowledge that offered me to help develop this thesis and the times to push me to the finish line.

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Abstract

Over the years, the global market and industries have changed, and with that they must adapt in crescent pace to keep up with the surge of new businesses, new collaboration opportunities and with the necessity to appeal to new customers by engaging in innovative services. The shift from a passive role to a more active role in the business made them realize that the customer is an important source of knowledge and opinions that can revolutionize and offer better services, transforming all the process to a win-win situation. Establishing co-creation networks allows different types of participants, from stakeholders to clients, to share their knowledge and resources to enhance an existing product or create a new and innovative one.

This thesis has the goal to create a collaboration system, with the aim of supporting co-creation networks with the use of gamification elements. The game elements, such as points or achievements, will influence the actions of the system participants to make the experience more engaging and fun in co-creating solutions for new business opportunities or co-creating new services for an existing product. Therefore, a forum-type system is proposed, merging the notion of collaboration and gamification between the users to earn points and achievements, while engaging in friendly competitions to receive the rights to develop a new service, building this way a cycle of new products and services development while maintaining the sense of collaboration.

To demonstrate the feasibility of the proposed system, a software prototype was implemented and then tested. The system and its implementation have been validated through benchmarking, to select the most viable software to implement the proposed work, and validation using a case study from a real-life project to simulate its operation and how it would help in that case.

Keywords: Collaboration, Collaborative Networks, Co-creation, Gamification

Resumo

Ao longo dos anos, o mercado global e as indústrias começaram a mudar e sentem a necessidade de se adaptar num ritmo crescente para acompanhar o aumento de novas oportunidades de negócios e de colaboração, e com a necessidade de atrair novos clientes com serviços envolventes e inovadores. A mudança de um papel passivo para um papel mais ativo do negócio fez com que percebessem que o cliente é uma importante fonte de conhecimento e opiniões que pode revolucionar e oferecer melhores serviços, transformando todo o processo numa situação vantajosa para todos. Estabelecer redes de co-criação permite que diferentes tipos de participantes, desde stakeholders a clientes, compartilhem os seus conhecimentos e recursos para aprimorar um produto existente ou criar um novo e inovador serviço.

Esta tese tem como objetivo criar um sistema de colaboração, diferente dos que existem, com a utilização de elementos de gamificação. Aqui, os elementos de jogo, como pontos ou conquistas, influenciarão as ações dos participantes do sistema para torná-los mais envolventes e divertidos para co-criar novas oportunidades de negócios ou para criar novos serviços para um determinado produto. Assim, é proposto um sistema tipo fórum onde se junta a noção de colaboração e gamificação entre os utilizadores para ganhar pontos e conquistas, enquanto entram em competições amistosas para receber os direitos de desenvolver um novo serviço, construindo assim um ciclo de desenvolvimento de novos produtos e serviços em que é mantido o sentido de colaboração.

Para demonstrar a viabilidade do sistema proposto, um protótipo de software foi implementado e testado. O sistema e a sua implementação foram validados por meio de benchmarking, para selecionar o software mais viável para implementar o trabalho proposto, e validação usando um estudo de caso de um projeto real para simular sua operação e como o sistema iria ajudar na escolha da solução.

Palavras-chave: Colaboração, Redes Colaborativas, Co-criação, Gamificação

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List of Acronyms

B2B	Business-to-Business
CMS	Content Management System
CN	Collaborative Networks
CNO	Collaborative Networked Organization
ERD	Entity Relationship Diagram
ICT	Information and Communication Technologies
IoT	Internet of Things
PMS	Performance Management System
SDL	Service-Dominant Logic
SRS	System Requirements Specifications
VBE	VO Breeding Environment
VE	Virtual Enterprise
VO	Virtual Organization
UML	Unified Modeling Language

1 Introduction

In this initial chapter, it's introduced the problem that this research work wants to study and understand. An initial background is explored, focusing on the growth of the business services and the role of the customer nowadays. Contextualizing the background, it's verified the inherent problem and it's suggested a method to improve/solve it using gamification. At the end, a synthesize of the structure of this document is presented.

1.1 Background

The need of satisfying the customers and meet their expectations is the most important factor in the market, where enterprises try to create new products or develop even further the current ones. The competition between each organization grows each passing day, where it's necessary to adapt different methods and create new systems where all participants can share their knowledge and experiences with the products, (Oertzen et al., 2018) allowing for the business to grow and evolve.

Because the customers are demanding for products with better quality, the access to services that allows them to interact with the business and create business services regarding customer service will give a competitive advantage inside the business market (Teixeira et al., 2012). If it's included the co-creation or co-design of services, for the customer perspective it will increase the value of the product and the services being developed around the product. The development of business services has grown through the use of ICT, where it is possible to connect manufacturers with service providers or connecting manufacturers directly with the customer (Evangelista et al., 2013). The focus of the business services is to enhance or improve the product, and they can focus on multiple services like Marketing, Engineering, Logistics and Designing, depending on the type of product.

Through co-creation/co-design, these services are designed by various stakeholders to meet the customers' needs or requirements (Bel, 2006; Oliveira & Camarinha-Matos, 2014a). The involvement of customers in the product innovation can bring many opportunities to the business such as an increase in revenue or improving its performance, but it comes with other factors such as the establishment of rules between the parties in a way to solidify their trust and share the risks, so there isn't only a side that takes all the loses. This type of commitment may have an impact on the duration of the product life cycle while it's being developed and researched by a consortium composed of manufacturers and stakeholders/customers (Luis M. Camarinha-Matos, Ferrada, et al., 2013).

In this context, the role of the stakeholders/customers gained a new meaning and evolved from a passive role to a more active role, where some firms, like Spotify or Uber, gave their customers the possibility of helping to develop services that meet their needs (Bel, 2006), where the customer is, generally, the final step of the chain, and so they have a better comprehension regarding the quality of the product. Thinking that manufacturers/suppliers interact with customers, they may engage in the process of value creation, which most of the time may result in the creation of new services (Gummesson & Mele, 2010). Thus, it becomes a co-creation network.

A co-creation network is a network made by various stakeholders (manufacturers, customers, and members of the customers' community) where they share their knowledge and resources with the goal of co-design innovative and value-added services for products when it's necessary or there's a new promising business idea to implement (Luis M. Camarinha-Matos, Ferrada, et al., 2013). Then, the network is formed, and the participants gather up to do a brainstorming discussion, where new ideas of services are developed and created (Oliveira, 2010). After a decision regarding the service is made, the development and testing operations starts, using a support environment where the participants can share their opinions/knowledge and offer support. Afterwards, with the finished service, it's made an agreement between the participants where the final service meets the needs of the customers and is then launched to the public (Oliveira & Camarinha-Matos, 2014a).

1.2 Problem domain and Motivation

Nowadays, the concept of co-creation is made through personal connections in building a new team and already knowing their clients, and sometimes there are situation where the business isn't appealing enough to the customer to help them, so what is a possible solution that may help go around this problem?

One tool to help in value co-creation can be gamification (Nobre & Ferreira, 2017). Gamification is the process of using game elements in a non-game context to make the non-game context more engaging and entertaining (Harwood & Garry, 2015; Nobre & Ferreira, 2017; Patricio, 2017; Wood & Reiners, 2014). According to Finances Online, almost 2.6 billion people played video games in 2020, regardless of the platform, and year by year it increases even more (Online, 2020). The gaming industry is one of the biggest industries that exist in the world and supports every type of technology from mobile, like smartphones or Nintendo Switch, to more robust ones like PlayStation or Xbox, each with its advantages and disadvantages. The dimension reached by this sector relies on the fact that it's now possible for people to interact with each other through games. In the

online world, it is possible to develop huge gamer communities and build forums where they talk with each other, help new players or discuss problems inside the game they are playing. This kind of view makes it possible to be adapted in the co-creation of business services and using game elements may help build a big community and distribute rewards depending on the tasks solved.

Trying to unite the notion of gamification to co-creation of business services can have its opening of possibilities or it may fail, because it depends on the stakeholders' will and motivation to interact with a new type of system and which type of benefits it may bring to them. Using gamification is a way to propose a sense of joy and fun into mundane tasks and submit customers and suppliers to new experiences (Nobre & Ferreira, 2017). Gamification has room to grow and according to a speculation made by IEEE in 2014, almost 85% of the daily tasks will include game elements by 2020 (Patricio, 2017). Because games are growing side by side with technologies, it doesn't have restrictions regarding the software for computers or smartphones. It's best to not only focus on the game elements but see as a whole where the experience for the users can be rewarding and see the psychological or behavioural effects it may have on the social interaction between different parties (Patricio et al., 2020). It's possible with the correct approach to strengthen the process of collaborative innovation reaching new services, taking care of the customer needs, and allowing for a common ground where communication is facilitated and it's possible to keep in touch with new opportunities upon reaching the goal. There are plenty of people that want to arrange a new service or try to help/suggest new ways to improve and build a system that integrates this feature while rewarding the players, it can be a plus to building a better relationship.

Research question:

How the integration of gamification in a collaborative environment may help stakeholders engage in a co-creation process?

Hypothesis:

The integration of gamification into a collaboration system will help to create a positive impact in the system's participants and make them more engaged in continuing to find new co-creation opportunities through gamification, where they are rewarded game elements like points and achievements.

1.3 Objectives

The proposed idea is to use the concept of gamification as a platform for the creation of innovative business services through co-creation, to drive the participants' collaboration and engagement in innovation processes. Although it is necessary for the process of gamification to be properly implemented on the risk of being deemed to fail to meet the business objectives, due to poor implementation or a design that doesn't attract the users (Patricio, 2017). In a first instance, it's necessary to find a business opportunity. A quick way to show the availability of opportunities can be through forums, where people have free access to communicate with each other and post requests for collaboration. Using a similar approach to Kaggle[1], all the requests are listed and have their requirements uploaded at the same time, as with their reward. Afterwards, the competition begins where simultaneous teams can join and dispute the final reward. The "posters" must keep a constant watch on the solutions being provided by the teams to select one. Upon reaching the deadline, it is selected the winner and it proceeds

[1] Kaggle (https://www.kaggle.com/) is an online community that focus in data science and machine learning, where everyone can gather to discuss data sets, learn how to code and model data and host competition.

to the development of the idea/service in cooperation. The winner receives a game type reward, besides the real reward. The runners-up until the 10th place receive a lower-tier reward, regarding the place they ended up, where below receives an equal lowest tier reward. Independent of the results, it shows where they ended in different competition/opportunities.

Reaching certain goals or tiers, rewards an achievement, e.g: "Participation in 10 competitions", or "Reach one of the three first places in a competition". The amount of achievements can be multiplied by enabling the teams to achieve the same goals multiple times. Regarding the victorious team, they will engage in co-creation with the customer and proceed to brainstorms where they can refine the idea suggested by the team, until the end of the contract established.

Afterwards, the team receives an extra bonus, like points or badges, where each of the participants can show when they engage in other opportunities, showing their involvement with small and personalized badges, recognizing them for the number of opportunities they engaged as a team or as an individual representing other team.

It's proposed to build a prototype of a forum where the purpose is to connect the different stakeholders (customers, manufacturers, suppliers) to integrate a large community where they can share their knowledge and assets, while designing a gamified interface where it's possible to see different statuses like an experience bar, leader boards in several competitions, and the badges collected individually or as a team.

1.4 Structure

Regarding the structure of the present document, it will be divided six chapters which are:

- Introduction - The first chapter of this document, the main problem is introduced, with a small background and describes the contextualization of the research to solve the problem and the motivation around it.

- State-of-art - The second chapter will focus on the main points about the stated problem, and it will be separated concepts and briefly explained, and how they are related to the proposed work.
- Co-creation System Specifications - The third chapter will study the specifications of the system, starting with defining functional and non-functional requirements and then, to show in a more visual way, the structure using a class diagram, and the behaviour of the system using a use case diagram and flux diagram. With all these defined, it will be constructed a conceptual architecture for the system.
- Co-creation System Implementation - The fourth chapter will focus on the implementation of the system, beginning with research of some of the software available in the market, ending in the system's implementation with one of them.
- Thesis validation - The fifth chapter will have the thesis validation, where it will be validated all the implemented work in the system, through a benchmarking to show why the software used was chosen from a number of specific characteristics and then, a simulation of a operation using a real case to demonstrate the utility and usability of the system.
- Conclusion and future work - In this final chapter, it will be discussed the conclusions regarding the system and to check if it followed the specifications and reached that target and propose future work to be made on the system that can help make it better.

2

State-of-the-Art

In this chapter, several concepts that are important to the development of the proposed research work are introduced. The collaborative networks, focusing on their origins and their main goals, it's the starting point to understanding the basis and organization of rules and procedures of virtual organizations breeding environments. Afterwards, the notion of co-creation, being one of the most relevant areas, to understand how people come together to create and implement new and innovative ideas. In this line, the notion of business services is another important aspect to refer. Another important area to mention is gamification, which is where the focus will be, to see how it can help to obtain new results in the process. Therefore, this chapter includes relevant research and discussion on the relevant background areas, to understand how they are related to the objective of this work.

2.1 Collaborative Networks

With the increase of complexity with the customer's needs, it's necessary to align the business to target them. The creation of a CN, where different organizations work together to reach a common goal, by combining their major skills and core competencies (Romero & Molina, 2009) will help reaching the business necessities with new service methods. There are different forms of CNs, like virtual organizations, virtual enterprises, dynamic supply chains, etc., where each of these

have different behaviours and interactions (L.M. Camarinha-Matos & Afsarmanesh, 2012; Luis M. Camarinha-Matos & Afsarmanesh, 2008; Chavarría-Barrientos et al., 2015). A CN is defined by an alliance of a variety of entities, where each one is largely autonomous, geographically distributed and heterogeneous in terms of their activity, culture, social capital and goals, where they collaborate to achieve a common goal, being supported by digital means (Luis M. Camarinha-Matos & Afsarmanesh, 2008). It's possible to divide the notion of CN into two parts referencing their objectives, their timing and which type of actors can involve. One of them is a CNO, which is the most common form of a CN, where there is organization of its structure in which the definition of the participating actors' roles is established and the rules they must follow and compromise with. The other form is a more spontaneous form of collaboration normally doesn't present a defined structure or organization called ad-hoc collaboration (L.M. Camarinha-Matos & Afsarmanesh, 2012).

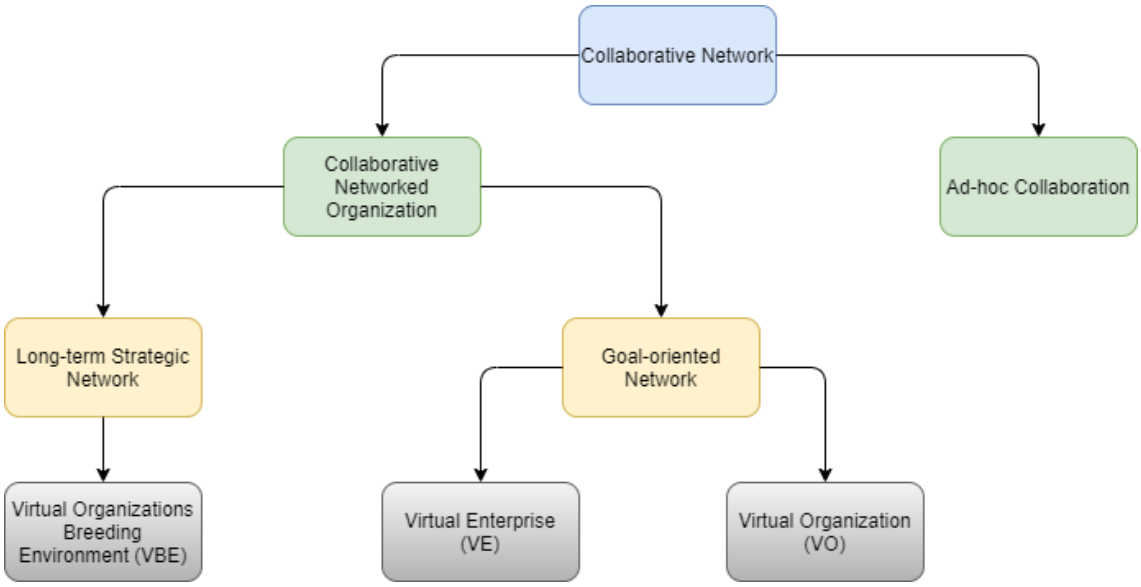

Figure 2.1 - Simple Taxonomy of Collaborative Networks adapted from (L.M. Camarinha-Matos & Afsarmanesh, 2012).

Although there are other examples of long-term strategic networks and goal-oriented networks, the ones shown in figure 2.1, will be the focus on the concept of co-creation, where they can engage between each other too. In goal-oriented networks, there will be two possible formations: VE or VO.

A VE is a representation of a temporary alliance of enterprises that group up and share their technologies and knowledge to quickly respond to business opportunities when they appear, supported by digital networks (L.M. Camarinha-Matos & Afsarmanesh, 2012; Luis M. Camarinha-Matos et al., 2009).

A VO has a similar concept to a VE, where independent organizations share their resources to achieve a common goal, not being limited to an alliance of oriented enterprises. From this definition, it's possible to conclude that a VE is a particular case of a VO.

In long-term strategic networks, the goal is to offer a solution when a business opportunity appears through the organization of a small consortium that will approach the opportunity with their own resources and skills. For this to happen, is necessary to search for partners that are open to gathering and have the readiness to reach a cooperation agreement, to be able to adopt common principles and infrastructures and built with the trust of each participant. This is the notion of a VBE (Hamideh Afsarmanesh & Ermilova, 2010; Romero & Molina, 2011).

As such, a VBE is the founding stone to allow its cooperating member organizations to guarantee a high level of preparedness to establish a VO when a business opportunity appears.

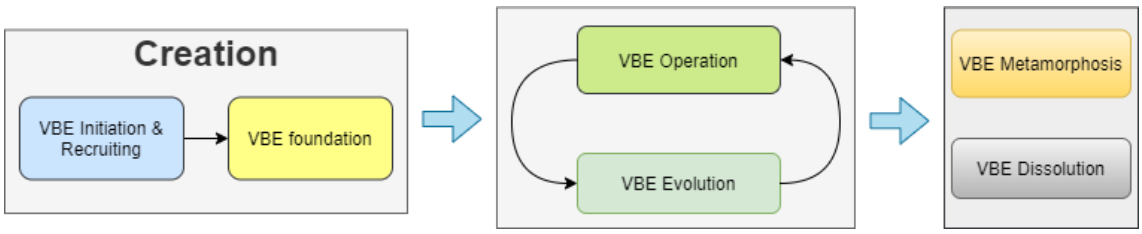

Figure 2.2 - Life cycle of VBEs adapted from (Hamideh Afsarmanesh & Ermilova, 2010)

The life cycle of a VBE is mainly composed of three steps, as shown in figure 2.2, which are:

- *Creation phase* - the creation of the VBE through the selection of partners and the organization of the network strategic planning (VBE Initiation & Recruiting) and after, the process of founding it where it's completed the registration of the founding members, the creation

of necessary databases and deployment of the necessary administrative tools (VBE foundation).

- *Operation phase* - the working phase of the VBE, where it's possible to occur a process of evolution (changing roles between the members, new operating principles). This phase is where most of the life cycle VBE is, until it reaches the last point.
- *Dissolution phase* - the VBE decides to dissolve and pass their current knowledge and assets to other organizations.
- *Metamorphosis phase* - the VBE can evolve to another type of organizational structure.

Normally, after a VO accomplishes its goal, it's dissolved, but in the case of a VBE, due to the amount of knowledge obtained, resources used and obtained, it's unusual the process of dissolution (Luis M. Camarinha-Matos et al., 2009).

2.1.1 Reference model

To model a collaborative network, which is a complex system involving different factors, a proper framework is necessary to understand its complexity. There are some modelling frameworks used by different authors such as GERAM and SCOR, mentioned in (L.M. Camarinha-Matos & Afsarmanesh, 2012) that focus

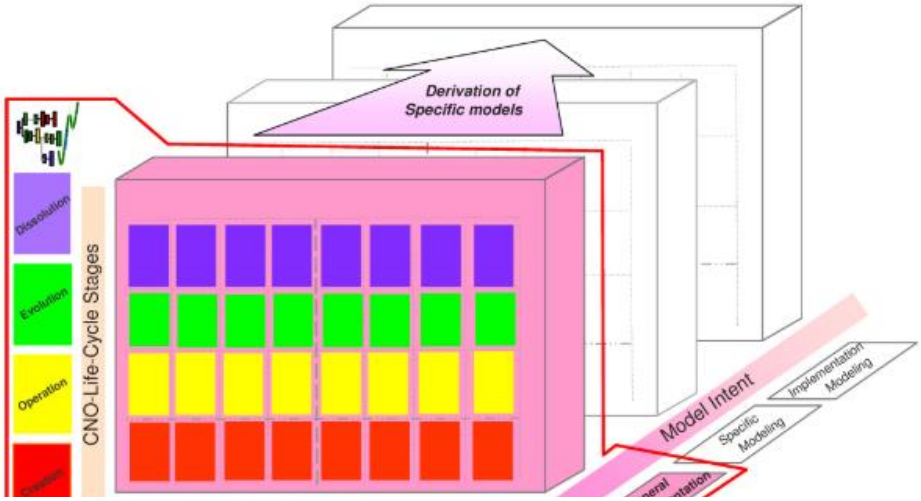

Figure 2.3 - Reference model in the ARCON framework context from (H Afsarmanesh, 2008)

on different types of CNs, and include new modifications to the one previously studied.

Regarding the development of new models for CNOs, it's necessary to have a more generic approach where all the base concepts, principles and recommended practices are arranged and organized to be easier to understand. Thus, the ARCON (A Reference Model for Collaborative Networks) was developed within the ECOLEAD project (H Afsarmanesh, 2008; Luis M. Camarinha-Matos & Afsarmanesh, 2008).

This reference model considers internal (Endogenous Elements) and external (Exogenous Interactions) aspects related to CNOs and offers a 3-dimensional perspective for the modelling, shown in figure 2.2.1.

Therefore, the development of a model should be characterized by some important attributes, such as its simplicity (easy to understand, clear and purely logical), showing a comprehensive capture of the unifying concepts (addressing the CNO in its entirety) and neutrality (independent of any tools or methodologies that can further model other aspects of CNOs and/or against the model) (H. Afsarmanesh & Camarinha-Matos, 2008).

The perspectives of ARCON are the following:

1) **Life-cycle perspective** refers to the 4 main stages of the CNO: *Creation*, *Operation*, *Evolution* and *Dissolution*, as is the example of figure 2.2 for VBEs.

2) **Environment characteristics perspective** focusing on the logical characteristics surrounding the CNO, internally and externally. The internal ones are the *Endogenous Elements*, and the external ones are the *Exogenous Interactions*.

Focusing the *Endogenous Elements,* mentions the integration of elements inside CNs and are defined in 4 dimensions:

- **Structural dimension -** refers to the structure or composition of the constituting elements of the CN in terms of its participants, the roles they perform and their relationships.
- **Componential dimension** - focuses on the individual tangible and intangible elements of CN in different resources (human resources,

software and hardware resources, knowledge, and information), and the description of knowledge and Information.

- **Functional dimension** - focuses on the "*Operation phase*" of the CN life cycle, showing all the "base functions and operations" being run at the network and time-sequenced flows of processes.
- **Behavioural dimension** - addresses all the principles, governance rules and policies that drive or limit the behaviour of the CN and its participants over time.

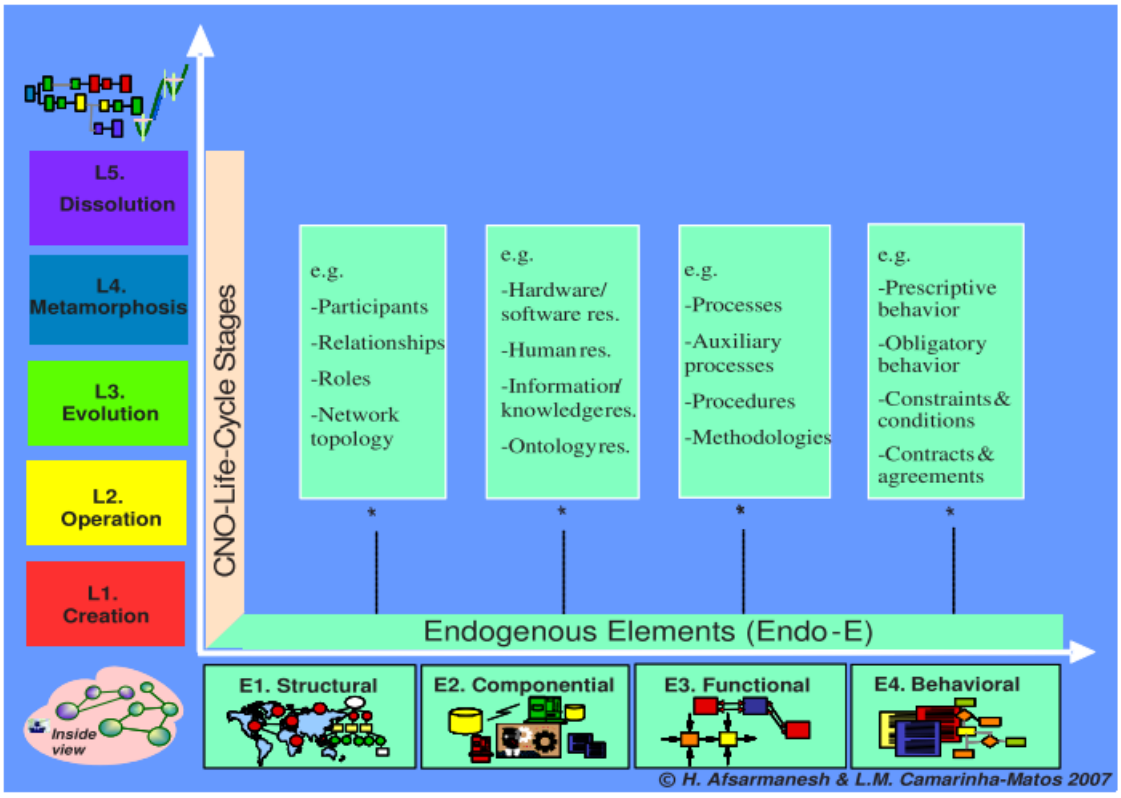

Figure 2.4 - Relation between CNO life cycle and the Endogenous Elements perspective from (H. Afsarmanesh & Camarinha-Matos, 2008).

In the external perspective, which are the *Exogenous Interactions*, it captures all the aspects of the interaction between the CN, as a whole, and the surrounding environment it's in (H Afsarmanesh, 2008).

These are also defined in 4 dimensions:

- **Market dimension -** addresses the interaction with "customers" and "competitors", such as transactions, marketing, etc.
- **Support dimension** - focuses on the services being supported by third party institutions.
- **Societal dimension** - focuses on the relations between the CN and the society in general, aiming to model the interactions and impacts the CN will have on society.
- **Constituency dimension -** relates to the interaction with potential new members of the CN. General issues like sustainability of the network, attraction factors are considered here.

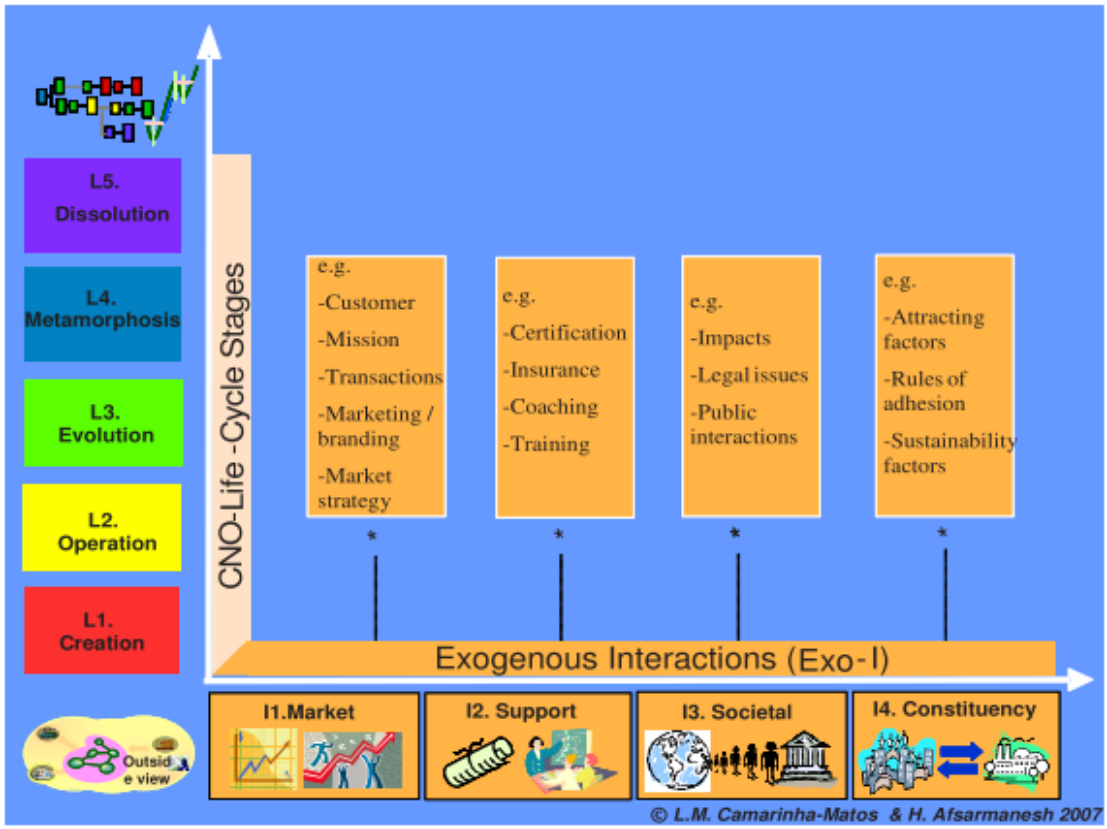

Figure 2.5 - Relation between CNO life cycle and the Exogenous Interactions perspective from (H. Afsarmanesh & Camarinha-Matos, 2008).

3) **Model intent perspective** allows to model CNOs in different levels of abstraction. It's considered three levels in ARCON:

- **General concepts level -** Includes most of the general concepts and related relationships, common to all CNs independently of the application domain.

- **Specific modelling level -** It's where the details of modelling different classes of CNs are focused.
- **Implementation modelling level -** represents models of concrete CNs.

As such, ARCON simplifies the understanding of CNs and provides a systematic basis for modelling new CNs (Luis M. Camarinha-Matos et al., 2009).

2.1.2 Performance indicators

The creation of VOs or VBEs can involve several steps to have some sort of control and organization among its members, so having a system where it's possible to manage the services inside the VBE makes the process more fluid. (Luis M. Camarinha-Matos et al., 2015; Luis M. Camarinha-Matos, Macedo, et al., 2013) proposed a VBE Management System, providing all the support for the management issues inside the VBE from admission/withdrawal of members, the member profiles and competencies, network performance management, to more advanced points such as services to help increase the life cycle of VBE, and functionalities for managing trust values among the members and balancing their value systems.

This work will be focused on performance indicators. The idea is to keep a detailed profile of the VBE members through a service to help in the preparation for future collaborations.

To start with an example, a PMS, according to (Sahu et al., 2014), it's meant to be an interactive system that simplifies the process of business strategies, to help achieve the performance objectives inside a company. This will help the employees succeed at the same time the company succeeds in their goals. Modern PMS focus on the management of human resources and help them grow through constant monitoring of individual and team performances and giving rewards based on their performance.

Although, this system can help with growth and goal achieving, there can be some unintended consequences, like selective attention or illusion of control (Franco-Santos & Otley, 2018), so it's necessary to be moderate and not use it in

an abusive way, misleading or promoting "evil actions" such as information manipulation or ethics abuse.

Nevertheless, it's important to establish trust between the users and the system, to help them grow and check for their plus points and not make them feel cheated by the system and create a sense of control by the organization (Kakkar et al., 2020).

The management of these performance indicators may help to reach a better conclusion in which a team or individual can be selected for a determined opportunity.

2.1.3 Co-Creation Networks

When the VOs or VBEs are established and they are ready to tackle a new opportunity of business, it's necessary to maintain a good relationship between its participants (e.g., stakeholders, members of the organization, customers). So, these types of CNOs show high potential as drivers of value co-creation where the organisations can share risk, resources, and knowledge. Besides, collaborative networks induce innovation, and can originate the co-creation of new sources of value (Romero & Molina, 2011). Besides this, the creation of new products and/or services allows for the parties to interact with each other through social interaction and the action of purchasing the product. The idea behind creation is not only to give birth to something, but to understand it and give it a meaning. According to (Ind & Coates, 2013), the meaning of a product is always co-created. The thought of togetherness is implicit in the creative processes and the needs of the stakeholder.

The notion of co-creation wants to move away from being associated only products. This shifting from a product-dominant business market to an SDL one has been investigated by (Lacoste, 2016), focusing on sustainability in value co-creation in business-to-business; (Hein et al., 2019), refers to how IoT platforms

in B2B can embed practices of value co-creation and (Blaschke et al., 2019) tries to complement the design of digital value co-creation networks employing SDL.

Firstly, most businesses use goods-dominant logic, and it works in the following order: firms embed value in goods and value is then added through Improvements on the attributes of the product, where customers take a passive position. Shifting to an SDL, changes the role of creating value from the supplier to a customer-driven process, where the supplier and customer work together within each other's processes.

According to (Lacoste, 2016), the value of the product will be created by the customer depending on its level of engagement. Showing how the suppliers and the customers interact with each other in the creation of value, can increase the sustainability of said business.

(Hein et al., 2019) had a similar approach as (Lacoste, 2016) in B2B systems and they focus on understanding how services platforms of B2B can foster value co-creation. They adopt the notion of service ecosystem where all the different actors are connected through services that foster mutual value creation and shared institutional logic. But to have a functional ecosystem it's necessary to supply structural flexibility and structural integrity. Therefore, a service platform will help facilitate the exchange of information and resources between the actors as long there are transparency regarding their members, their knowledge, and their capabilities, seen from an SDL point of view.

(Ramaswamy, 2002) suggests that consumers are challenging the corporate logic of value creation and shows all the advantages of a company co-creating value together with their customers, trying to change the idea of the customer taking a passive role to a more active role through analysis of elements of exchange (transactions, choices, consumption experience, price, and performance) affect, positively or negatively, customer experiences and discovering improved ways to create value. So, it’s necessary to engage the customer and operate in a networked environment that is possible to learn continuously about the wants and needs of people and interact with them in ongoing exchanges of values. The process is divided into four blocks for co-creating value: **Dialogue**, for the

knowledge sharing and understanding between companies and customers; **Access**, challenging the notion of ownership, and giving access to the customers allowing them to experience value; **Risk Reduction**, due to consumers becoming co-creators, they need to be aware of the risks and gain more responsibilities for these; and **Transparency** of the information being given, where it's necessary to create trust between parties.

In (Oliveira & Camarinha-Matos, 2014a), it suggests an improvement in designing new business services which were developed in the context of the European research project GloNet. The collaboration among the manufacturers, including the customers, helps create new ideas for business services or solutions needed to solve problems. The networks developed in a collaboration environment will help design and provide business services based on innovation, customer orientation and knowledge, through collaboration between the several stakeholders. It's suggested two concepts: business services and service design, and the system design promotes the co-design of business services to enhance physical products.

(Romero & Molina, 2011) elevates the role of the customer as value co-creator, referring to customer communities where they have experience in handling products and/or services, and exchange between each other personal opinions and news about their products, so they learn from other experiences and obtain Information for buying decision-making. Some of the roles that the customer can play are:

- Co-designers - It involves the customer's participation in the conceptualization of an idea and the design and testing of the same Idea. The customer will have a continuous relationship with the development of the product, seeking specific outcomes or services to engage in the co-production
- Innovators - Instead of companies trying to guess the customers' needs, they give toolkits to the customers to help design and develop their own ideas of products and services.

- Marketers/branders - the customer have a big paper in "branding" the product, where they talk to other potential customers or announce it via Internet (social networks, podcasts, blogs).

To sum up everything that has been stated regarding co-creation, the customers will have an important role in the design of products or services for the existing ones. It can help improving the value in the creation, targeting the necessities of the customers. This way allows the customer and producers to have a deeper relationship and understand each other in how to meet their needs and share knowledge and impressions.

2.2 Gamification

Gamification is the use of game-design elements and game rules in non-game context, in a way to improve user engagement in an activity (Wood & Reiners, 2014). This term started gaining popularity since 2010, although it was mentioned years earlier.

According to (Wood & Reiners, 2014), the addition of game elements into common tasks and/or processes have the objective of increasing the motivation of the users to succeed in these tasks. Therefore, it's integrated a combination of "building blocks" into the design and structure of a given process, incorporating game elements. The interaction between process and user will be more fun and engaging and influence the user's behaviour to keep motivated and try to surpass the "next level". This behaviour can be researched in behaviour and psychology areas to understand the user's motivation and their reactions to stimuli, relying heavily on the levels, duration, frequency, and recency of all its interactions.

Gamification can be used in different areas to promote and encourage certain behaviours in its users. There are some examples like Nike or Pokémon Go, promoting health with trackers in physical activity; Duolingo, engaging people in learning new languages through friendly competitions with each other and getting achievements; or Starbucks, with a loyalty system to get prizes.

To make a system more engaging and entertaining, it's necessary to think carefully about how to use gaming elements, becoming challenging to try to implement an intelligent use of these elements. With the example of figure 2.6, some of these elements can be:

- **Points** - basic elements of several games, where they are rewarded upon completion of specific tasks and represent the player's progress. The most important purpose is to offer feedback.
- **Badges** - visual representations of earning achievements. They show the player's success in obtaining levels or reaching goals. Badges have a similar function as points, in providing feedback on the player's performance. The badges may be known in advance to help in the motivation of the players without having too much competition.
- **Leader boards** - to display the ranking of the participants according to their performance. The motivational potential of this element can be mixed, affecting the players negatively, if they are in the low tiers of rankings, or positively, when they are in top tiers. It's necessary to find a good balance to not undermine the motivation of the participants.
- **Quests/Challenges** - where the players thrive to complete them with the objective of being rewarded.
- **Others.**

Figure 2.6 - Examples of gamification elements (badges and their respective achievements) from (Begumsemis, 2013)

Nonetheless, there is some research about co-creation value together with gamification, suggesting new ways of innovation inside a brand (Nobre & Ferreira, 2017), where the implementation of gamified systems, will create an impact on the consumer's brand experience which will have consequences in brand value co-creation. Making use of gamification to support the brand engages the process of co-creation from an SDL perspective, where gamers/customers interact with each other, making their experience more fun and engaging. The use of game elements in brand applications brings more loyalty, motivation and engagement through achievements, rewards, points, levels, among other features. Because the consumer is engaging with the brand, there is an opportunity for value co-creation activities. The involvement of the customer is based on the needs, values and Interests that make the customer being connected with the brand. There are two main points to focus on gamification to 1) Understand the consumer behaviour, offering means to stimulate its motivation, engagement, and self-brand connection; and 2) Use it as a platform to offer brand-related experiences and rewards, fortifying the brand relationship enhancement.

(Harwood & Garry, 2015) have a similar approach as (Nobre & Ferreira, 2017), but only from a customer engagement point of view and how it interacts with the concept of gamification. Basically, with the unification of a brand's gaming experience with customers' engagement, it is possible to verify the type of behaviours possible to obtain from completing tasks and how well do they perform using the system, resulting in rewards and achievements being completed, increasing the competitivity and engagement of the customer. These interactions play a major role in the customers' emotions and depending on the outcomes can result in a positive response, meaning, the customers will continue engaging with the experience, or negative, resulting in a loss of interest and motivation to keep using the system. Either way, independently of the outcomes, it will bring

consequences for the relationship with the brand and affect the loyalty of the customer.

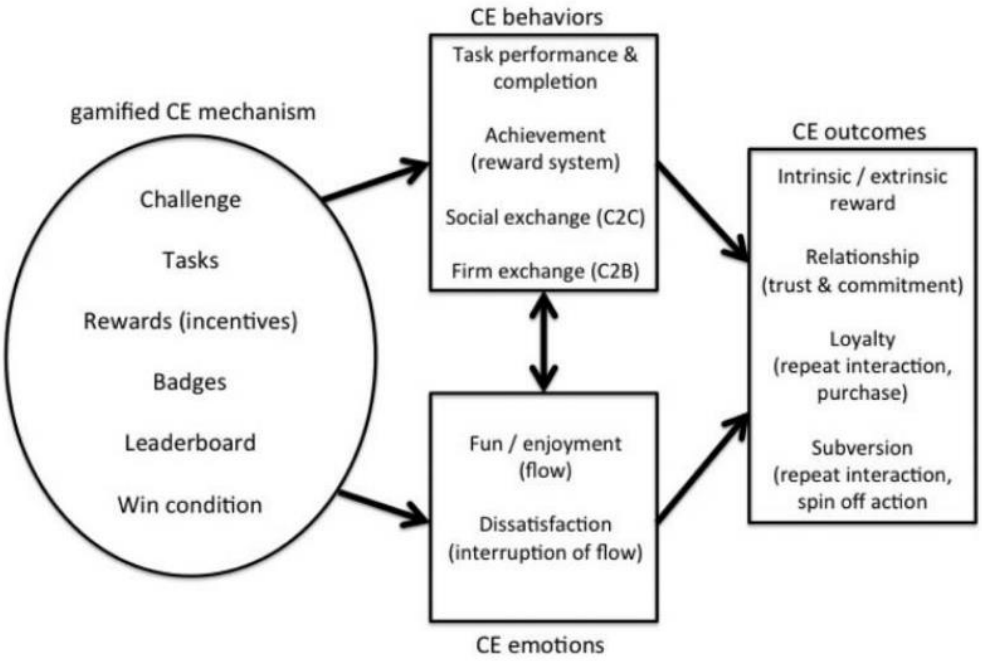

Figure 2.7 - Example of a gamified customer engagement experience model from (Harwood & Garry, 2015)

The emotions of the customers/stakeholders play a very important role to engage in co-creation communities. But what happens when the customers start to lose contests? (Leclercq et al., 2018) considers this possibility and states several hypotheses from how the notion of competition impacts the customer's engagement and the outcome of winning or losing, focusing on the losing outcomes and how affects the customer's motivation and level of engagement.

Figure 2.7 shows a model to explain how the behaviour and emotions of interacting with gamified systems can result in positive or negative outcomes, influencing the decision made by the user. Depending on the outcome, it may result in establishing a powerful relationship with the benefits of receiving rewards or losing completely the interest in the company or their products. But either way, the engagement of the customer will always be there using gamification.

2.2.1 Serious Games

Serious games are an example of gamification where its objective is to achieve a more serious goal (Wood & Reiners, 2014). There are numerous fields for the application of serious games, ranging from education, training or even military. The definition of serious games has three main components: experience, multimedia and entertainment, wherein the completion of these components want to convey some source of input, such as knowledge, skill, or in general some content to the player (Laamarti et al., 2014). The idea proposed in this work slightly touches this topic, because the goal is to help develop innovative business services through entertainment but to meet a serious goal.

Normally, this type of games is used by people working or studying in a specific area. For example, in the business sector, most of these games are used by employees to train their leadership or develop new business strategies. (Abdelali et al., 2014) suggests some serious games used in some companies like Delloite, Cisco or IBM to train their workers or other type of games for a more educational sense and then study several proposed criteria, to understand what type of population it targets and check for their game objectives and actions done.

The reason for the use of serious games in different areas is because this type of games are growing and help understand specific and realistic situations through an entertaining way, utilising games elements. (Laamarti et al., 2014) studied several types of serious games and was able to build a taxonomy around them, as shown in figure 2.8. Divided by the application area, ranging from education to simulation, the type of activity done in the game, which modality will affect, how it's possible to play and the environment being used. With the evolution of technology, it's possible to emerge the user even further in a digital world, representing the real world and the search for solutions to complete the game.

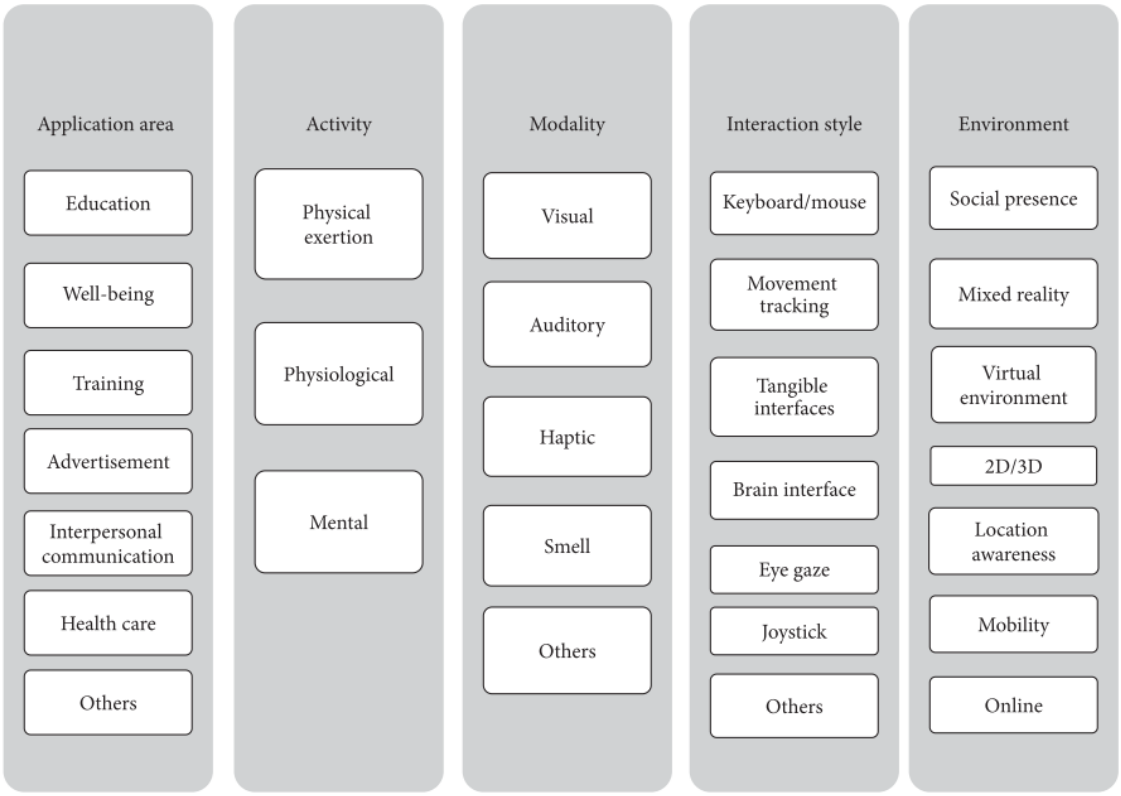

Figure 2.8 - Taxonomy of Serious Games from (Laamarti et al., 2014)

2.3 Service Design

Service design is an activity that has the main goal of designing user-oriented services to improve their usefulness, effectiveness and make them different from existing ones (Oliveira & Camarinha-Matos, 2014b). The idea is to connect all relevant stakeholders from different areas, considering for the needs of the users and the capabilities of the service providers. This type of interaction can originate co-creation/co-design of services, where the participants can engage in a service co-creation network (Luis M. Camarinha-Matos, Ferrada, et al., 2013), where it can involve actors from different areas and it's a short-term consortium, only being active during the development of the services, depending of the necessities of both the providers and customers.

The process of service design can be supported through numerous tools, but most of them are still in the manual phase, although there are emerging some software supported tools. Nevertheless, there is no integrated environment

available (Oliveira & Camarinha-Matos, 2014a). (Alves & Jardim Nunes, 2013) researched different tools and methods to understand the why, whom, what, how, when, where of these tools and their uses in different circumstances.

The development of different service designs, or actualization of the current ones will bring benefits for both engaging parties: the organization/enterprise can develop its capabilities to innovate (Steen et al., 2011) and the customer receives better services for their products, allowing to maintain interaction with the enterprise.

3

Co-creation System Specifications

This chapter introduces the requirements to develop the system being studied. These requirements are divided into functional, which define what the system must do and non-functional, that define how the system will work. A visual support to these requirements is made with diagrams, such as class diagrams, to demonstrate the structure of the system and which classes are necessary for its implementation, and use cases, to show how the actors will interact with the system and what they will do and show a possible ERD of the system. Finally, is suggested a conceptual architecture of the system to show how the layers will deployed and how they will interact with each other.

3.1 Functional and Non-Functional Requirements

Before starting the development of the platform, it's necessary to see which requirements (functional and non-functional) are necessary to understand what the system will do and how well it will perform, and how the users can interact with it and how will influence their decisions and motivations.

Functional requirements will define what the system will do and how it will work, thus it's important to make the requirements clear to their users and stakeholders, and the development team.

Some of the most common types of functional requirements are:

- Business rules
- Authorization levels
- Historical Data management
- Authentication

These are the ones that match the notion of the system being developed.

Firstly, what this system will do? The proposed system will work as a collaboration environment where it will have gamification properties such as badges and achievements, and competition possibilities, where the goal is to motivate its users to engage in situations of co-creation and be able to amplify their motivation to pursue new opportunities. This will be a business requirement for this system.

Because the system will accommodate several users, it's necessary to have an authentication system where it will give access to the system and it's possible to create a profile around the user. As the goal of the system is to have collaboration between VOs or with solo users, authorization levels are required because each type of user (Administrator, VO Broker, VO Planner, VO Member, or other users who wish to participate) will have different types of access and functions, like updating a topic, moderating a topic, or creating a competition, just to name a few.

These are some of the functional requirements that are a priority to implement, but to summarize:

- The system must have a login system by entering their email and providing a password.
- The system sends a confirmation email to the user when it registers.
- The system must allow users to reset their password by clicking on "I forgot my password" button and receive a link to the provided email when they registered.
- The system must have a profile section where it's possible to complete all the personal information of the user and display its activity.

- The system must have an area to allow interaction between the users and a "playground" to design their ideas.
- The system requires an area to post competitions and accessible to the users engaging the problem topic.
- The system must have different authorization levels to different types of accesses and functions.
- The system must have achievements, meaning that when a user completes a task, must receive an award.
- When a user receives an award, it must send an email notifying the user of completing a task and show the badge in the profile.
- The system must have a database to save all the data related to the users, activities, interactions, and competitions information.
- The system must show which type of awards/achievements can obtain and be able to add new ones to motivate the users to receive them.
- The system requires a point system to show how well the users are doing according to the points they are receiving.

Regarding non-functional requirements, they focus on the "quality" of the system or in other words, on how the system shall perform. There are plenty of non-functional requirements out there, but this work will be focused on the most common ones only.

The requirements that will be targeted are:

- Usability - Regarding the system, it's simple for a user to engage with it. The user, depending on its role, can deploy new ideas into the system and everybody can reach them, the same is applied to the competitive side of the system, where the user needs to ask to begin a new competition and the participants just need to send an answer or a resolution to the problem being asked.
- Performance - Because the system is simple and built through a design platform, it runs smoothly without any major breaks due to some tests, where several people can interact with the system without going down.

- **Scalability -** As long the system is provided with enough memory, it can increase the amount of traffic going around it and support more users in the system.
- **Reliability** - The system must be reliable, in a way that the users must be able to use the system and interact with it 95% of the time, without major troubles or even there is necessary small updates on the system.
- **Security -** Although it's a simple system, all the information is safely kept using a login system and roles system. This way it's possible to only show the forums the users are engaged in and interact with them, according to their role and position.
- **Availability -** The system is available to use 95% of the time, in which the remaining 5% goes to emergency or scheduled maintenances.

With the requirements written in text form, it will be shown through visuals how these requirements will work using diagrams with the UML notation.

Most of the diagrams follow the UML, which is a standardized modelling language that helps developers (system and software) to visualize, specify and construct each point of software systems. This can be used for business modelling and systems that are non-software. The UML is the representation of the best engineering practices using its integrated set of diagrams, to graphically show the design of software projects, allowing teams to communicate with each other, explore new designs and be able to validate the final design. The great advantage of UML is to simplify the increasing complexity of the systems and to give simpler techniques to automate software production, to obtain comprehensive and expressive models to users, extension of core concepts through specialized mechanisms, be independent of the programming language being used to develop the system and give good practices to all (Visual Paradigm, 2021).

3.2 Class diagram

The diagrams can be of two types: Structural and Behavioural; and in their turn, sub-divide into other classes.

Structural diagrams have the function of showing the structure of the system and each element on these diagrams represent the concepts of the system, abstract and real, and are divided into these types of diagrams:

- **Class**
- Component
- Profile
- Composite Structure
- Deployment
- Object
- Package

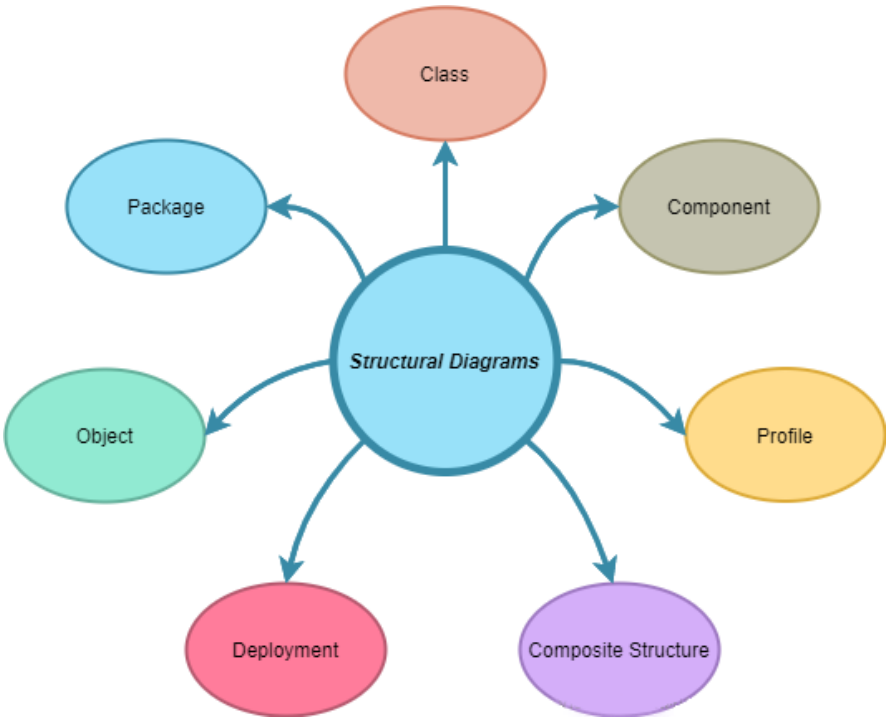

Figure 3.1 - Types of structural diagrams

Focusing on this system, it will be used only for the class diagram. A class diagram describes the types of objects in the system and the intrinsic relationship between them. The classes in the diagrams are composed of three parts:

- The top part with the name of the class.
- The middle part that has the attributes of the class.
- The bottom part that has the operations of the class.

Each of these classes can relate to each other through the following relationships:

- Association - representing the relationship between two classes, and it's normally represented by a line.
- Aggregation - represent the "has a" association relationship and it's more specific than association and it's represented by a line with a hollow diamond shape in one of its ends.
- Generalization - represent the specialization of a class (superclass) upon other (subclass) and it's represented by a line with a hollow triangle in one of its ends.

In the diagram below (figure 3.2), it shows a proposed class diagram for the system taking into the main objects that will be necessary for the system to function and have a general idea of its structure.

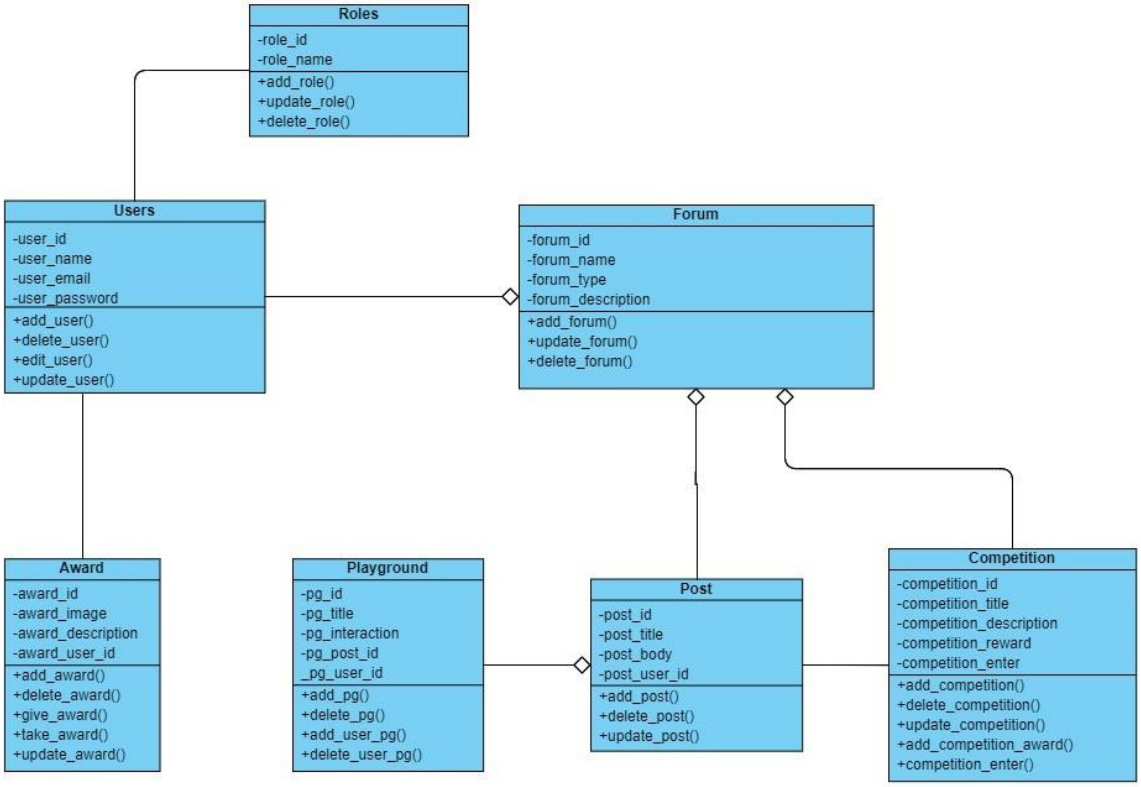

Figure 3.2 - Class diagram for the collaboration system with its integrant classes.

So, the first class named *Users*, representing the users that will be in the system and it will have the following attributes: *ID*, *name*, *email*, and *password;* keeping the attributes simple and direct. And the main operations this class will have will be: *add_user()*, allowing the system to add a new user; *delete_user(),* when a user needs to be removed of the system; *edit_user(),* when it is needed to change a definition of the user.

The second class with the nomination *Roles*, represents the roles that each user will have and it's a generalization of the *Users* class and it has the following attributes: *ID* and *name;* and the operations for this class are: *add_role(),* to add a new role; *delete_role()* to delete an existing role and *update_role()* to change the definitions of the role.

The third class with the name of *Awards*, will represent the awards a user can receive, and it's associated to the *Users* class. This class attributes are *ID, image*, to illustrate the type of award being given, *description*, meaning what type of reward will be given and *user_id,* to whom the award will be given. Their operations are the following: *add_award(),* to add a new type of award to the system; delete_award(), to delete an award; *give_award(),* to give an award to an user; *take_award(),* to take an award of an user and *update_award(),* to change the award.

The fourth class is the *Forum* class, that represent the forums inside the system, and it will be aggregated with the *Users* class, *Posts* class and the *Competition* class. The class have the following attributes: *ID, name, type,* and *description.* The operations of this class will be *add_forum()*, to add a forum to the system if necessary, *delete_forum(),* to remove a forum that is no longer useful and *update_forum()*, that allows to change the properties of the forum. This will be the nucleus for the system where everything will gather and that's why it's shown in the center of the diagram.

The fifth class is the *Post* class, representing the posts or the interactions that the users will have inside the forum with each other, and it has the following attributes: *ID*, *title, body,* and *user_id*, to identify to each user the post belongs. The operations are *add_post(),* to add a new post, *delete_post(),* to delete one post and *update_post(),* to change the details of a post.

The sixth class is the *Playground* post, and it’s an aggregation of the *Post* class, because it will be inherent to the post, where the users can interact with drawings and visual interactions. As such it has the following attributes: *ID, title, interaction*, to show what type of interaction it will have (drawings, pictures, post-its), *post_id*, to identify to which post it belongs and *user_id,* to check what users are using the playground. The operations are: *add_pg(),* to add a new playground, *delete_pg(),* to delete an existent playground, *add_user_pg(),* to allow an user to join and use the playground and *delete_user_pg()*, to delete an user from the playground.

The last class is the *Competition* class, and it's the class that will have the competitions for the users belonging to a post, thus the association with the *Post* class, participate and try to win the rights to start to co-create the proposed idea/solution with the organizer. The class will have the following attributes: *ID, title, description, award* and *enter*, this one represents the method to submit their entries for being evaluated. Thus, the operations inside the class are: *add_competition(),* to add a new competition, *delete_competition()* to remove an existing competition, *update_competition()* to update the details of the current competition, *add_competition_award(),* to add a type of award to the competition and finally, *competition_enter()* to program the ways to enter the competition.

3.3 Use Case Diagram

Following all the above, this is the structure that the system will be implemented with the possibilities of changes with the addition of new classes and have new type of interactions, but for a starting point this will the core and the system will follow this class diagram proposal.

After checking the structure of the system, the next step is to study and check the dynamic behaviour of the objects in the system. So, it will be used behavioural diagrams to implement the changes the system will have over time.

Behavioural diagrams, contrary to structural diagrams, focus on the dynamic behaviour of the objects in the system, taking into account the changes over time, and they are divided into these types of diagrams:

- Use Case
- Activity
- Interaction
- State Machine

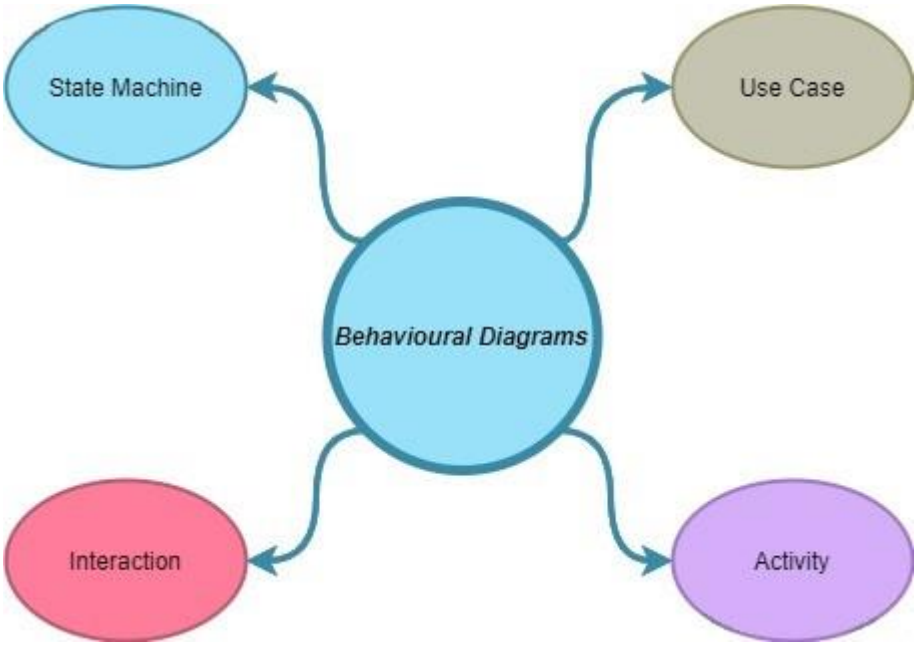

Figure 3.3 - Types of behavioural diagrams

Focusing on this system, only the use case diagram will be used. Use cases diagrams can demonstrate the expected behaviour of the system, through textual and visual representation, thus, a diagram. This type of diagram is often used in the early stage of development with the purpose of explaining the context of the system and capture the requirements of said system.

The components of use case diagrams are:

- Actors - Represents the users which interact with the use case.
- Use Case - The function of the case, where it shows what the system will do.
- Communication Link - The actors and the use cases are normally linked through a solid link.
- Boundary of the system - Represents the entire system and all the interactions between use cases and actors.

All these components will be linked using different types of relationships where it shows their dependencies between two use cases. They are:

- Extend relationship
- Include relationship

- Generalization

Focusing on the system that is being studied, in the figure below it's the use case for the co-creation system. Its components are explained in tables focusing the use cases (table 3.1) and its actors (table 3.2).

Use Case	Description
User Authentication	Actor provides its username and password to login into the system where it's verified in the database
Forum interaction	Actor interacts with the system (forum) where can engage with other participants
Post creation	Actor can create different posts with informative news, ideas proposition and gather other participants
Competition participation	Actor or party of actors may engage in competitions to earn the right to engage in co-creation with the competition's organizer
Competition creation	Actor may create a competition to gather teams or individuals that help him co-create its own innovative idea
Profile Check	Actor can check its profile to see the achievements and rewards gained and see personal information regarding the account

Table 3.1 - Use cases inserted into the system to show the different functions it will be implemented

Actors	Description
VO Member	Any actor that belongs to a VO
VO Broker	Actor with the role of searching or creating new opportunities and performing processes to search and selection partners to participate in these opportunities
VO Planner	After confirmation to start a competition from the VO Broker, it interacts with the system to proceed with the launch of the competition
Free Member	Anyone who joins the system looking for new business opportunities
Administrator	Controls the system and supervise the moderation of the interaction between different participants

Table 3.2 - Actors involved in the system

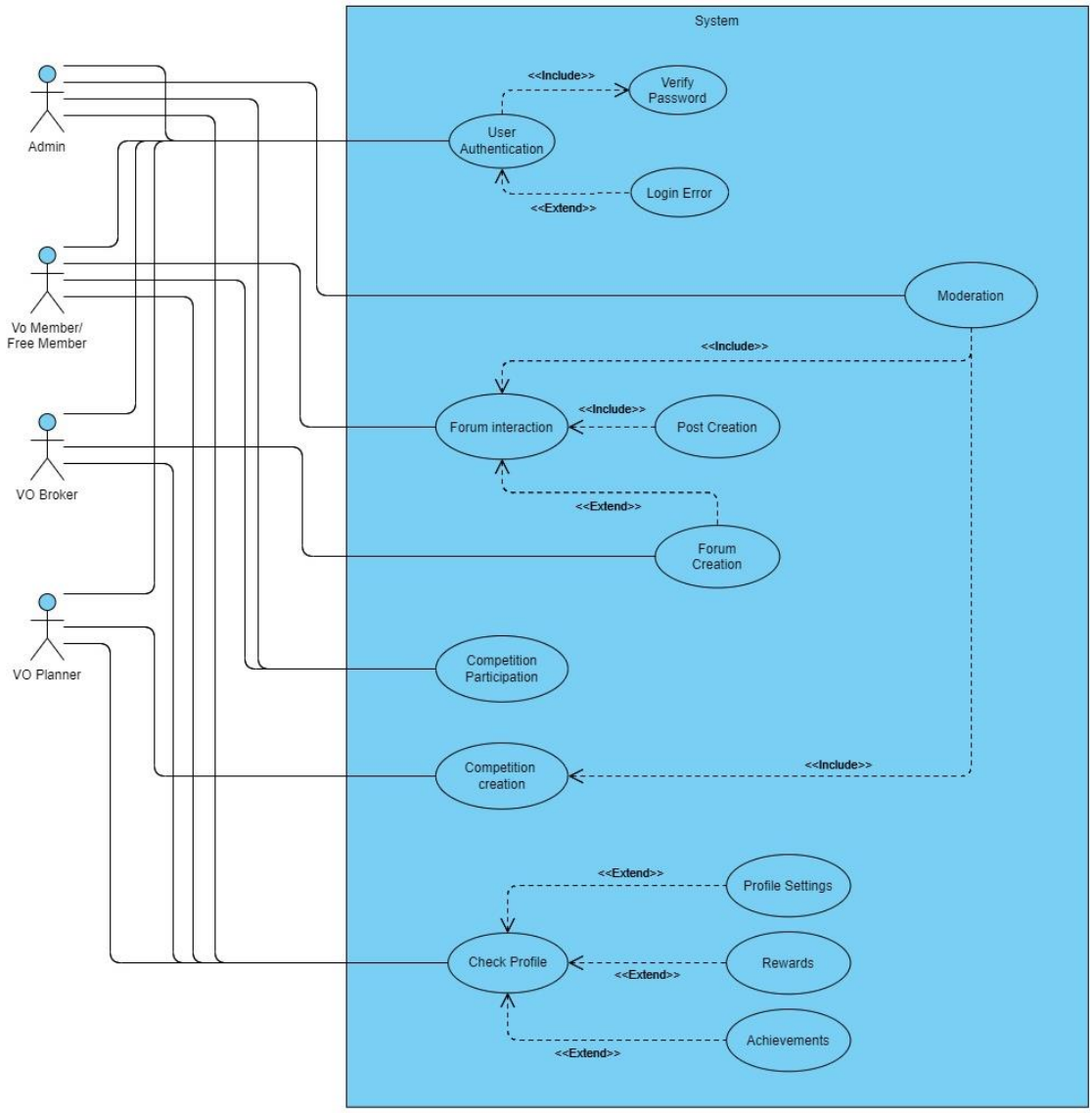

Figure 3.4 - Use case diagram for the system

This diagram shows the use case for this system considering the boundary of the system and the interactions that goes with each actor. All the actors will have the same base actions, which are registering into the system and interact with it in a low level (check menus, see forums) while the higher level of actions must be done between the interested participant and the system administrator to give those rights to post new opportunities and moderate it.

Because it's not possible to show the relationship between the VO Broker and the VO Planner in the use case diagram, and it's an important step for the launch of an opportunity competition, it will be demonstrated using the following flow diagrams.

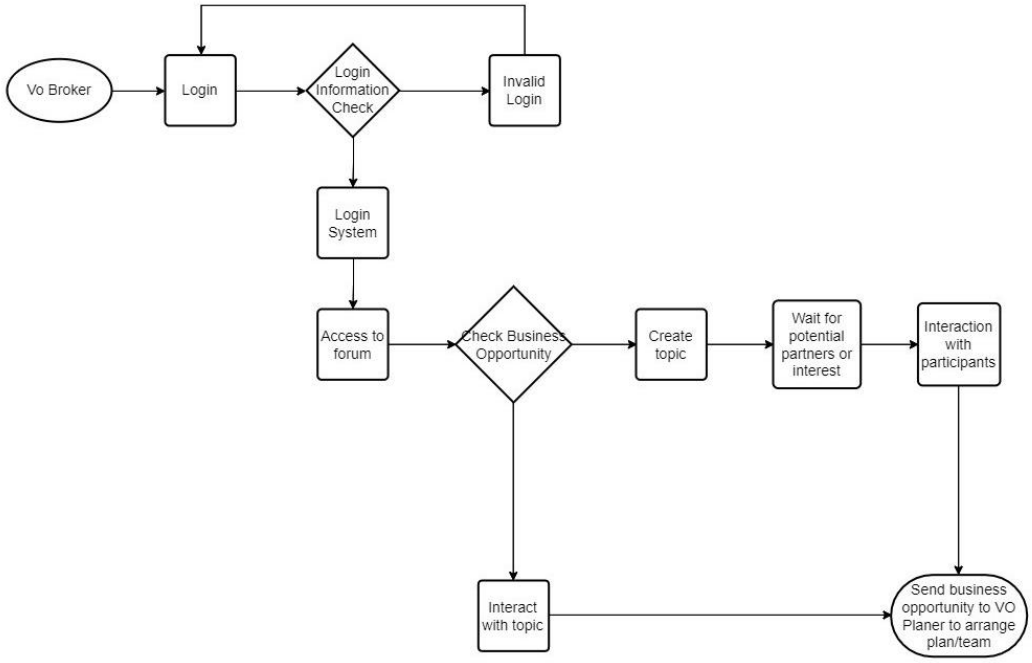

Figure 3.5 - Flow diagram for the activity of the VO Broker in the system

The flow of the VO Broker in the system starts with the login, where the information is checked to guarantee that is a person with the role of broker signing in, if not its necessary to try again with the correct information. Afterwards, it will have access to the system's forum where they will start searching for business opportunities. If it finds one opportunity worth exploring and creating, it will interact with the post and after with the author of the post to understand the idea that is behind the proposal to then decide if it wants to accept it or not, to then send the opportunity for the VO Planer to arrange a team/plan. If there isn't a business opportunity available or the broker wants to launch a new one, it will create a post with the idea of the opportunity and then wait for other brokers or entities that are interested to engage in this opportunity. When the broker

gathers enough interested people, sends information to the planer to organize a competition to see who will co-create and participate in the proposed opportunity.

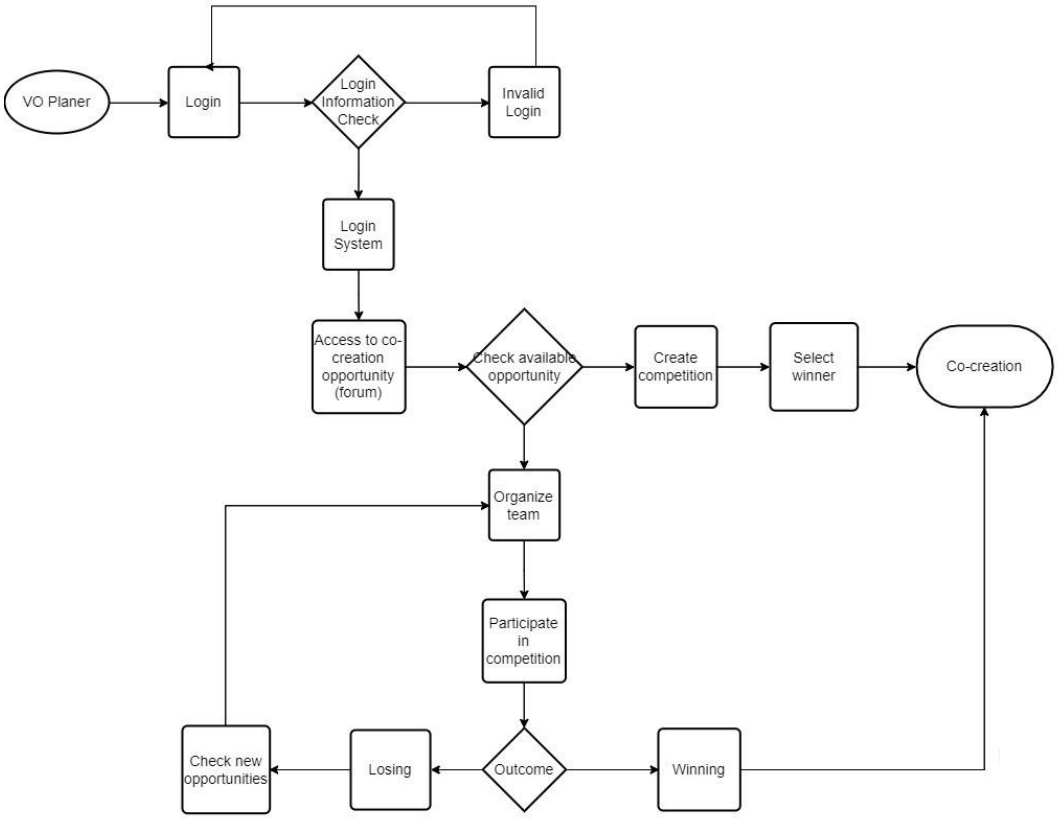

Figure 3.6 - Flow diagram for the activity of the VO Planer in the system

The VO Planer has the role of coordinate a plan and arrange teams to tackle new business opportunities. In this system, the objective is to organize "competitions" where everyone is free to join to try to be able to co-create the proposed idea with the one who launched the competition.

Like the VO Broker flow diagram, it starts with the login on the system and obtain access to co-creation opportunity, meaning the forum, to see the interaction between the participants and what was discussed around the idea that the group/enterprise/entity wants to develop. In the competition area, the planer must check if there is competition for the desired opportunity, where it will organize a team to tackle this problem, offering an innovative solution among other

participants, to try to win the competition and gain the possibility of co-create the idea. Depending on the outcome, if the team wins, the two parties (the idea's author and the winning team) will establish a trust agreement, and both sign a contract to co-develop the idea and delivered the finished product in a determined period. Afterwards, this team will receive points for how well the final work went and enter a ranking to have more chances to enter in new competitions and originate a small cycle of more points, more chances to be chosen.

If the team loses, the planer must check for new opportunities and send the team again to compete to try to win the next one.

In the case the planer wants to promote an idea suggested by the broker, he must act as the author of the competition and create a new one and choose a winner to help them co-create the idea. After the winner has been selected, it will proceed as mentioned above, when the team wins the competition.

After showing the use case diagram, it will be shown an ERD for the system, to propose how the database will function and save all the information.

The system will have five main entities: Forum, Topic, Post, User and Competition.

This is the proposed architecture for the system because it focuses on the main entities for it.

- Forum - In here, it's necessary to have an ID as the primary key to identify the forums that are intrinsic to the system, then it's the title for each of the forums, the description of them and then the activities surrounding them.
- Topic - It will have an ID as primary key and will be associated to the Forum entity because it will belong inside of it; this topic needs to have posts, links, a title, and a description to describe the main goal of the topic.
- Post - It will have, too, an ID as a primary key and will be associated to the Topic entity because it's the way the participants will communicate with each other, and for that it's necessary a body to put the message
- User - this will focus on the participant, where it has an ID as primary key and it will have a username, a password, a picture, and the activity of said user

- Competition - it will be focused the competitions where it shall be selected the team who will develop the proposed idea, so it needs the ID, functioning as a primary key, a body, the users, and the reward.

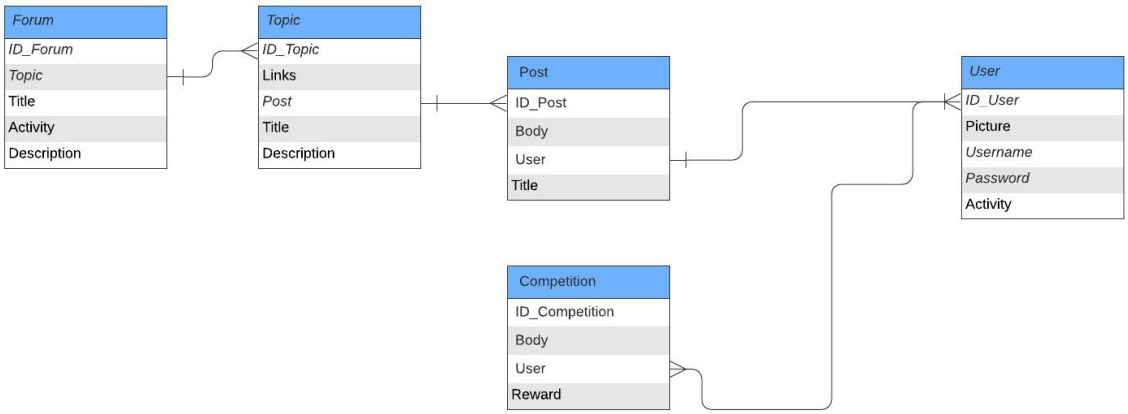

Figure 3.7 - ERD for the system database

3.4 Conceptual Architecture

With the structure of the system defined by a class diagram and the behavioural function shown by a use case, it's possible to define a system concept architecture diagram like the one shown in figure 3.6. The way the system architecture will be developed is centered on the collaboration layer will go around the collaboration layer, because that's the focus of all the processes and the participants.

As such, the architecture will be divided into three parts: a user layer, a collaboration layer, and a data layer.

The user layer will focus on the interfaces through which the users can access the system. The system will be available in an online version so it's possible to access it through a computer or a mobile device, like a tablet or even a phone.

This layer will be in contact with the collaboration layer in the activities of collaboration and gamification will happen around the forum area. This area will target the communication part between users where they can start new discussions by asking for help to solve a problem, to get some insight related to a business case, or to find new business opportunities. Besides the communication

between the participants, there should be a way to show these ideas through live drawings and small diagrams to better illustrate solutions and opinions, as such there is a "playground" block to where the posts will be linked, and the information will be easily accessed from inside the post.

The other important block that will have a major role in the gamification part will be the competition block, which will be integrated in the forum but will also be related to the posts of the user, where a competition will be launched taking account the inputs the organizer received and try to reach one that will suit best for the opportunity in the moment. So, it's necessary to prepare all the details, including a description of the problem, time to deliver a solution to the business opportunity and a proper reward for the selected winner besides having the rights to develop the solution.

All this information needs to be stored in a database to not lose the data related to the users, forums, posts, and competitions. The system requires a data layer too, based on a MySQL DB, a simple database that will be integrated into the system. The data of the competition can be saved inside a simpler database such as an excel file and then stored in the primary database.

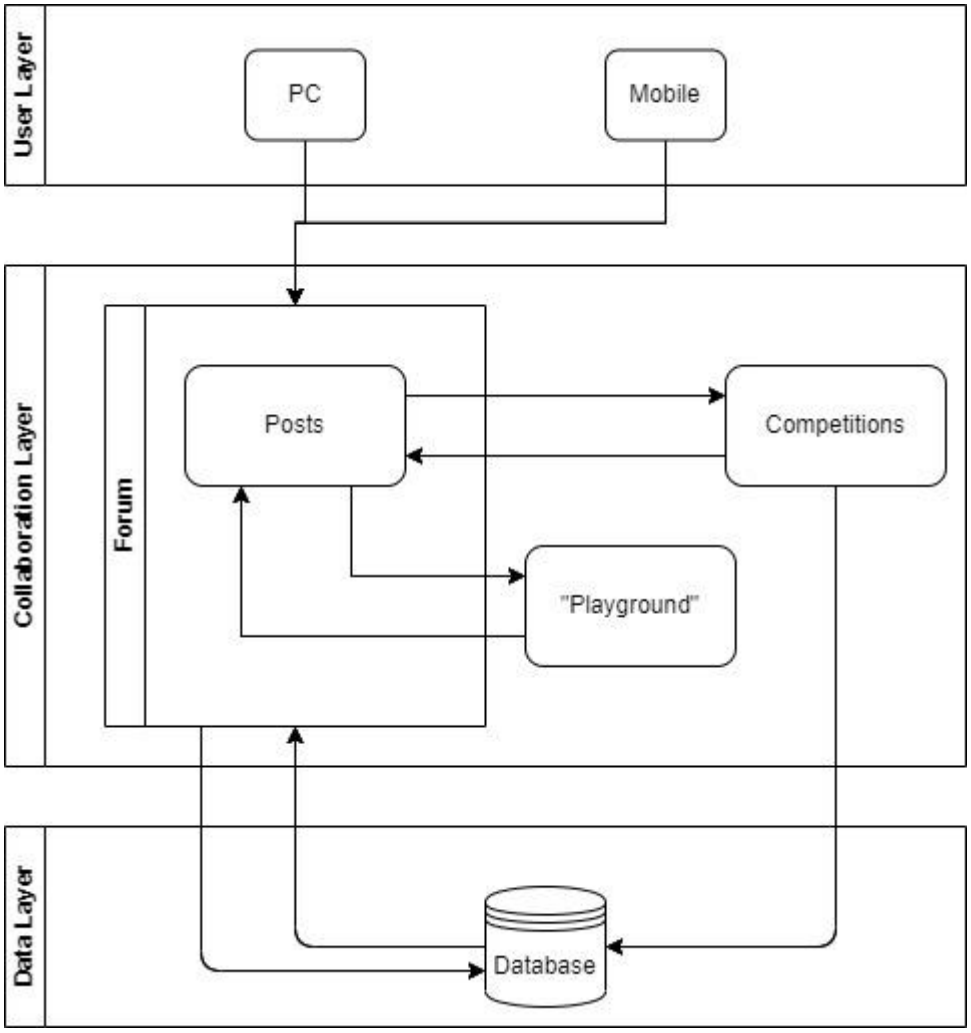

Figure 3.8 - System conceptual architecture

With most of the main non-functional requirements checked and planned, the next step will be to implement the system considering all these features, meaning the functional and non-functional requirements.

4

Co-creation System Implementation

In this chapter, it's introduced the implementation of the proposed system. Before starting the implementation, the first step is to research what type of software it will be used in constructing the system, considering the requirements proposed in the previous chapter, and then selecting to start the implementation. Afterwards, it's shown how the proposed software works and it's explained step by step in how it will culminate in a functional system for co-creation with the aid of gamification.

4.1 Software research

With all the requirements specified (functional and non-functional), it's possible to start the development of this system with the goal of building a co-creation system that could be used by everyone and be rewarded for using the proposed system and engaging them in continuing using it to develop new and innovative ideas.

The main goal of this system is to function as a gaming forum where every participant (it will be considered to have the following types: VO Broker, VO

Planner, VO Member, and Free Member) can join and engage in innovative ideas in a co-creation environment, through communication and discussion in small posts where they tackle an opportunity and offer solutions to solve the problem in hands. Afterwards, it will be organized a competition where the participants can engage and offer the solution for the problem and try to win it. All of this is joined by a gamified system that awards points, badges, and achievements.

The main inspiration for this system came from Kaggle, which is a gamified platform with an online community of data scientists and machine learning developers, where they tackle real world problems through modelling of data sets, where they interact with each other and participate in competitions to solve data science challenges. These competitions work in the following order:

1. The competition host prepares the data and gives a small brief regarding the problem.
2. Any participant can enter the competition and try to use different techniques and compete to reach the best model to the question. Anyone can see the answers where it's possible to originate new ideas to modelling. Almost all the submissions are scored and summarized in a leaderboard.
3. After the deadline passes, the host closes the competition and awards the person who has the solution with the higher score, and then, the winning model is used to further explore and enhance the solution.

The system will try follow similar steps to these ones to insert the component of gamification into the system, with the goal of gathering more users to co-create and give them a more entertaining and challenging environment to create and explore the most innovative ideas.

As such it is necessary to research which type of software/technology will be used to develop this system. There are several ways to build a new system from the ground up like using phpbb, Angular, ReachJS, Flarum or MyBB. Each of this prioritize the development of a system, using open-source software available to all.

Flarum works like a plug-in to a system/website, where it's possible to create a simple discussion platform with the possibility of including several extensions and offer a vast amount of ways to customize. This software is open source and maintained by several volunteers.

phpbb and MyBB have similar features between each other, where they have the goal to help building forum sites from scratch, with the need of hosting a server to get the site running and a building system around of plugins to develop a full pledge forum/system. Both are heavily relied in PHP language to build its structure. Also, they support database systems such as MySQL, PostgreSQL, and SQLite, although phpbb can support Oracle database and Microsoft SQL Server.

It's possible to put one against each other with its own advantages and disadvantages, but normally it depends on the system that is intended to build. It has a plus side, whenever it's necessary to upgrade between these software, it's possible to maintain all the information safe and be able to quickly deploy to a new software.

Another way to build this system is using programming language through Angular or React.js. Each of these have the goal of building single-page clients, for website or mobile.

In a few words, Angular is a framework that uses HTML and TypeScript, being written in the latter. All the functionalities are imported from TypeScript libraries to the applications being built. The building components of Angular are called NgModules, which is where all the compiled information and functions will be in the application. It has two types of components:

- Views - these are the screen elements of Angular where it's possible to modify through program logic and data.
- Services - provides the functional part of Angular. They can be inserted into components as dependencies, making the code modular and possible to reutilize.

React.js, or React, is not a framework per se, but a library of JavaScript where it's possible to create big web applications where it changes data without the need of reloading the page. React uses JSX instead of regular JavaScript, and it’s

based in HTML quoting and uses HTML tag syntax to render subcomponents, but if the user wants, it's possible to code in JavaScript too. React works in a single-way data flow due to its simplicity, where the values that is necessary to pass are rendered through components' properties in their HTML tags. To modify these properties, it's necessary to use call back functions. The reason why it's possible to change data, without reloading the page is because of Virtual DOM, where React creates an in-memory data structure cache, computing all the changes being made and then updating the browser and displaying the DOM efficiently, allowing the programmer to code as if the whole page is rendered on each change, while React libraries only render the subcomponents that change.

These are all the available software and framework possible to build a system, mainly a gamified forum system, that are completely free but with the disadvantage of needing to build everything from the ground up and taking account more errors in development and the application process.

Besides these softwares, there are many more, that are paid but with the advantage of having all the framework built and only require to mount all the pieces and components to have a full operational system.

There are some examples like Vanilla Forums, that is a community software where the enterprise and its customers collaborate, communicate, and share ideas and opinions for the products and services that are being offered. This comes close to the system being developed but without the gamified part that is proposed in this document.

It could be used a system like The Gamifiers, which is a gamification end-to-end powerhouse that provides all its clients with all the gamified processes, through program design, implementation of the gamification and interacting with the clients through consulting.

The last software that was researched and is a mix of free and paid is the one selected to build the system: Wordpress.

Wordpress is an open-source CMS, written in PHP and uses a MySQL database. Its main traits are the uses of plugin architecture and a theme system, allowing the user to personalize the system/website that it wishes to create. In the

early days, Wordpress was created as a blog publishing system but over the years it has evolved to include other function such as forums or online stores.

The notion of themes allows the user to change the look and functionality of the website without changing much of its code, where it requires to have at least one operational theme to work. The other trait, plugins, allows users to extend the functionality of the website and help them tailoring it for their specific needs.

For what it could be investigated around these softwares and platforms, the choice was fallen upon Wordpress because it's the tool more indicated to produce and develop the co-creation system proposed by this work because of its tools and easy implementation to build a system from scratch and make a functional gamified collaboration system.

4.2 Benchmarking

Taking account all of what was mentioned in the study of the researched software, it is necessary to do a benchmarking between all the tools and software to show why the chosen software was WordPress against other softwares.

To do this, it will be considered several characteristics to compare between them:

- Motivation - how good the software is to gather participants and maintain them in a long term through updates, system enhancement and other upgrades.
- Collaboration - the system promotes collaboration and allow interaction between the users.
- Gamification - the software can have gamification elements or has gamification integrated.
- Interaction - the interaction with the software is of easy comprehension and implementation.
- Price - the software is free or it's necessary to pay to use it.

- Engagement - if the software is possible to interact with the users to provide an environment rich in interactions and easy to use.
- Implementation - the implementation of the system is done quickly, and it maintains a robust framework to hold all the users and if it has integrated databases.

It was built a table using the considered characteristics to check if any of the software has that specific characteristic and then reach a conclusion from the full table analysis.

The chosen software, WordPress, is the one that have most of the check marks, if not all of them, showing that it's the best to implement this type of system effortlessly and provide a good framework to maintain the system running and allow any user to join.

The second software with the greatest number of checks was Flarum. Although it has a similar structure to Wordpress (focus on forums), it doesn't have the support for gamification elements, removing the purpose to build the proposed system.

The third software was "The Gamifiers" but it's limited because it only focuses in providing gamification solutions to systems already implemented to enhance them and because it's a paid software to use.

Software	phpBB	MyBB	Angular	ReactJS	Flarum	Vanilla Forums	The Gamifiers	WordPress
Characteristics								
Motivation						x		x
Collaboration					x			x
Gamification							x	x
Interaction	x	x	x	x	x		x	x
Price	x	x	x	x	x			x
Engagement					x	x	x	x
Implementation					x	x	x	x

Table 4.1 - Benchmarking table with the different characteristics

The benchmarking was done based in what were the principal characteristics in the implementation of the system from the user's interaction and motivation to keep using it and if the notion of collaboration and gamification would be achieved. Other characteristics like the price and the implementation can influence in how reliable it's to use a software against the other and with that the choice of the system fell on WordPress.

4.3 Implementation of software

Following the requirements proposed in the previous chapter, the system will be implemented through Wordpress, a powerful and reliable software to build websites and forums relying on several plugins and themes offered by the software.

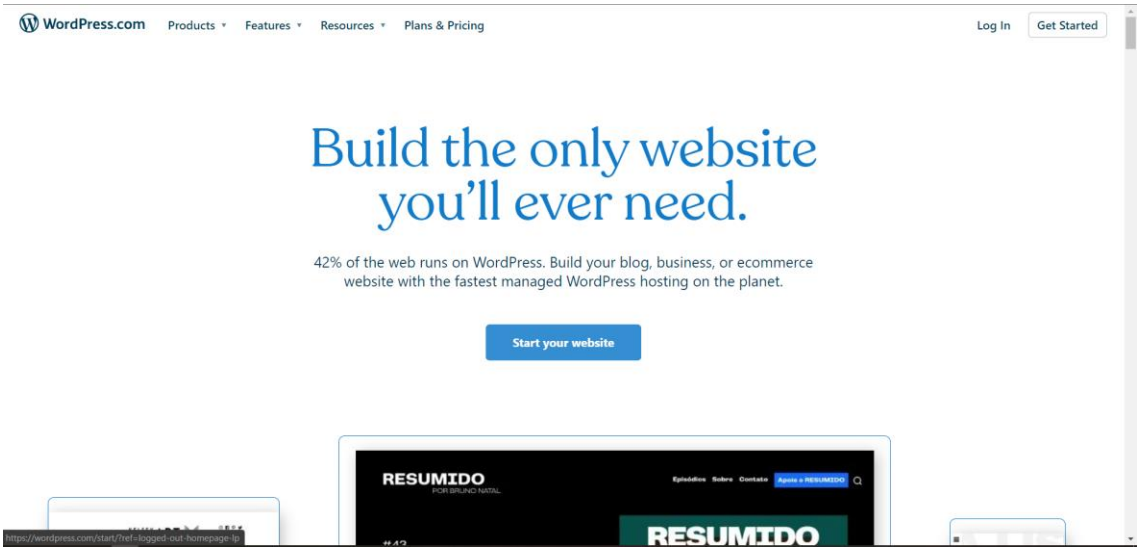

Figure 4.1 -WordPress initial page

Before beginning the implementation of the system, it's important to note that Wordpress is majorly done in a low code level. There isn't much to code because when it's added a new feature to the website it's coded automatically in PHP, the main language of this software.

With that said, it's necessary to create an account and take control of a domain in where it will reside the collaboration system. The domain will generate a website link for users' access and will be the unique identity to this system. The name chosen for the domain of the system was *cocreationsystem.wpcomstaging.com,* to give a small hint in what the website will target. In the image below, is shown how to originate a domain name, and depending on the choice, can be a paid or free version. In here, it was used a free version (*Note: the image below is shown as a merely example in how it's chosen the domain name*).

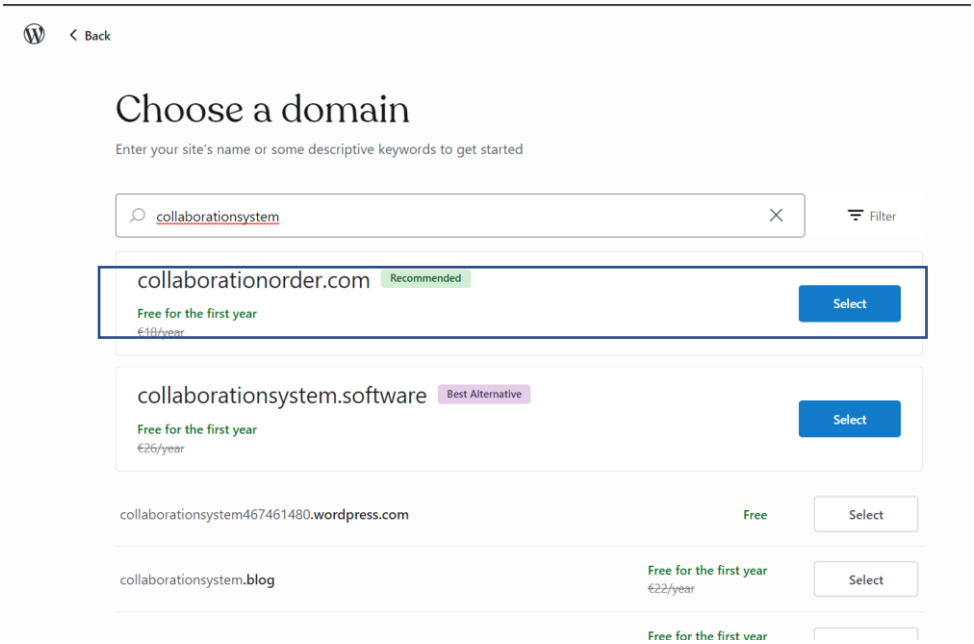

Figure 4.2 - Domain choice example. Due to some of them requiring a paid plan, it was selected the free domain

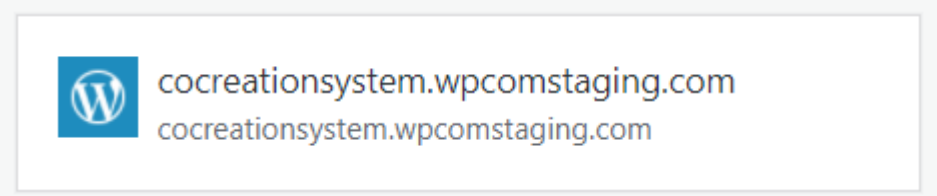

Figure 4.3 - System real domain

After choosing the domain name, the software will arrange the framework to allow the user to build the system.

The simple and clean interface of WordPress allows to a smooth interaction and offers plenty of tutorials to help building the interface of the website effortlessly and to quickly deploy a new website. Thus, taking account the type of structure that it was idealized, it shall be built a forum type website, promoting collaboration through means of gamification.

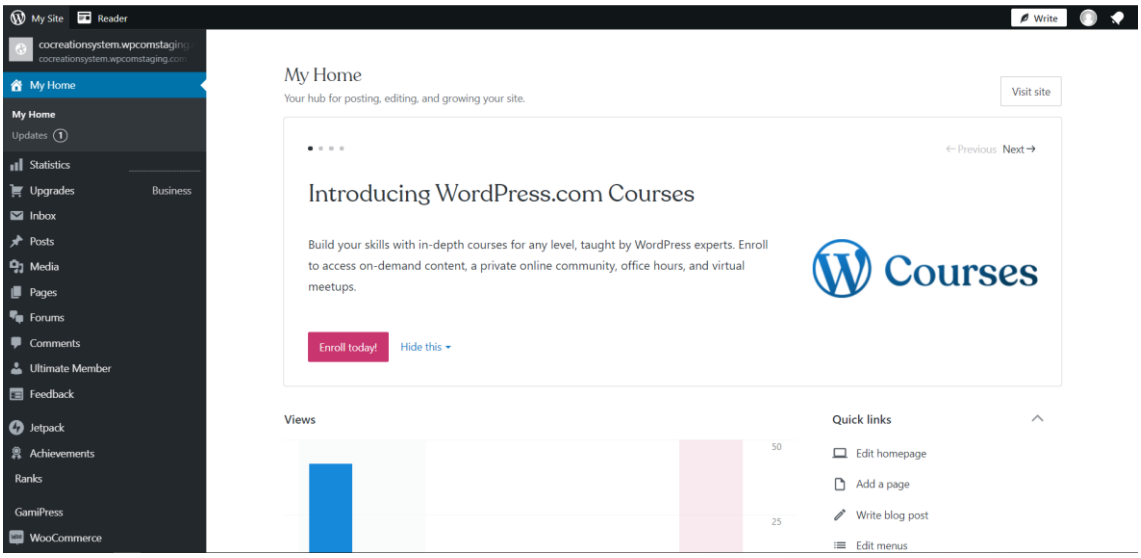

Figure 4.4 - Introdutory page to start developing the system

Firstly, it is mandatory to select a theme to the system because without it, it's not possible to create pages and interact with the plugins. There are many types of themes to choose, and the final choice depends in how the developer wants to show the final product to the users. It's important to say that although it's mandatory to have a theme, it's possible to change the theme whenever without changing too much of the work already made and implemented on the

website. In here, it was chosen the *Hever* Theme because it was the most neutral option without having too much detail but with the possibility to create a bit of impact on the side of the user.

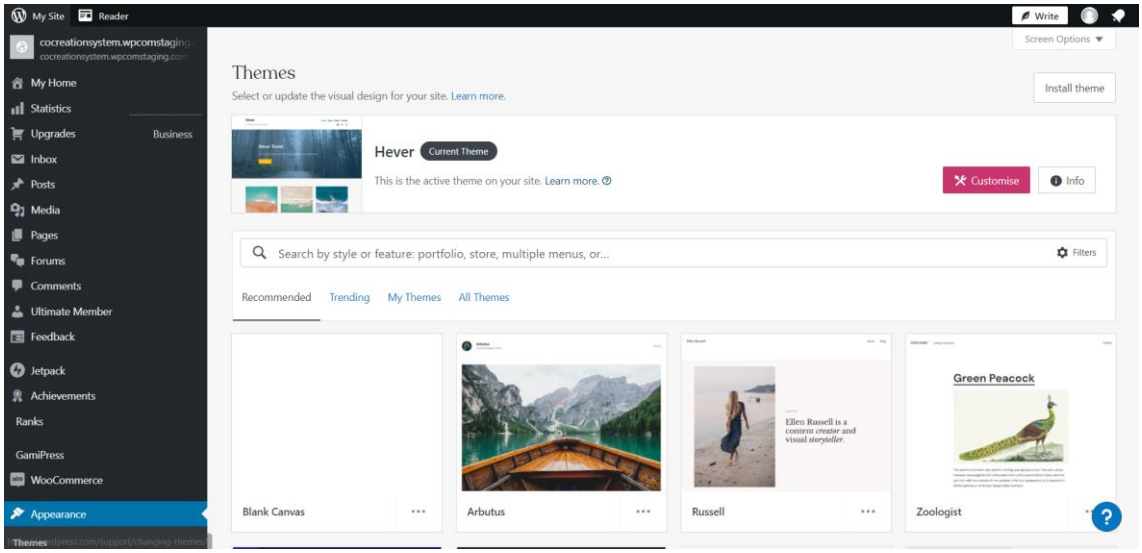

Figure 4.5 -Theme selection page

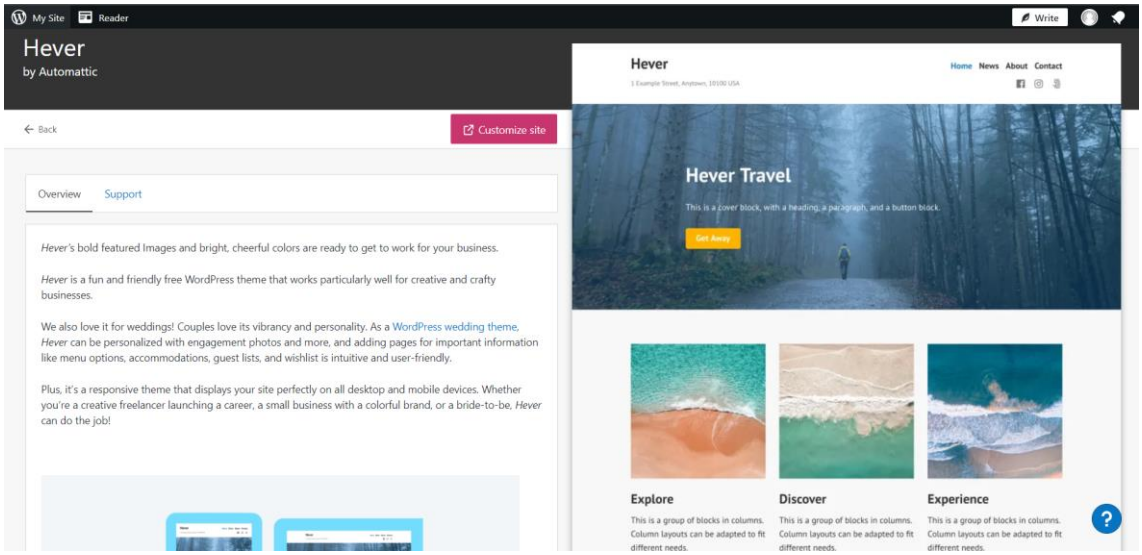

Figure 4.6 - Theme Hever selection and presentation

After choosing the theme, it's now possible to start creating the visual aspects of the system. All the visuals that will be implemented, will be integrated

with their respective functionality, for example, a button will direct the user for the page that it's linked to it, meaning that there is no need to program its main function.

Because WordPress offers a plenitude of plugins, it will be selected the ones necessary for the system: forum plugins, competition plugins and gamification plugins.

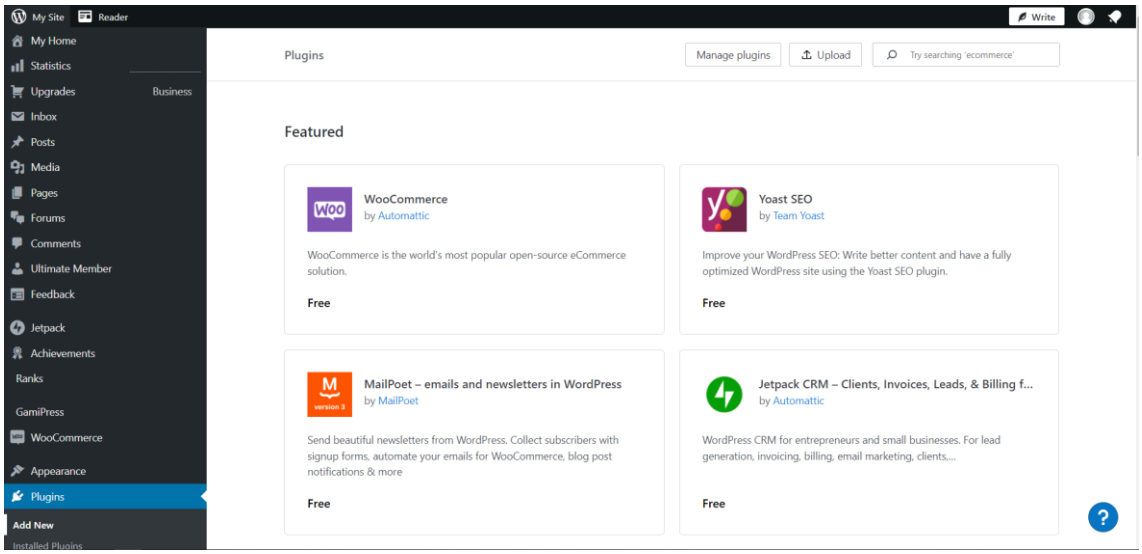

Figure 4.7 - Plugins page with some examples to incorporate in the new system

There are several that come integrated when it's created the framework of the new website because they are mandatory to keep the system working. Some of the plugins are related to security, like *JetPack*, that is automatically managed by the system for the developer focus in other parts of the site construction. This plugin helps create backups to safekeep all the information and optimise the performance of the implemented site, looking out for spam activities and maintaining a historical review of all the activities that happened to the site like visits, changes of structure and similar functions. Other plugins have the function of controlling the CSS and JS of the WordPress to allow a fluid performance in rendering and faster page loading. Other plugin to help build pages for the site to make each page rich and built through blocks, with the name of *Gutenberg*, where transforms the implementation of new functionalities to a modular way, allowing to arrange the pages and add new functions from buttons, paragraphs, and other plugins.

Regarding the collaboration system, it will be used one of the most predominant plugins for forums, WpForo. The implementation of this plugin will target the collaboration layer that was proposed in the previous chapter.

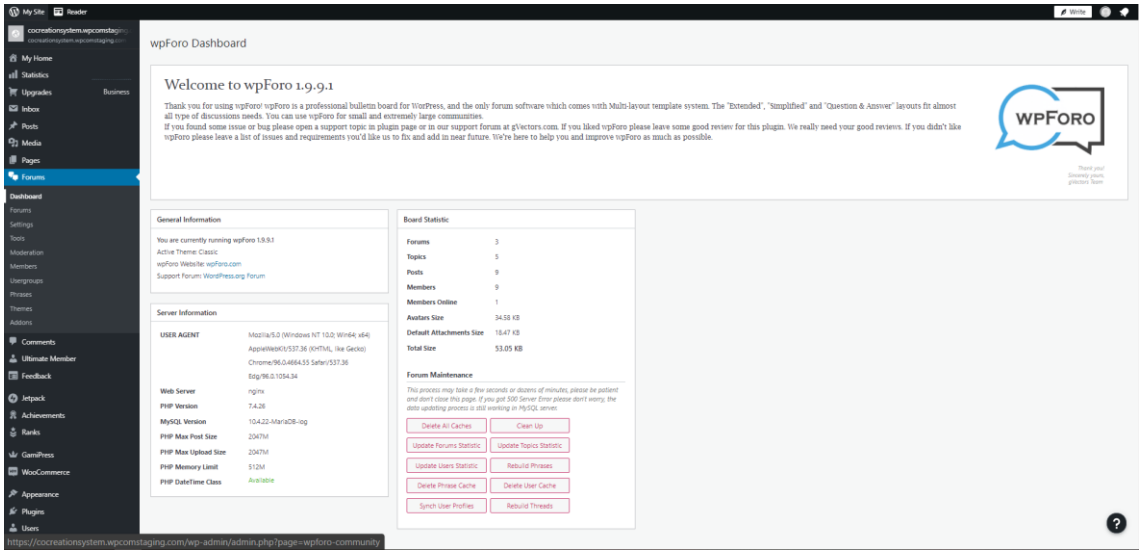

Figure 4.8 - WpForo initial page showing all the details regarding the plugin and activities in the system

Wpforo is a professional plugin for forum systems that allow to build big and small communities around discussions and communication. It offers a self-made template to be easier to setup and start constructing new forums. Besides, it gives all the stats regarding the website like the number of forums, topics, posts, members, and it's possible to give immediate maintenance without entering the site.

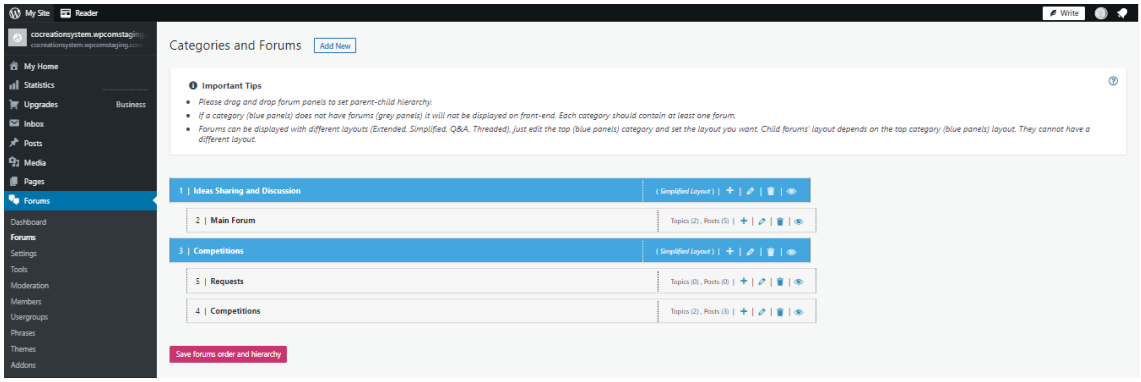

Figure 4.9 - Creation of forums and categories with WpForo

After installing the plugin, it's necessary to create an initial forum to populate the collaboration system. Following the SRS, it will have two forums, one for the collaboration/communication in where the users will interact with each other, and the other for the competitions, divided in two: one for requesting the beginning of a competition and the other to launch the competition. Inside here, the remaining pieces of the communication layer will be implemented through other type of plugins and connected to this one. The functional requirements will fall under this plugin because it offers a login system with the possibility of profile creation to allow the user to define what type of participant it will be.

It's possible to define user groups to differentiate the type of users it can exist in the system. The idea is to have three types of users, besides the administrator role. The roles are the following: **User**, associated with the subscriber role, it's the lowest role only able to join forums and post replies; **VO Broker**, associated with the author role, where besides having the same rights as the subscriber role, it can post new topics to initiate a new process of collaboration and then **VO Planner**, associated with the editor role, which has the same rights as the VO Broker but it will be the one to request the start of new competitions.

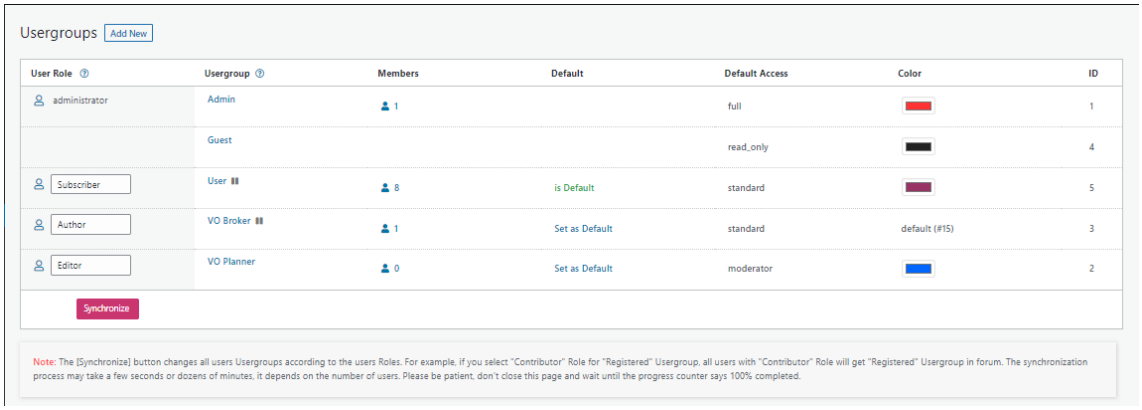

Figure 4.10 - Creation of usergroups to associate to each type of user

The definition of these usergroups goes with the different types of actors shown in the previous chapter, with the use case diagram (figure 3.4) and how the VO Broker and VO Planer usergroups interact with each other and share information (figure 3.5 and figure 3.6), so they must be able to both access the same topics to select and view all the details left by the other participants.

WpForo offers some addons to increase the functionality of the forums created but it's necessary to subscribe a paid plan and for the implementation of this system is not required.

With the plugin installed, it will be inserted the playground module through the plugin Ziteboard Online Whiteboard. This plugin allows to add a whiteboard to the forum through a link.

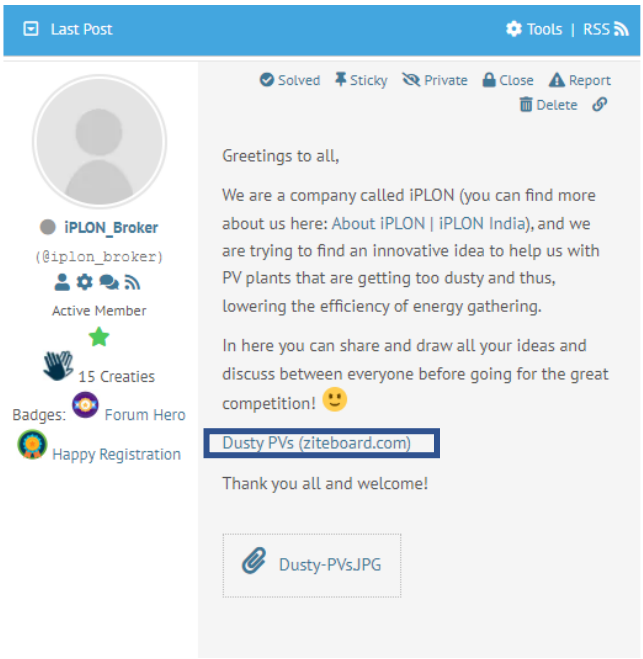

Figure 4.11 - Link example to a playground inside a topic

The link opens the "playground" where the users with access to that link can enter and start to "play" and give ideas through drawings, erase small mistakes, post-it with bullet points, and add images to the board. Because it's an online tool, it's possible to check how many users are accessing it.

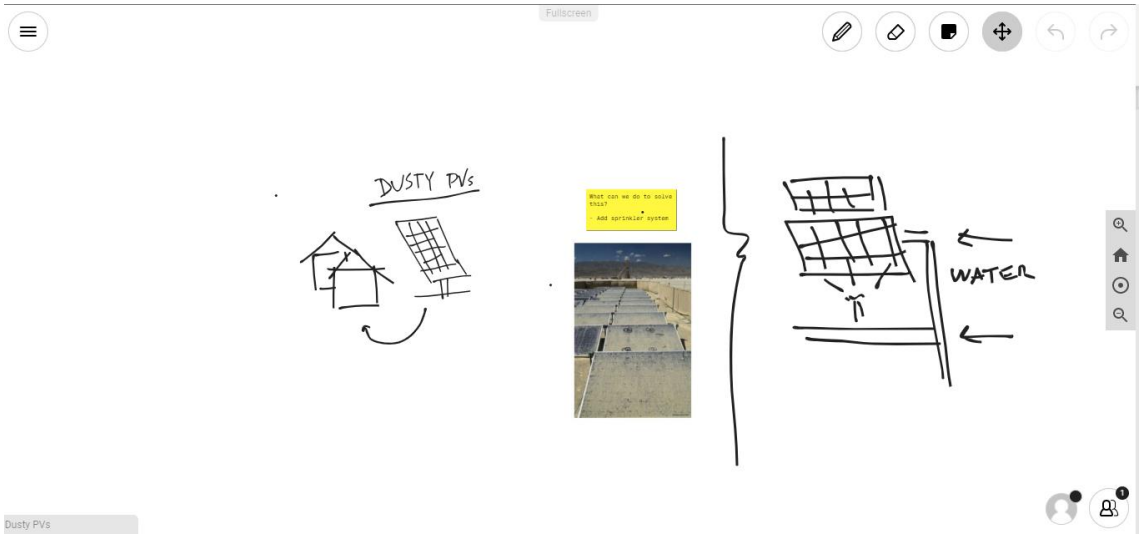

Figure 4.12 - Playground example with different interactions

The advantage of using the WpForo as a plugin for the system, is that it will help create the database, in MySQL, as the system is being built and being added new components to it. Several tables are created regarding some of the main characteristics of the system like the *wp_wpforo_forums* table that focus on all the details of the forums being create.

wp_wpforo_forums | Rows: 5 | Status: OK					
forumid	int(10) unsigned		-	PRI	
title	varchar(255)	latin1_swedish_ci	-		
slug	varchar(255)	latin1_swedish_ci	-	UNI	
description	longtext	latin1_swedish_ci	NULL		
parentid	int(10) unsigned		-	MUL	0
icon	varchar(255)	latin1_swedish_ci	NULL		
last_topicid	int(10) unsigned		-		0
last_postid	int(10) unsigned		-	MUL	0
last_userid	int(10) unsigned		-		0
last_post_date	datetime		-		0000-00-00 00:00:00
topics	int(11)		-		0
posts	int(11)		-		0
permissions	text	latin1_swedish_ci	NULL		
meta_key	text	latin1_swedish_ci	NULL		
meta_desc	text	latin1_swedish_ci	NULL		
status	tinyint(1) unsigned		-	MUL	0
is_cat	tinyint(1) unsigned		-	MUL	0
cat_layout	tinyint(1) unsigned		-		0
order	int(10) unsigned		-	MUL	0
color	varchar(7)	latin1_swedish_ci	-		

Indexes			
PRIMARY	forumid	Un	BTREE
UNIQUE SLUG	slug	Un	BTREE
order	order	0	BTREE
status	status	0	BTREE
parentid	parentid	0	BTREE
last_postid	last_postid	0	BTREE
is_cat	is_cat	0	BTREE

Table 4.2 - Table regarding the forum creation in the system.

The components of this specific table, will be the following:

- **Forumid** - primary key of the table, corresponding to the identifier of the forum.
- **Title** - title of the forum, with the varchar type.
- **Slug** - small description of the type of forum being created, this is part of the plugin to show the short code for the forum being created, with the varchar type.
- **Description** - description of the forum, with the longtext type.
- **Parentid** - is an identifier for the parent table of forum.
- **Icon** - the icon of the forum and it has a varchar type.
- **last_topicid** - saves the last topic that was accessed using an int type.
- **last_postid** - saves the last post that was accessed using an int type.
- **last_userid** - saves the last user that was accessed using an int type.
- **last_post_Date** - saves the date of when the post was accessed using a datetime type.
- **topics** - keeps all the information regarding the topics being created in a forum, and it has an int type.
- **posts** - keeps all the information regarding the posts inside the forum that belongs to each topic, where they are related to each other, and it has an int type.
- **permissions** - relates to all the permissions that rules the forum, taking account the users that interact with them, and it is a text type.
- **meta_key** - the meta key that originates from creating the table, and it is a text type.
- **meta_desc** - the description of the meta key with a text type.
- **status** - shows the status of the forum with a tinyint type.
- **is_cat** - it's a variable to influence the code of the forum, and it has a tinyint type.
- **cat_layout** - describes the layout of the cat, and it has a tinyint type.
- **order** - shows the order of the information of the forum with an int type.

- **color** - saves the color in which the forum will be shown, and it has a varchar type.

This is an example of a table that belongs to the database of the system. Any further table will be in the annex chapter of this document.

This implementation will be focused in the first part of the data layer, suggested in figure 3.8, where all the information of the forum part will be stored, such as customers id, their profile, the post that were created and the interactions around them. Because the process of the database is developed as the system implementation goes on, all the interactions between each data table are automatically made when it's inserted a new component into the system.

Having the forum framework created and operational, it will be implemented the gamification structure to transform the system and make it interactive and entertaining. The term of gamification suggests the use of game elements to make the system more engaging (Wood & Reiners, 2014). For that it shall be used some elements like points, achievements, and ranks, that will be given to the users according to the actions they complete. The plugin that will be used here is called *GamiPress*, one of the most powerful gamification plugins in WordPress, with lots of assets to offer (although most of them are paid, the free version is enough to gamify the system).

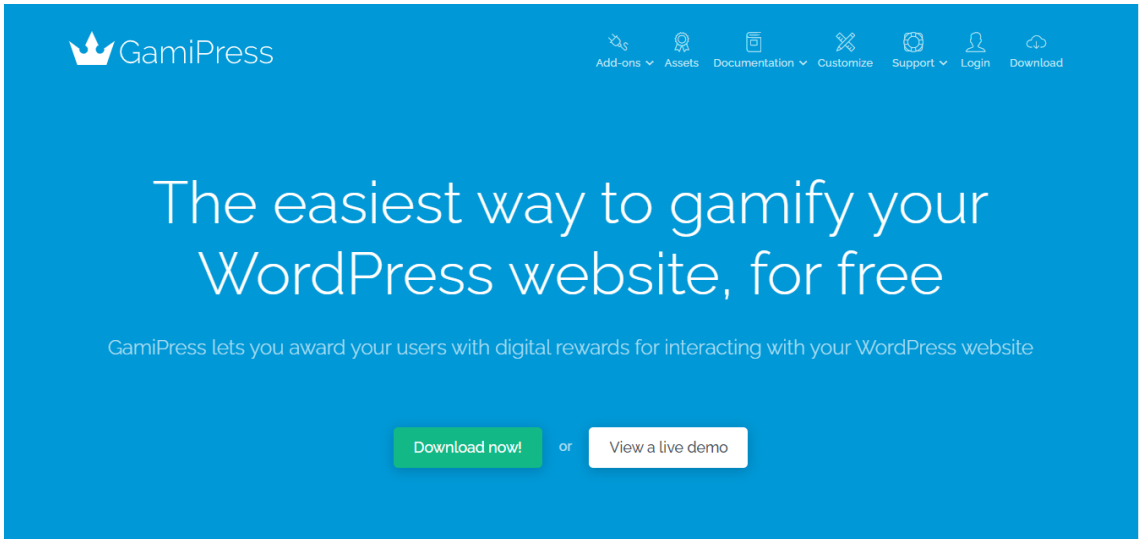

Figure 4.13 - GamiPress initial page

GamiPress has the possibility of interacting with the plugin WpForo, having its own integration system, so that's one of the major reasons in why it was selected to be implemented in the system, becoming easier to gamify it and distribute different awards to the users.

Introducing the types of gamifications, the first one is the points system.

Depending on the type of activity or complete action, the system shall reward a type of point. Knowing that this system will focus collaboration and co-creation, the name of the points is the **Creaty**.

Figure 4.14 - Suggested system point called Creaty, with a complementing image

Creaties are given when several of actions are finished and it's given unlimited times to show how much the user is engaged with the system and promoting itself to others, showing that it's an active user and always looking out for new opportunities. In the image below, it's shown some ways to automatic receive Creaties from daily visiting the website to reply to a topic. These are some of the created automatic achievements but it's possible to add even more, allowing to turn the website even more engaging and rewarding or if, there's too many, delete some of these achievements. The number of points given depends on the type of activity and it could range from 1 to 9999, but it's best to keep it realistic and not exaggerate in the number of points given to small and easy achievements. Because the system is like a serious game, the reward should feel fulfilling to the user and not scare him with the number of points being tallied.

Figure 4.15 -Examples of automatic achievements to receive Creaties

The second type of gamification are the achievements.

Achievements are small or big tasks that must be completed or achieved to receive the reward associated with it, normally extra points, a badge, or other type of reward like a videogame, but because this a real system and focusing on the notion of serious games, the system will only reward extra points and a badge to illustrate the achievement received.

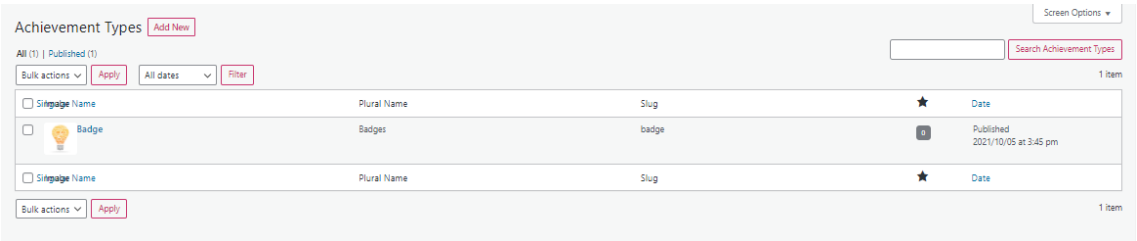

Figure 4.16 - Achievements associated with badges

All the achievements are saved under a group type table called *Badges*, in where it's possible to create new achievements and show all the details like the number of points rewarded, how it's earned, and the max amount it is possible to receive.

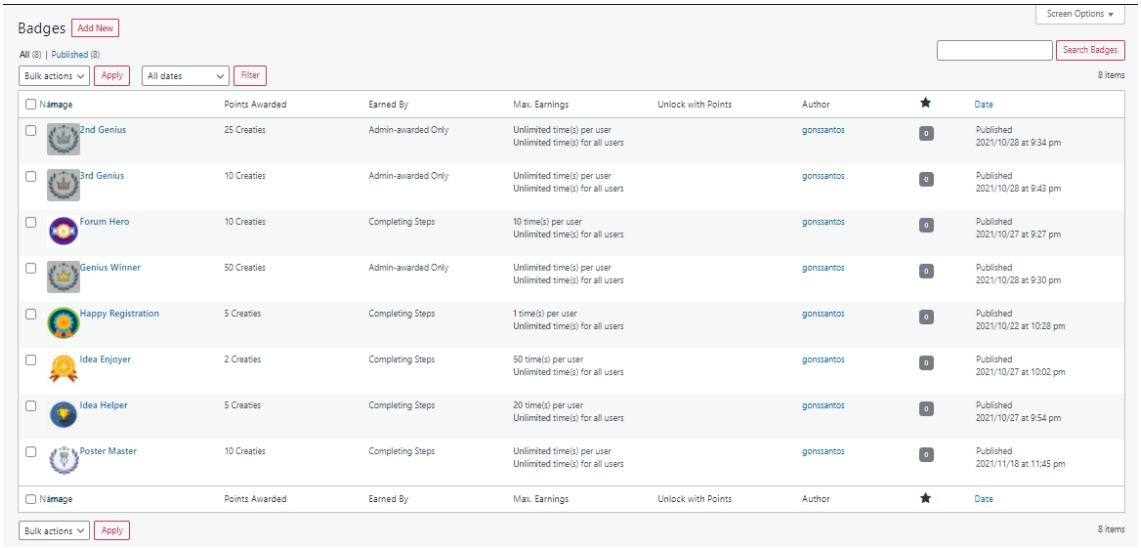

Figure 4.17 - Examples of badges with their respective achievement

Like the points, is possible to create an array of achievements filling the system with achievements of different types for the users to get and try to focus in them because it will be shown in the profile which badges a user already got, promoting them and show the resilience and how active the user is for getting so many achievements.

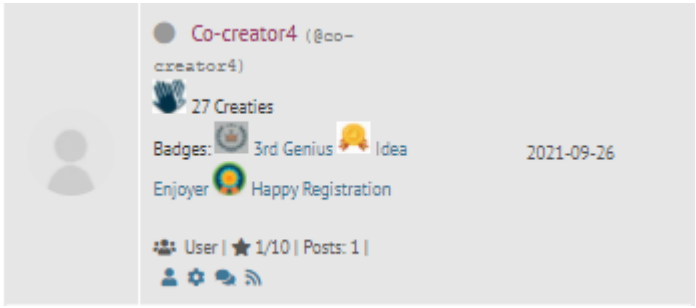

Figure 4.18 - Example of a user showing the different awards received and their respective badges

Each of them is associated with an action to be completed and it's given once is done and the user will receive an alert saying that it received a new badge

and has completed the achievement through the site and through email. Of course, for each achievement it shall receive, too, Creaties, where the number of points depends on the difficulty of the task, where the higher the difficulty, the more points it shall be received.

The definition of the badge is done through the WordPress framework, to program how many points will be awarded, the congratulations text, how it's given and the title of the achievement.

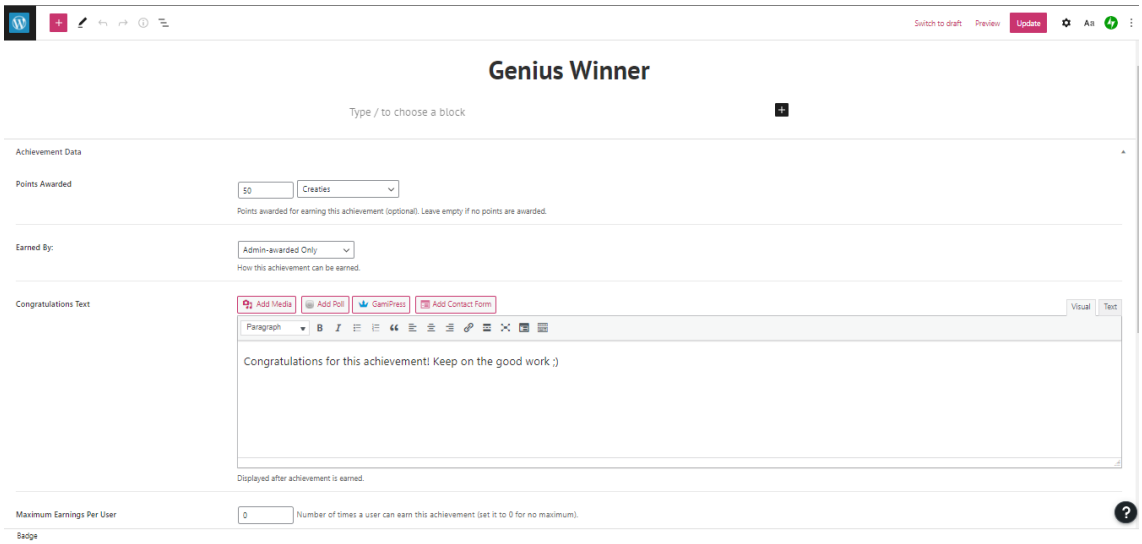

Figure 4.19 - Implementation of a badge with the respective achievement

The plugin allows to monitorize the user earnings to check if all the awards are being delivered correctly and taking the right action in case of malfunction or bad distribution and check the logs for every type of gamification.

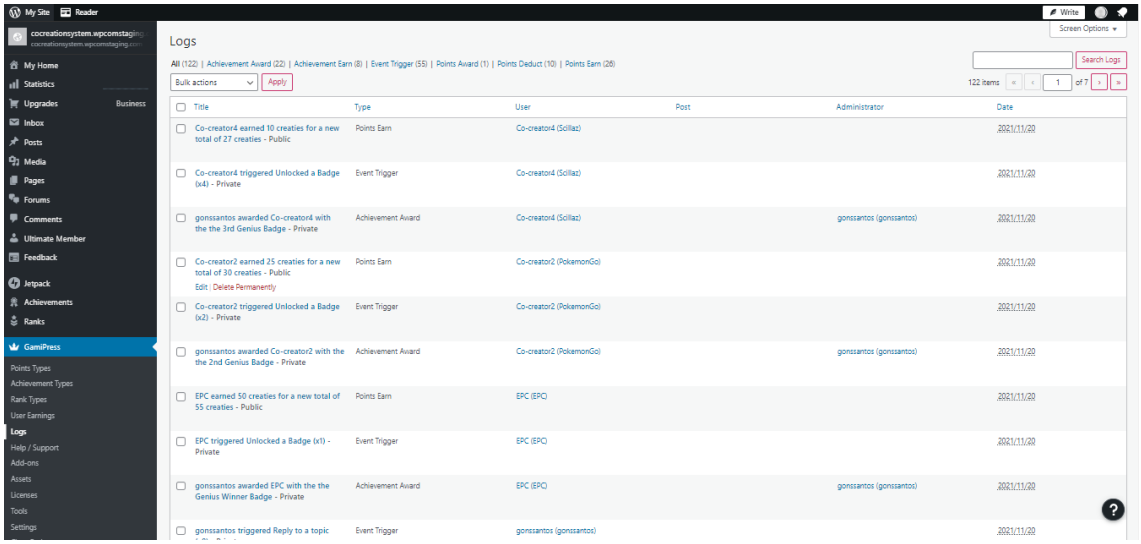

Figure 4.20 - Logs of all the awards received by the participants on the system and the type of event that made reward the points/badges.

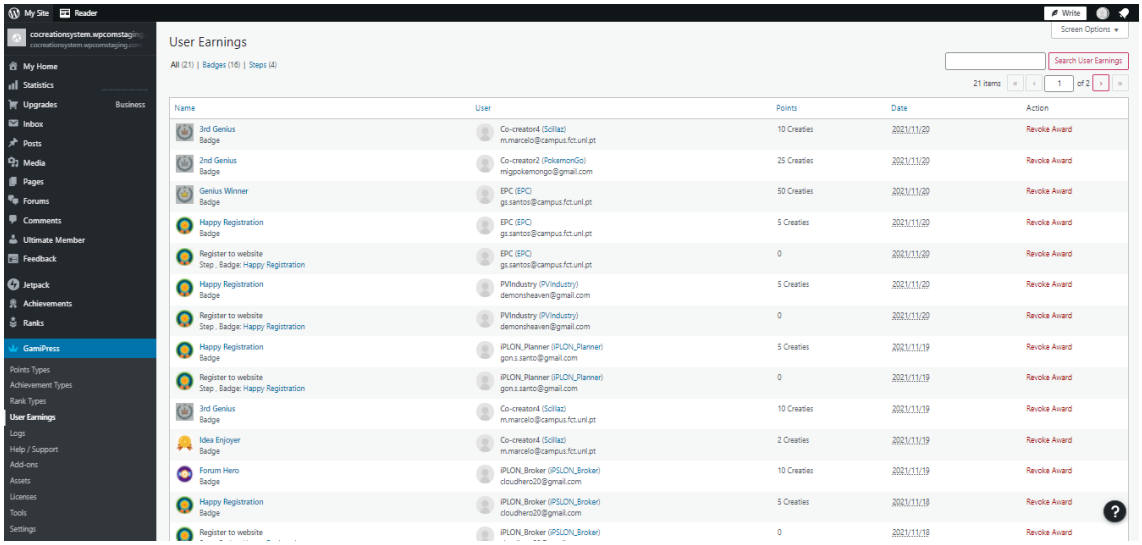

Figure 4.21 - List of the earnings for each user with the points associated

The last type of gamification type in the system are the Ranks.

Basically, ranks are a way to define what type of user it is, giving it an honorary title to bear in its profile and it's possible to unlock them with Creaties. Depending on the amount that a user already has, it can unlock three types of rank: Reacher, unlockable with 25 Creaties; Helper, unlockable with 50 Creaties; and Co-creator, the highest ranking, unlockable with 100 Creaties. This way it gives the users of the system to spend their points but not losing their value in points terms because it's in the ranking title obtained.

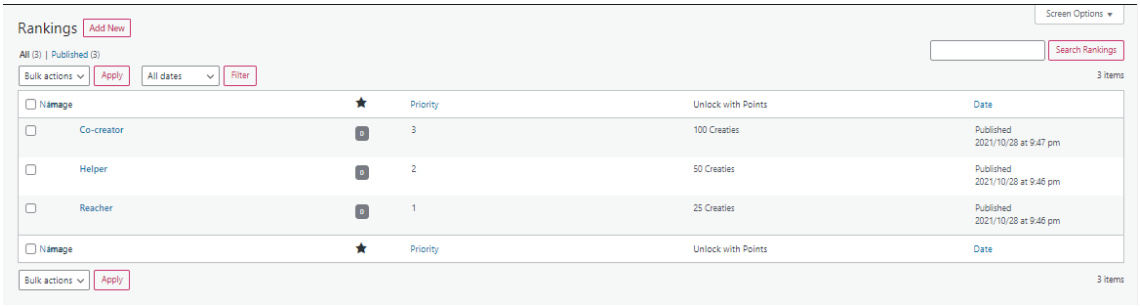

Figure 4.22 - Rankings and the associated price to unlock them

And the way its implemented, it's the same ways as the achievements through the framework of WordPress, by giving a title, a congratulations text and allowing to unlock the rank spending some points.

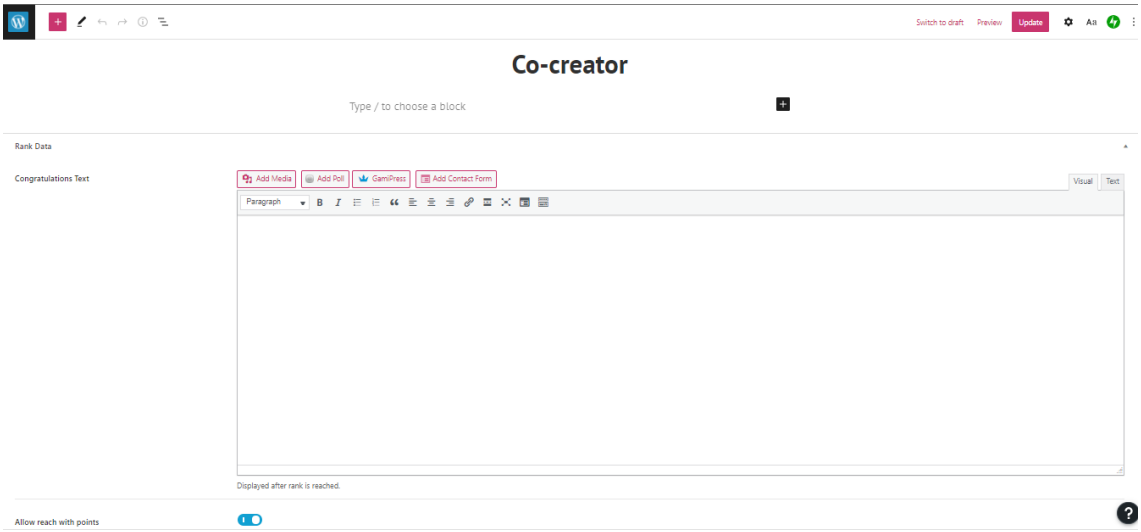

Figure 4.23 - Example of the creation of a ranking.

With this last type, it covers the gamification plugin and how it will function system-wise and interact within the collaboration process between users.

These game elements are inserted in the collaboration layer and integrated with the forum and competition component of the proposed system architecture because that's where most of the gamification will focus, involving all the users in the system.

It also exists other type of gamification here and it takes the form of competitions.

Competitions, in a certain way, is a gamification element because depending on the ranking it's achieved, the participants will receive a natural reward from winning the competition and they will get an achievement for getting on, for the first time, the first, the second and the third place of the competition, and receive points any number of times they reach one of these places. The first place will receive 50 Creaties, the second place will receive 25 Creaties, and the third, 10 Creaties. This will succeed as long the users participate in the several competitions being launched in the system.

To implement these, it was used a plugin called Social Boost and it works as an application to run giveaways, contests, and instant win campaigns. The way it works is simple and straightforward. Because the contests require the posting of a solution, it's necessary to build a competition with an entry method of inserting brief solution descriptions and links to documents.

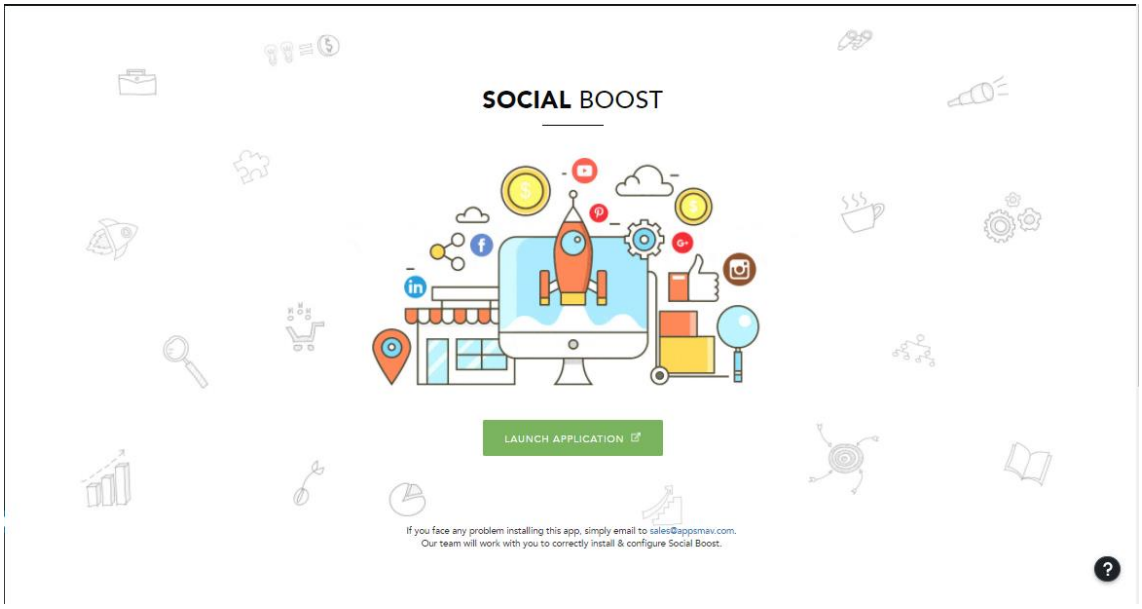

Figure 4.24 - Initial page to launch the competition plugin, Social Boost.

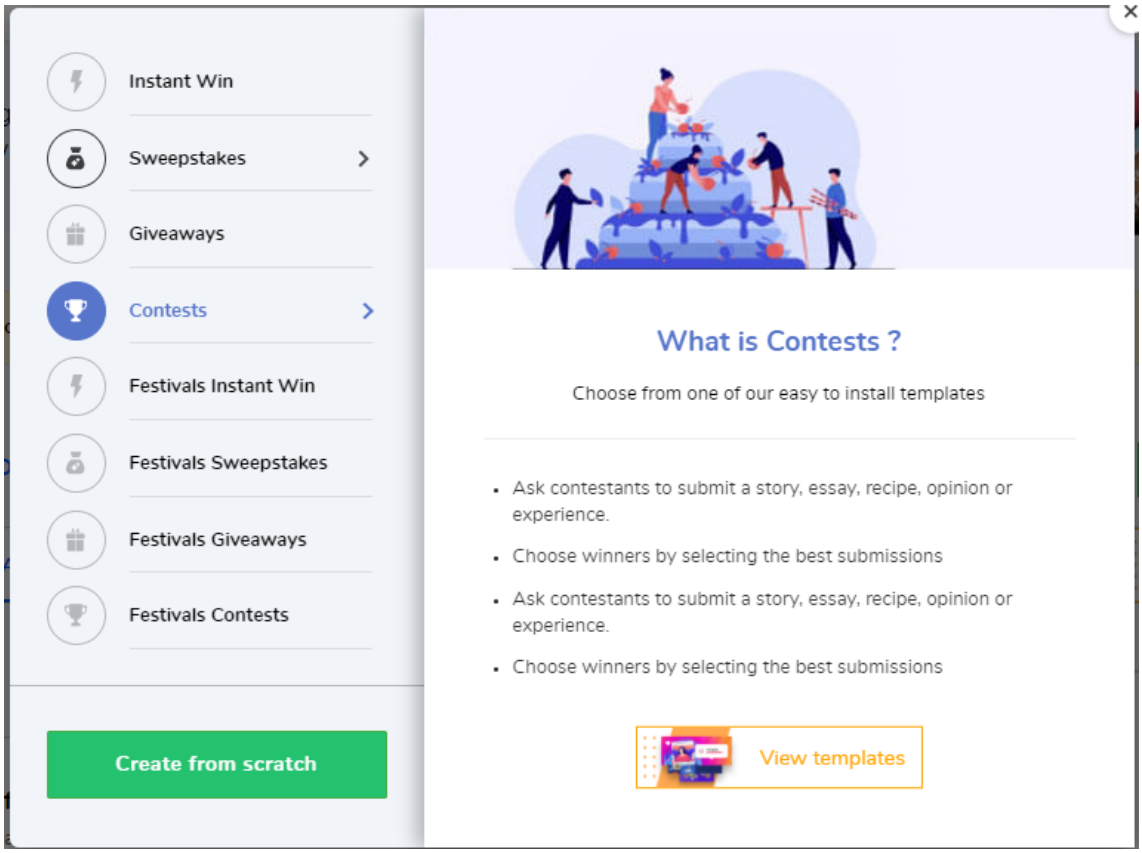

Figure 4.25 - Menu to start the creation of a new contest. The plugin offers multiple types of events with rewards.

To do that, it's necessary to setup a new competition with a name, a brief description of the problem that requires to obtain a solution, give a determined time gate for users to participate, and show the Terms and Conditions for this competition and Privacy Policy. These documents are automatically generated through the system, only being needed to change a few points according to the competition being created.

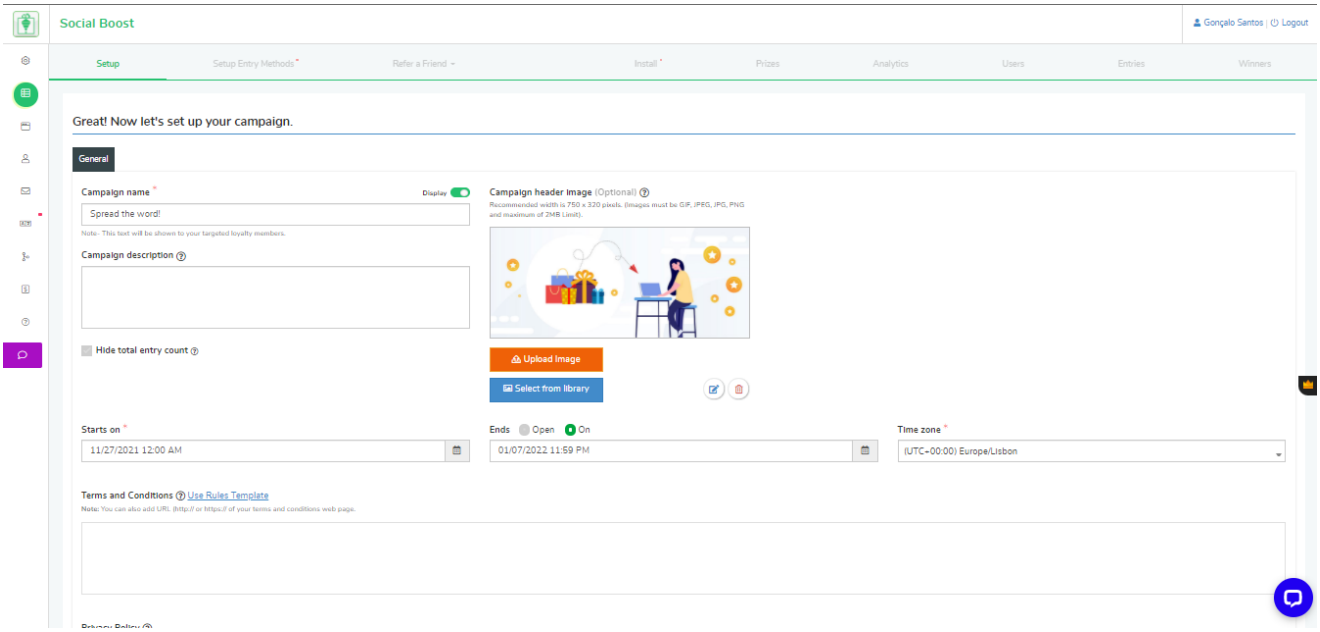

Figure 4.26 - Setup menu of a new competition

After the initial setup, it will be selected the type of entry method. Because it's necessary to answer with a technical solution, the entry method must be able to accept links and written text so in that way the organizer can check all the answers receive.

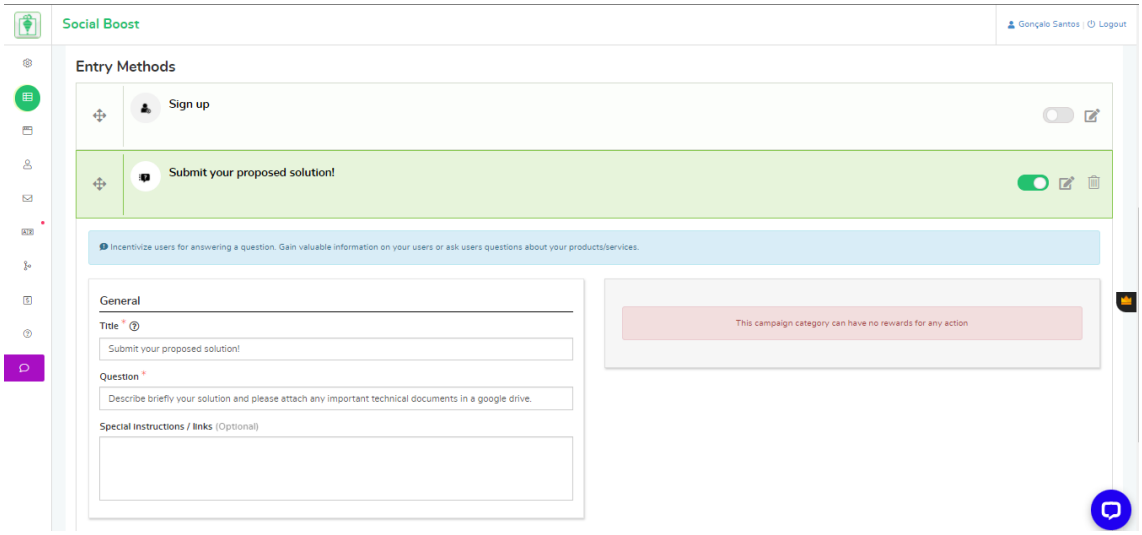

Figure 4.27 - Selection of the entry methods for the competition

Afterwards, it's possible to define the layout of the interface to enter the competition. In here, it will have a preview of the definitions that will be implemented like the font, the background colour and image.

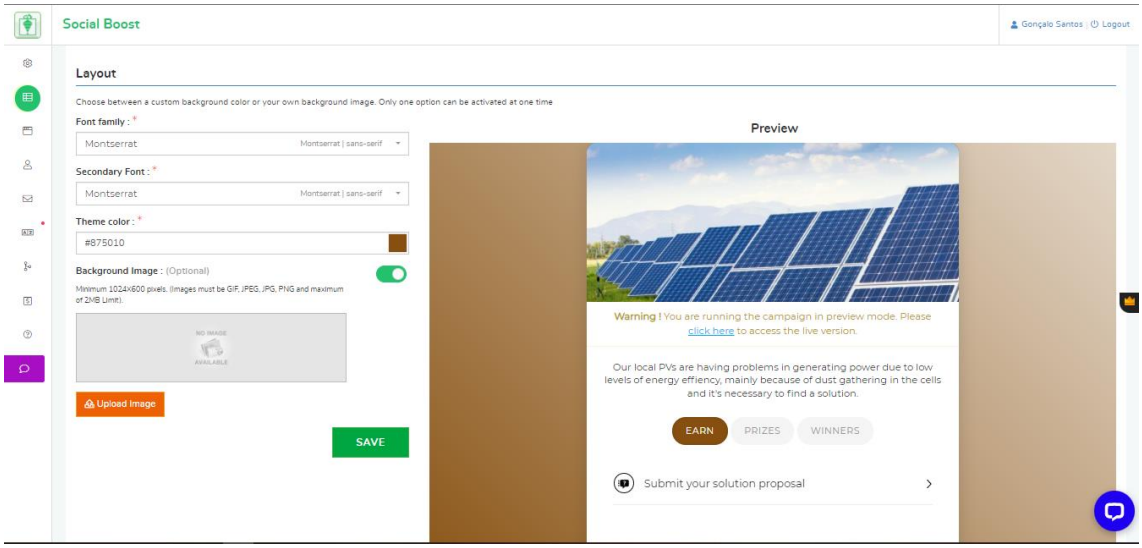

Figure 4.28 - Selection of the layout for the competition.

The next step will be to publish the competition inside a page of the collaboration system, where it's defined the path and a way to be easier to access through a link (image 4.29). This link will be posted in the competition forum and

created a post with the title of it, to show the participants of the collaborative interaction that the competition is open to participate (image 4.30).

The page is automatically created through the framework of Wordpress where it's called a block from the plugin with a shortcode for it and then it's added a home button to return to the main page (image 4.31).

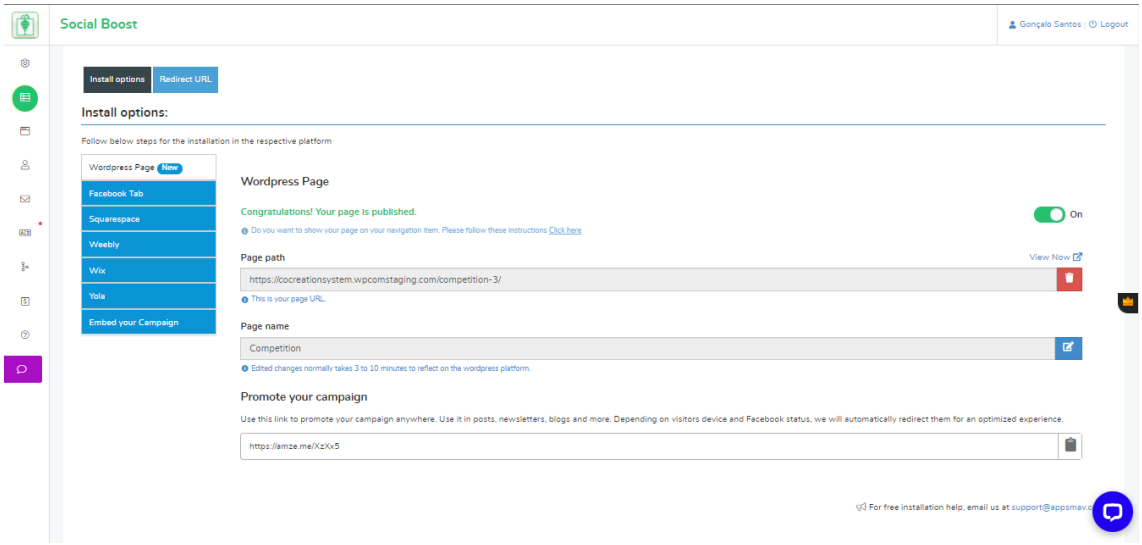

Figure 4.29 - Creation of the page and link to access directly to the competition

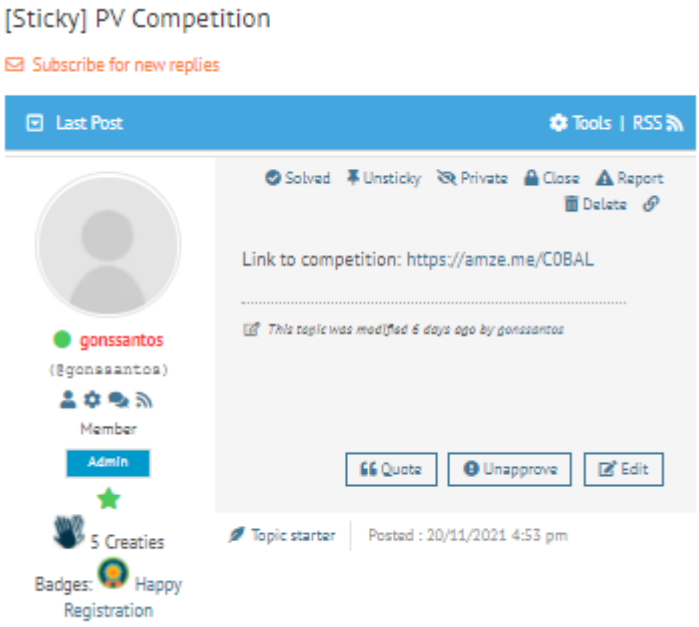

Figure 4.30 - Example of competition link share allowing the participants to enter

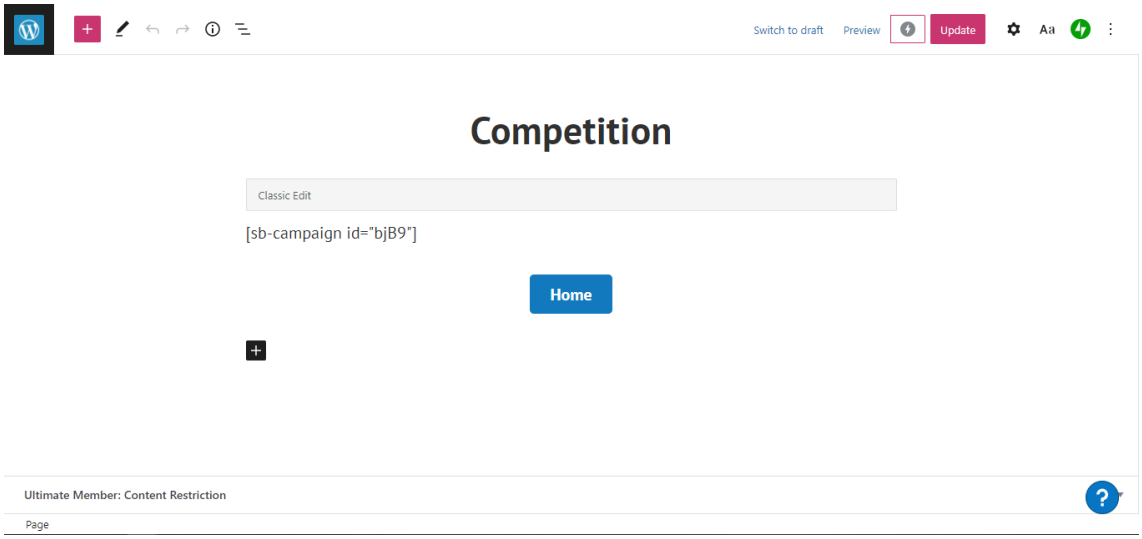

Figure 4.31 - Creation of the competition page with the associated block link

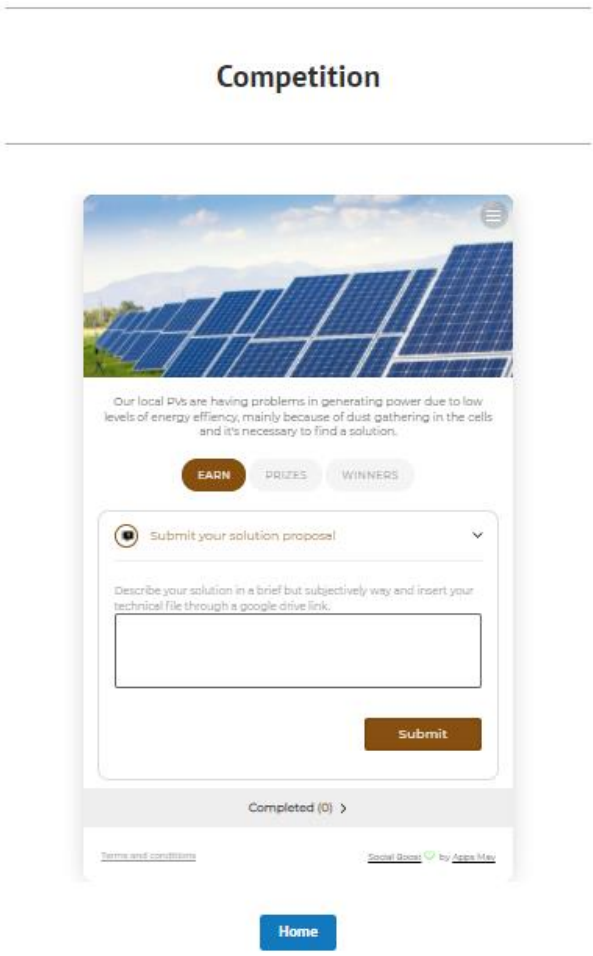

Figure 4.32 - Example of a competition

The complete competition page is shown in the figure 4.32.

All the information related to the competition can be accessed through a .csv file where it saves all the information regarding the participants in a competition, meaning their solution for the proposed problem, the name of the participants and when they posted their solution into the competition. This information data is related to the second part of the data layer of the architecture, which then it will feed the information obtained to be updated in the main database of the system.

With this, the system is fully implemented and ready to use by the VOs who wish to use a new type of collaboration system with gamification elements, showing a new way of creating innovative ideas and develop even further existing business services. The possibilities for this system are limitless and is bound to generate positive reviews to the higher activity users. The sense of receiving achievements and reward can give a sense of winning and allowing them to participate even further. Although, there can be downsides for some participants, the system considered those situations and it's constructed in a way where if some participants don’t win or don't reach the top standings, the users can still receive awards for doing small tasks, giving them a sense of reassurance and to fortify the spirit of not giving up and keep on thriving.

5
Thesis validation

5.1 Study case

Due to the pandemics and the nature of this work, it was not possible to test this in a real-life situation and define partners to participate in the system, so it will be used a case to simulate the interaction between the participants to achieve the same end as the study case.

The study case will begin with a real example case of iPLON (iPLON 2021), where they have low efficiency in electrical power generation due to dust gathering and other impurities encounter the photovoltaic panels and it's necessary to find a solution for this problem. They engaged in co-creation with EPC, where they suggested a semi-automatic cleaning system where they can recycle the water that is being wasted in several activities and then treated and used to clean the dusty solar panels. This case was inserted in the GloNet project, in its early phase, so there wasn't many relevant research results and so it was implemented through traditional methods (Luis M Camarinha-Matos et al., 2015).

Taking all of this into account, it will be simulated in the system all this process and show all the functions and how they work together and simulate other participants to show the challenges everyone can pass to reach the final goal.

For easy understanding, it shall be considered that iPLON and other participants are already registered into the system.

To give a little introduction, the system is a gamified forum with the following URL: https://cocreationsystem.wpcomstaging.com. In the image below, it shows the initial menu, where it's divided in two parts:

- Ideas Sharing and Discussion - where all the participants can interact with each other in the corresponding forum in which they are registered.
- Competitions - where all the participants in a determined forum can participate to win the rights to develop the idea to the problem proposed.

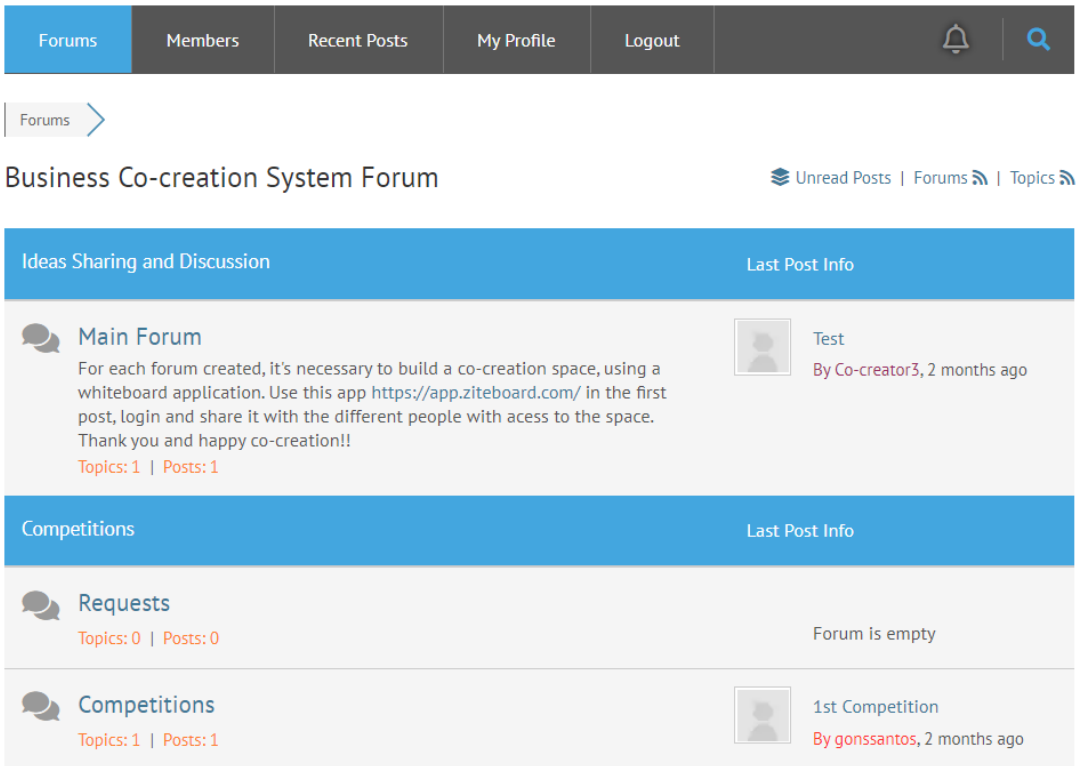

Figure 5.1 - Initial menu of the collaboration system, with the two types of forums: the first with the collaboration part, and the second with the competition part

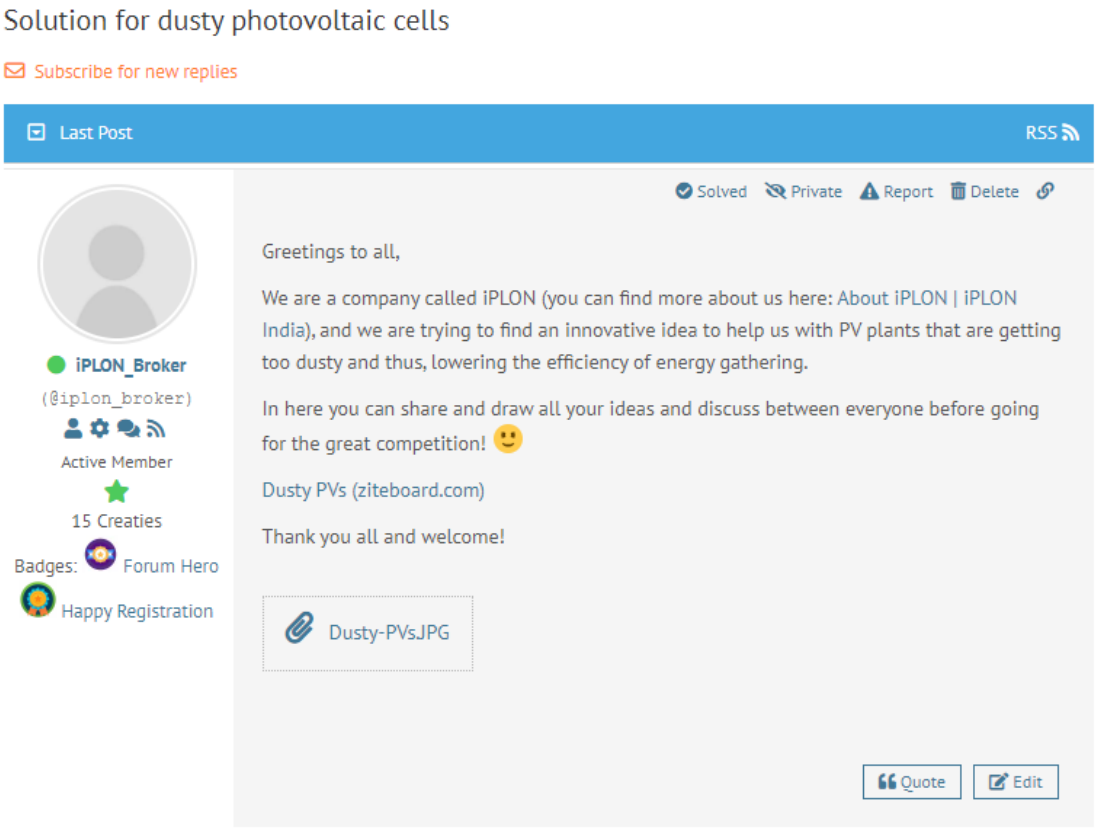

Figure 5.2 - Topic to begin collaboration between the users, giving a small introduction to the problem and inserting a link to the "playground"

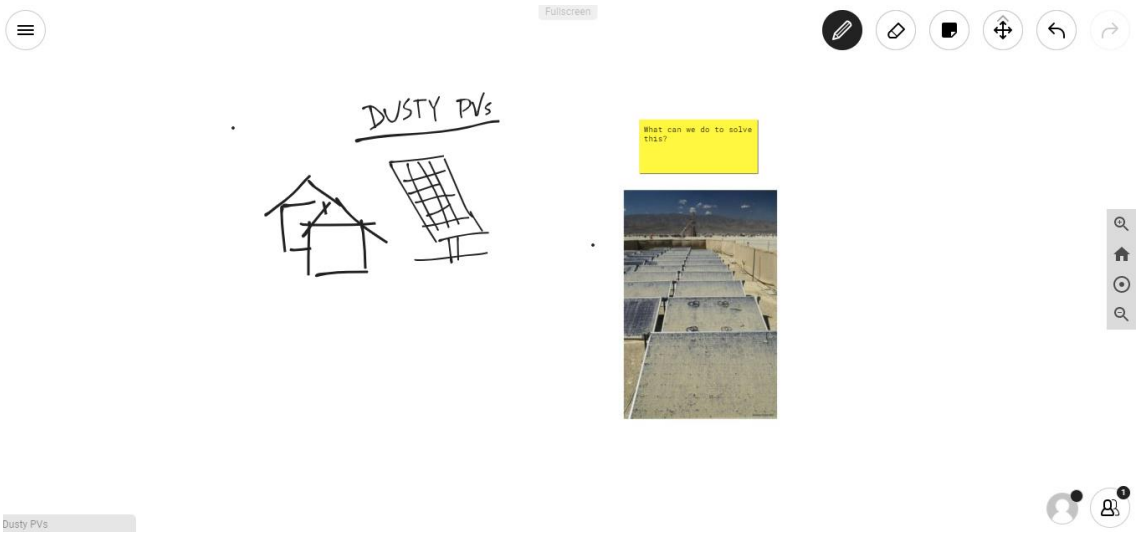

Figure 5.3 - Whiteboard, aka "Playground", where there are some ideas inserted, with bullet points and an image to share with the other participants.

To initiate the co-creation, the VO Broker needs to post a topic with the problem the VO wants to solve. In this case, the problem of having low efficiency with photovoltaic cells. With the topic posted, everyone who wishes to participate is free to do so or the Broker can ask to make the topic private and accessible to a few participants and groups. This area is divided in two parts: one for discussion and the other as a "playground" to design ideas. This kind of interaction can go as long the broker/enterprise wants and feels like the participants gather enough ideas and gained new ways to offer solutions to the problem in hand.

Afterwards, the broker gathers with the planner and stakeholders to hold the competition that will give the rights to develop the idea and receive the final reward.

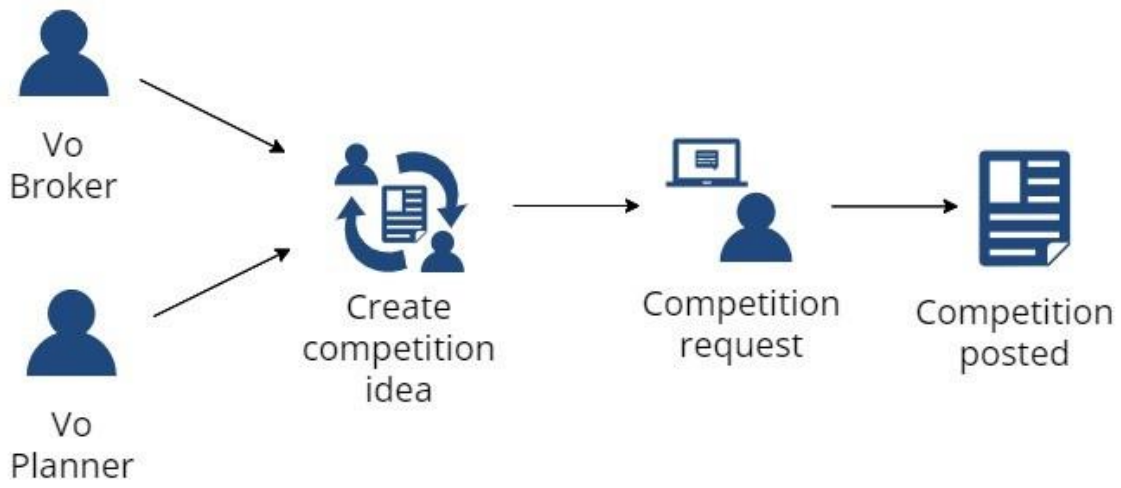

Figure 5.4 - Evolution in how the competition will start from the collaboration ideas inside the forum and posterior activities

After having the full details of the competition and the rewards being given, it will be solicited to the system to create a competition. All the information must be relied on to appeal all the competitors who are engaged in the discussion who wishes to try obtaining the final prize. Because it works like a competition, it's necessary to give a time frame for the participants rearrange the solution and

deliver a final document in how they will tackle the problem, solution proposal and the software and hardware needed to develop the idea

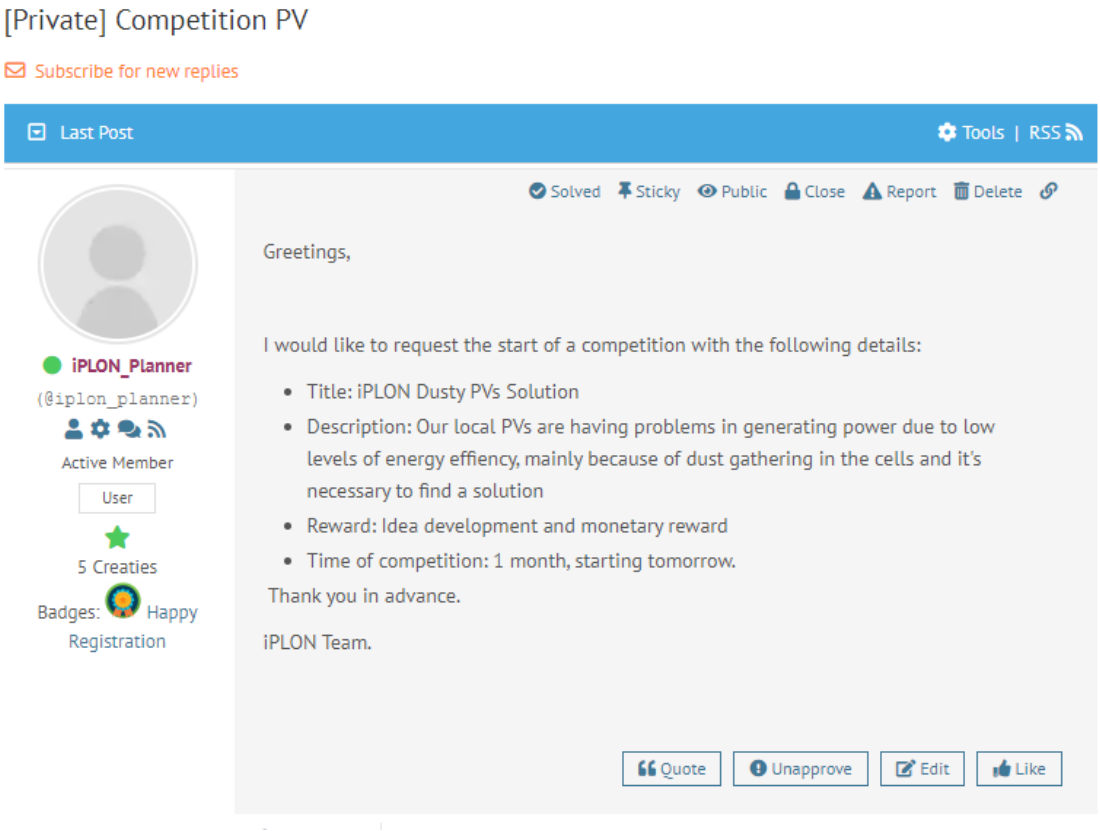

Figure 5.5 - Request for the system administrator, by the part of the VO Planner, to start the competition following the proposed details.

After the system administrator approves the request, it's necessary to create the competition. It will be used an integrated plug-in to create the competition.

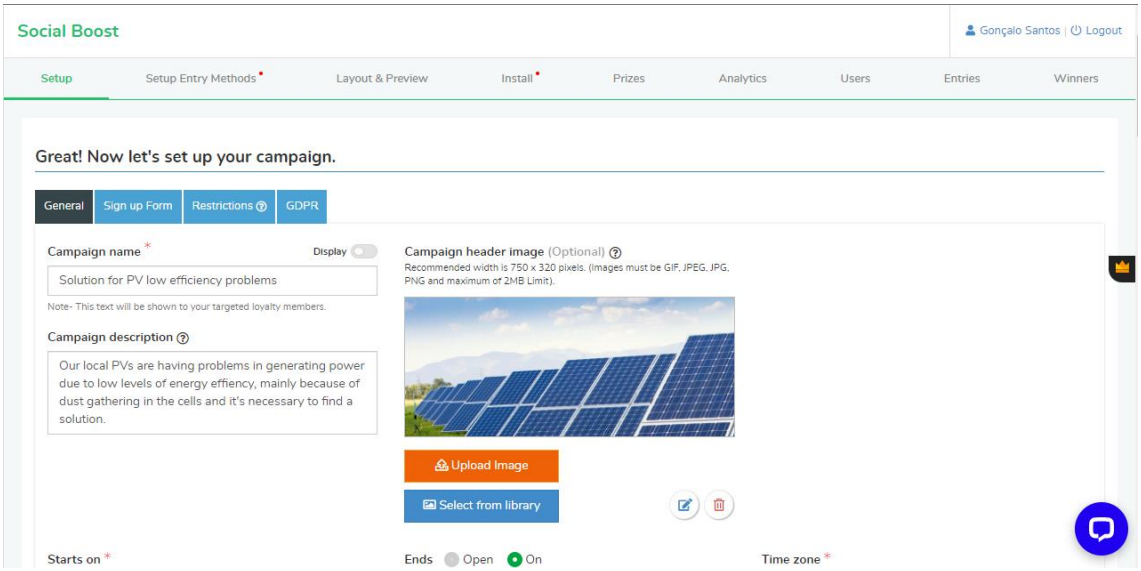

Figure 5.6 - Setup of the PV competition

It was implemented a simple competition form, where the participants just need to post their solution and linking the technical components and files to support their answer.

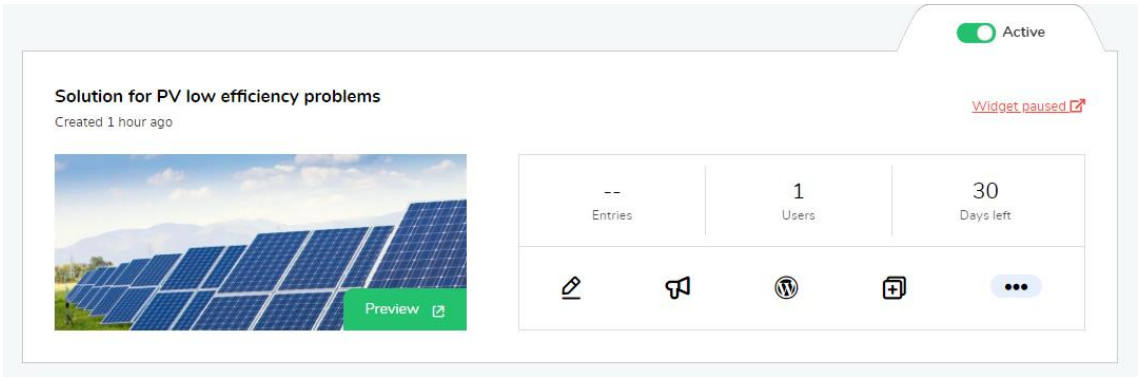

Figure 5.7 - Completion of the PV competition showing all the details related to it

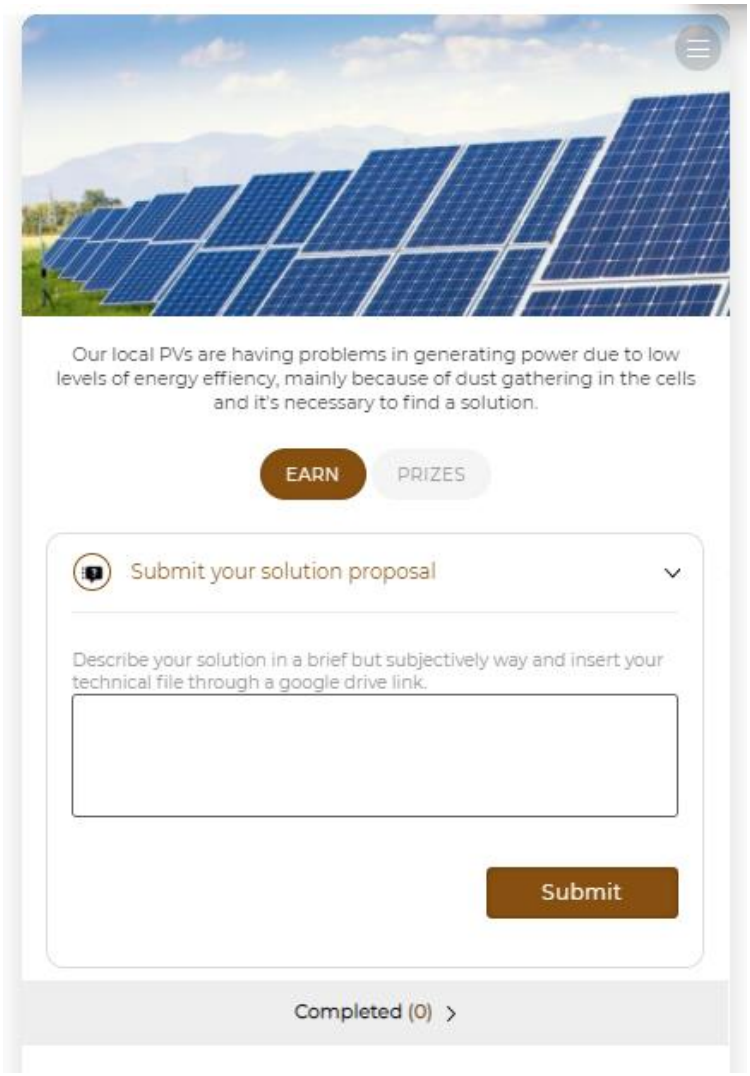

Figure 5.8 - Competition page

The link is then made available to everyone in the forum to participate and try their luck.

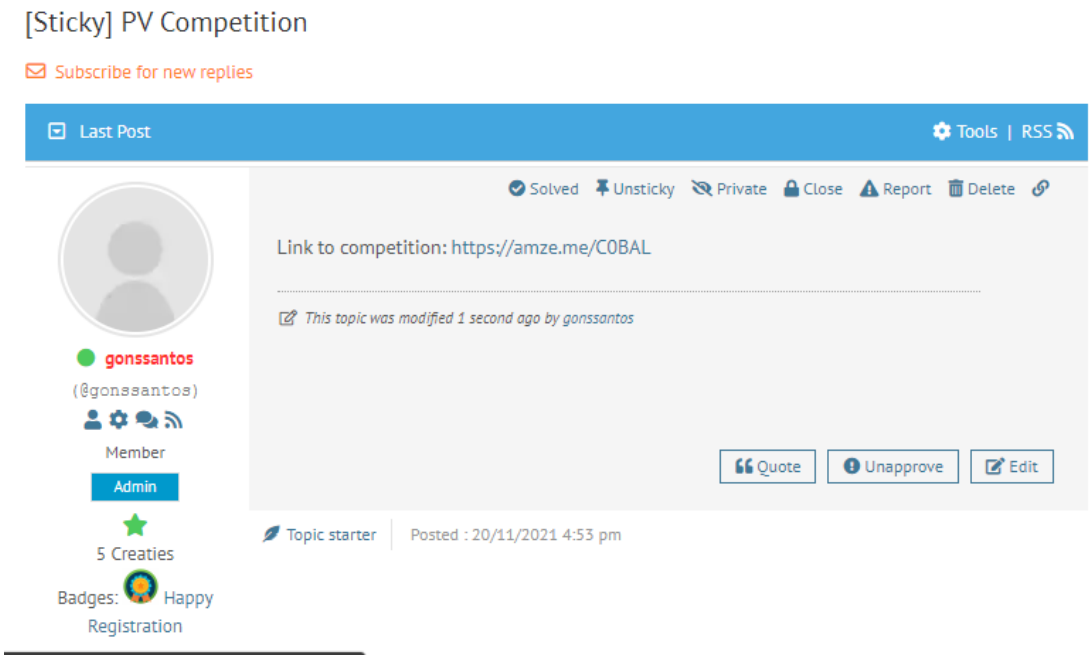

Figure 5.9 - Administrator shares the page and link to the competition for the participants of the collaboration forum

After the time to participate and deliver a solution to the problem ends, the solutions will then be checked by the VO Planner and VO Broker, and the winner and runners-up will be selected, receiving their respective gamified and real rewards.

The system admin can gather all the entries for the competition and share with the VO Planner, where it will share with the VO Broker and decide what solution will give the VO more benefits and it's the most promising and innovative one. For that, it must follow a set of rules and regulations, and through the majority vote of the gathering of interests including stakeholders to reach a conclusion.

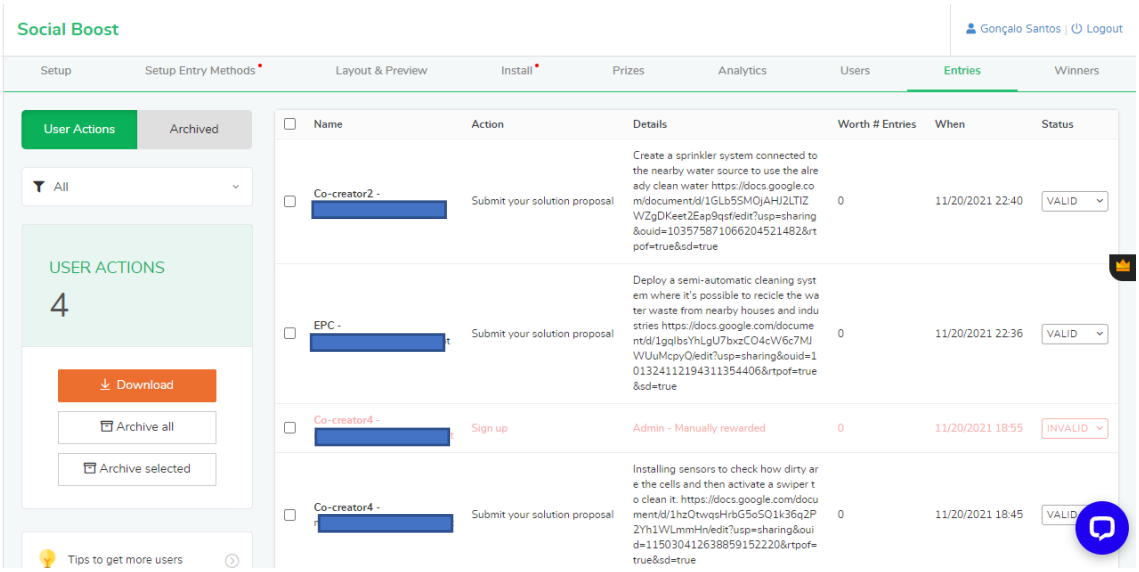

Figure 5.10 - Entries analysis to select the winner and validate all their entries

Reaching a conclusion between the analysis of which entry, the system will proceed with picking the winner and contact him through the email registered in the system, and then deliver the competition awards. Then it shall be announced the winner and the runners-up in the forum.

The victorious participant and the VO will communicate afterwards through a platform of their choice or through direct contact to proceed with all the legalities and contract creation and start the co-creation of the proposed idea together.

The competition will then be finished and the access and further activity with it will be closed.

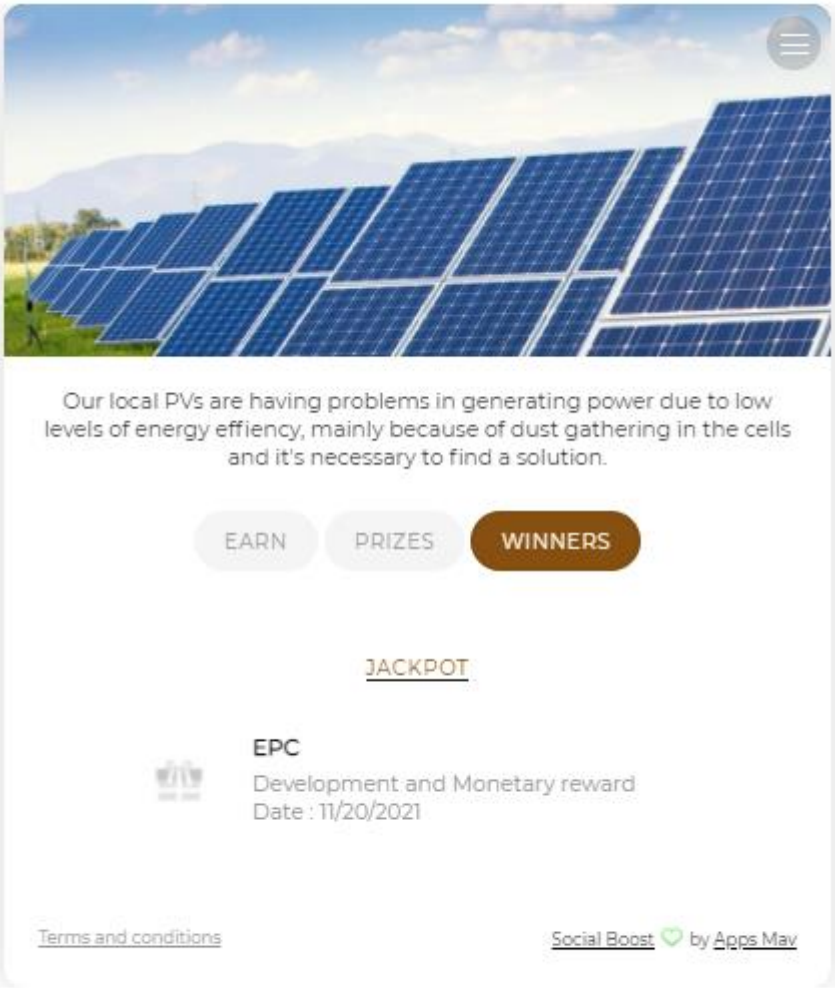

Figure 5.11 - Choice of winner through deliberate discussion and then announced in the competition page.

Figure 5.12 - Announcement of the winners and runners-up on the system.

All the participants were awarded their respective badges and received the amount of "creaties", which is the point system of this system, where is possible to see how much each of the participants achieved. Normally, the higher the number of points, the more active is the user but it must be considered what kind of badges and achievements the user obtained. Either way, these points can be used to gain advantages such as new rankings. Once you win a badge, it will be shown under your name, although it doesn't show how many times you receive it. But when it reaches a new milestone, there will be a warning, and it will be sent an e-mail regarding it.

With the case study replicated to the co-creation system, it was possible to see that the system can help other type of business opportunities to find a solution in a more engaging way and offer a new way of collaboration through friendly competition and game-like elements to be more motivating to enter the cycle again and co-create innovative ideas or enhancing existing services.

The advantage of this type of system is the ease with which it is possible to find solutions or new service ideas to a business that is searching new ways to offer a better service to their clients. In here, the clients or other businesses can help each other through constant communication and being able to "play" with their ideas, showing how they would work and drawing the plan for it. The gamification in the system will enhance the motivation side of the client due to the

reward system implemented and because of the competitiveness amongst the participants of said forum. Anyone can choose an idea that goes with their knowledge and skill, where any type of business or person can participate.

6

Conclusion and future work

Analysing the previous chapter, with the case study from the GloNet project it was possible to simulate all the proposed functionalities focusing collaboration and gamification through the implementation of simple system through Word-Press, a powerful website developer, selected between other researched software like Flarum or The Gamifiers, through a selection of characteristics to organize a benchmark between them.

The notion of gamification was reached using the several elements related to the notion such as points, achievements and rankings (Begumsemis, 2013). This type of elements will help increase the levels of engagement and motivation of the participants to keep using the system and collaborate in the development of new opportunities and ideas. Considering that the competition part makes some people win and lose, (Leclercq et al., 2018) says it can influence the engagement levels of the users, giving a more negative to the loser users. To go against this, it's still possible to receive rewards by doing other tasks or reaching the runners-up place, so that it makes less probable to a user to get frustrated by not winning many competitions and make them to be still in game for future opportunities.

Related to collaboration between VOs, it's possible to any type of user to participate in the system and associate the type of role the VO member wishes to take, mainly a broker and/or planner, to keep in check the opportunities that are appearing or create one themselves.

The hypothesis suggested in the introduction chapter was the following: The insertion of gamification into a collaboration system will help to create a positive impact in the system's participants and make them more engaged in continuing to find new co-creation opportunities through gamification, where they are rewarded game elements like points and achievements. Through the validation chapter, it was shown that the use of game elements potentially increases the levels of engagement in collaboration because the number of rewards received and the interaction between the participants can help in engaging in new co-creation opportunities and turn all the interaction into a cycle of new business services creation.

Regarding the future work for this system, it's possible to enhance through the installation or development of new tools like upgrading the system with a full private conversation program that allows the users to contact with each other in a more efficient way, upgrading the playground with extra activities like attach small videos of examples for the proposed idea.

Related to the gamification, it can be enhanced by installing the system with a leaderboard system to show the position of each user by their number of points or other related elements like the number of achievements received or the number of times it reached the first, second and third place in several competitions.

There are numerous possibilities to enhance the system even further to make it function in a smoother way and with even a better performance, that's where, once more, WordPress shines due to great number of plugins and developing tools to put in the collaboration system.

Other important work to be made is the analysis and study of the engagement and motivational levels to fully understand the impact of these type of gamified collaboration system will have in the technological and business world and how the ways of co-creation can change with them.

7

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8

Appendix

Annex A - Database tables

wp_wpforo_accesses | Rows: 5 | Status: OK					
accessid	int(10) unsigned		-	PRI	
access	varchar(255)	latin1_swedish_ci	-	UNI	
title	varchar(255)	latin1_swedish_ci	-		
cans	longtext	latin1_swedish_ci	-		

Indexes			
PRIMARY	accessid	Un	BTREE
access	access	Un	BTREE

Table 8.1 - Database table regarding accesses to the system.

wp_wpforo_activity | Rows: 13 | Status: OK					
id	bigint(20) unsigned		-	PRI	
type	varchar(60)	latin1_swedish_ci	-	MUL	
itemid	bigint(20) unsigned		-		
itemtype	varchar(60)	latin1_swedish_ci	-	MUL	
itemid_second	bigint(20) unsigned		-		0
userid	bigint(20) unsigned		-		0
name	varchar(60)	latin1_swedish_ci	-		
email	varchar(70)	latin1_swedish_ci	-		
date	int(10) unsigned		-	MUL	0
content	text	latin1_swedish_ci	NULL		
permalink	varchar(1024)	latin1_swedish_ci	-		
new	tinyint(1) unsigned		-		0

Indexes			
PRIMARY	id	Un	BTREE
type	type	0	BTREE
type_objid_objtype	type, itemid, itemtype	0	BTREE
type_objid_objtype_userid	type, itemid, itemtype, userid	0	BTREE
itemtype_userid_new	itemtype, userid, new	0	BTREE
date	date	0	BTREE

Table 8.2 - Database table showing the activity of the system from each user and what type of item they changed or created.

wp_wpforo_languages | Rows: 1 | Status: OK						Indexes			
langid	int(10) unsigned		-	PRI		PRIMARY	langid	Un	BTREE
name	varchar(255)	latin1_swedish_ci	-	UNI		UNIQUE language name	name	Un	BTREE

Table 8.3 - Database table for the language of the system.

wp_wpforo_likes | Rows: 3 | Status: OK						Indexes			
likeid	int(10) unsigned		-	PRI		PRIMARY	likeid	Un	BTREE
userid	int(10) unsigned		-	MUL		userid	userid, postid	Un	BTREE
postid	int(10) unsigned		-			post_userid	post_userid	0	BTREE
post_userid	int(10) unsigned		-	MUL					

Table 8.4 - Database table for the likes gifted or taken depending on the post and user.

wp_wpforo_phrases | Rows: 707 | Status: OK						Indexes			
phraseid	int(10) unsigned		-	PRI		PRIMARY	phraseid	Un	BTREE
langid	int(10) unsigned		-	MUL		lng_and_key_uniq	langid, phrase_key	Un	BTREE
phrase_key	text	latin1_swedish_ci	-	MUL		langid	langid	0	BTREE
phrase_value	text	latin1_swedish_ci	-			phrase_key	phrase_key	0	BTREE
package	varchar(255)	latin1_swedish_ci	-		wpforo				

Table 8.5 - Database table for the phrases of the system.

wp_wpforo_postmeta | Rows: 0 | Status: OK						Indexes			
metaid	bigint(20) unsigned		-	PRI		PRIMARY	metaid	Un	BTREE
postid	bigint(20) unsigned		-	MUL		postid_metakey	postid, metakey	0	BTREE
metakey	varchar(255)	latin1_swedish_ci	-			forumid	forumid	0	BTREE
metavalue	mediumtext	latin1_swedish_ci	NULL			topicid	topicid	0	BTREE
forumid	int(10) unsigned		-	MUL	0	is_first_post	is_first_post	0	BTREE
topicid	bigint(20) unsigned		-	MUL	0	status	status	0	BTREE
is_first_post	tinyint(1) unsigned		-	MUL	0	private	private	0	BTREE
status	tinyint(1) unsigned		-	MUL	0				
private	tinyint(1) unsigned		-	MUL	0				

Table 8.6 - Database table for the metadata of the posts in the system.

wp_wpforo_post_revisions | Rows: 0 | Status: OK					
revisionid	bigint(20) unsigned		-	PRI	
userid	bigint(20) unsigned		-	MUL	0
textareaid	varchar(50)	latin1_swedish_ci	-		
postid	bigint(20) unsigned		-		0
body	longtext	latin1_swedish_ci	NULL		
created	int(10) unsigned		-		0
version	smallint(6)		-		0
email	varchar(50)	latin1_swedish_ci	-		
url	text	latin1_swedish_ci	NULL		

Indexes			
PRIMARY	revisionid	Un	BTREE
userid_textareaid_postid_email	userid, textareaid, postid, email, url	0	BTREE

Table 8.7 - Database table related to the modifications done to a post.

wp_wpforo_profiles | Rows: 10 | Status: OK					
userid	int(10) unsigned		-	PRI	
title	varchar(255)	latin1_swedish_ci	-		member
username	varchar(255)	latin1_swedish_ci	-		
groupid	int(10) unsigned		-	MUL	
posts	int(11)		-	MUL	0
questions	int(11)		-		0
answers	int(11)		-		0
comments	int(11)		-		0
site	varchar(255)	latin1_swedish_ci	NULL		
icq	varchar(50)	latin1_swedish_ci	NULL		
aim	varchar(50)	latin1_swedish_ci	NULL		
yahoo	varchar(50)	latin1_swedish_ci	NULL		
msn	varchar(50)	latin1_swedish_ci	NULL		
facebook	varchar(255)	latin1_swedish_ci	NULL		
twitter	varchar(255)	latin1_swedish_ci	NULL		
gtalk	varchar(50)	latin1_swedish_ci	NULL		
skype	varchar(50)	latin1_swedish_ci	NULL		
avatar	varchar(255)	latin1_swedish_ci	NULL		
signature	text	latin1_swedish_ci	NULL		
about	text	latin1_swedish_ci	NULL		
occupation	text	latin1_swedish_ci	NULL		
location	varchar(255)	latin1_swedish_ci	NULL		
last_login	datetime		-		0000-00-00 00:00:00
online_time	int(10) unsigned		NULL	MUL	
rank	int(10) unsigned		-		0
like	int(10) unsigned		-		0
status	varchar(8)	latin1_swedish_ci	NULL	MUL	active
timezone	varchar(255)	latin1_swedish_ci	NULL		
is_email_confirmed	tinyint(1)		-	MUL	0
secondary_groups	varchar(255)	latin1_swedish_ci	NULL		
fields	longtext	latin1_swedish_ci	NULL		

Indexes			
PRIMARY	userid	Un	BTREE
groupid	groupid	0	BTREE
online_time	online_time	0	BTREE
posts	posts	0	BTREE
status	status	0	BTREE
is_email_confirmed	is_email_confirmed	0	BTREE

Table 8.8 - Database table regarding the profiles of the users in the system.

wp_wpforo_posts | Rows: 9 | Status: OK					
postid	bigint(20) unsigned		-	PRI	
parentid	bigint(20) unsigned		-	MUL	0
forumid	int(10) unsigned		-	MUL	
topicid	bigint(20) unsigned		-	MUL	
userid	int(10) unsigned		-	MUL	
title	varchar(255)	latin1_swedish_ci	NULL	MUL	
body	longtext	latin1_swedish_ci	NULL	MUL	
created	datetime		-	MUL	0000-00-00 00:00:00
modified	datetime		-		0000-00-00 00:00:00
likes	int(10) unsigned		-		0
votes	int(11)		-		0
is_answer	tinyint(1) unsigned		-	MUL	0
is_first_post	tinyint(1) unsigned		-	MUL	0
status	tinyint(1) unsigned		-	MUL	0
name	varchar(50)	latin1_swedish_ci	-		
email	varchar(50)	latin1_swedish_ci	-	MUL	
private	tinyint(1) unsigned		-	MUL	0
root	bigint(20)		NULL	MUL	

Indexes			
PRIMARY	postid	Un	BTREE
topicid	topicid	0	BTREE
forumid	forumid	0	BTREE
userid	userid	0	BTREE
created	created	0	BTREE
parentid	parentid	0	BTREE
is_answer	is_answer	0	BTREE
is_first_post	is_first_post	0	BTREE
status	status	0	BTREE
email	email	0	BTREE
is_private	private	0	BTREE
root	root	0	BTREE
forumid_status	forumid, status	0	BTREE
topicid_status	topicid, status	0	BTREE
topicid_solved	topicid, is_answer	0	BTREE
topicid_parentid	topicid, parentid	0	BTREE
forumid_status_private	forumid, status, private	0	BTREE
forumid_answer_first	forumid, is_answer, is_first_post	0	BTREE
title	title	0	FULLTEXT
body	body	0	FULLTEXT
title_plus_body	title, body	0	FULLTEXT

Table 8.9 - Database table related to the posts of the system.

wp_wpforo_topics | Rows: 5 | Status: OK					
topicid	bigint(20) unsigned		-	PRI	
forumid	int(10) unsigned		-	MUL	
first_postid	bigint(20) unsigned		-	MUL	0
userid	int(10) unsigned		-	MUL	
title	varchar(255)	latin1_swedish_ci	-	MUL	
slug	varchar(255)	latin1_swedish_ci	-	MUL	
created	datetime		-	MUL	0000-00-00 00:00:00
modified	datetime		-	MUL	0000-00-00 00:00:00
last_post	bigint(20) unsigned		-	MUL	0
posts	int(11)		-		0
votes	int(11)		-		0
answers	int(11)		-		0
views	int(10) unsigned		-		0
meta_key	text	latin1_swedish_ci	NULL		
meta_desc	text	latin1_swedish_ci	NULL		
type	tinyint(4)		-	MUL	0
solved	tinyint(1)		-	MUL	0
closed	tinyint(1) unsigned		-		0
has_attach	tinyint(1) unsigned		-		0
private	tinyint(1) unsigned		-	MUL	0
status	tinyint(1) unsigned		-	MUL	0
name	varchar(50)	latin1_swedish_ci	-		
email	varchar(50)	latin1_swedish_ci	-	MUL	
prefix	varchar(100)	latin1_swedish_ci	-	MUL	
tags	text	latin1_swedish_ci	NULL		

Indexes			
PRIMARY	topicid	Un	BTREE
slug	slug	0	BTREE
forumid	forumid	0	BTREE
first_postid	first_postid	0	BTREE
created	created	0	BTREE
modified	modified	0	BTREE
last_post	last_post	0	BTREE
type	type	0	BTREE
status	status	0	BTREE
email	email	0	BTREE
solved	solved	0	BTREE
is_private	private	0	BTREE
own_private	userid, private	0	BTREE
forumid_status	forumid, status	0	BTREE
forumid_status_private	forumid, status, private	0	BTREE
prefix	prefix	0	BTREE
title	title	0	FULLTEXT

Table 8.10 - Database table related to the topics of the system.

wp_wpforo_subscribes | Rows: 1 | Status: OK					
subid	bigint(20) unsigned		-	PRI	
itemid	bigint(20) unsigned		-	MUL	
type	varchar(50)	latin1_swedish_ci	-		
confirmkey	varchar(32)	latin1_swedish_ci	-	UNI	
userid	bigint(20) unsigned		-	MUL	
active	tinyint(1) unsigned		-		0
user_name	varchar(60)	latin1_swedish_ci	-		
user_email	varchar(60)	latin1_swedish_ci	-		

Indexes			
PRIMARY	subid	Un	BTREE
fld_group_unq	itemid, type, userid, user_email	Un	BTREE
confirmkey	confirmkey	Un	BTREE
itemid_2	itemid	0	BTREE
userid	userid	0	BTREE

Table 8.11 - Database table related to the subscriptions of posts/topics/forums by determined user

wp_wpforo_tags | Rows: 2 | Status: OK					
tagid	bigint(20) unsigned		-	PRI	
tag	varchar(255)	latin1_swedish_ci	-	UNI	
prefix	tinyint(1) unsigned		-	MUL	0
count	int(10) unsigned		-		0

Indexes			
PRIMARY	tagid	Un	BTREE
tag	tag	Un	BTREE
prefix	prefix	0	BTREE

Table 8.12 - Database table related to the tags of the topics.

wp_wpforo_usergroups | Rows: 5 | Status: OK					
groupid	int(10) unsigned		-	PRI	
name	varchar(255)	latin1_swedish_ci	-	UNI	
cans	longtext	latin1_swedish_ci	-		
description	text	latin1_swedish_ci	NULL		
utitle	varchar(100)	latin1_swedish_ci	-		
role	varchar(50)	latin1_swedish_ci	-		
access	varchar(50)	latin1_swedish_ci	-		
color	varchar(7)	latin1_swedish_ci	-		
visible	tinyint(1) unsigned		-	MUL	1
secondary	tinyint(1) unsigned		-	MUL	1

Indexes			
PRIMARY	groupid	Un	BTREE
UNIQUE_GROUP_NAME	name	Un	BTREE
visible	visible	0	BTREE
secondary	secondary	0	BTREE

Table 8.13 - Database table related to the user groups of the system and how they are classified.

wp_wpforo_views | Rows: 0 | Status: OK					
vid	int(10) unsigned		-	PRI	
userid	int(10) unsigned		-	MUL	
topicid	int(10) unsigned		-	MUL	
created	int(10) unsigned		-		

Indexes			
PRIMARY	vid	Un	BTREE
user_topic	userid, topicid	Un	BTREE
userid	userid	0	BTREE
topicid	topicid	0	BTREE

Table 8.14 - Database table related to the views of each topic.

wp_wpforo_visits | Rows: 16 | Status: OK					
id	bigint(20) unsigned		-	PRI	
userid	bigint(20) unsigned		-	MUL	
name	varchar(60)	latin1_swedish_ci	-		
ip	varchar(60)	latin1_swedish_ci	-	MUL	
time	int(10) unsigned		-	MUL	
forumid	int(10) unsigned		-	MUL	
topicid	bigint(20) unsigned		-	MUL	

Indexes			
PRIMARY	id	Un	BTREE
unique_tracking	userid, ip, forumid, topicid	Un	BTREE
userid	userid	0	BTREE
forumid	forumid	0	BTREE
topicid	topicid	0	BTREE
time	time	0	BTREE
ip	ip	0	BTREE
time_forumid	time, forumid	0	BTREE
time_topicid	time, topicid	0	BTREE

Table 8.15 - Database table related to the visits to each forum and topic in the system.

wp_wpforo_votes | Rows: 0 | Status: OK					
voteid	int(10) unsigned		-	PRI	
userid	int(10) unsigned		-	MUL	
postid	int(10) unsigned		-		
reaction	tinyint(4)		-		1
post_userid	int(10) unsigned		-		

Indexes			
PRIMARY	voteid	Un	BTREE
unique_vote	userid, postid, reaction	Un	BTREE

Table 8.16 - Database table related to the number of votes made in a post depending on the user.

wp_wpforo_logs | Rows: 11 | Status: OK					
logid	bigint(20) unsigned		-	PRI	
sessionid	varchar(255)	latin1_swedish_ci	-	MUL	
key	varchar(255)	latin1_swedish_ci	-		
value	mediumtext	latin1_swedish_ci	-		

Indexes			
PRIMARY	logid	Un	BTREE
sessionid_key	sessionid, key	0	BTREE

Table 8.17 - Database table related to the logs of the system.