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TRABAJO FIN DE GRADO

DEVELOPMENT OF A TRUSTED GAMIFICATION PLATFORM FOR EMPLOYEE INCENTIVIZATION BASED ON BLOCKCHAIN AND REACTJS

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ENERO 2020

TRABAJO DE FIN DE GRADO

Título:	Desarrollo de una plataforma de gamificación de confianza para la incentivación de empleados basada en Blockchain y ReactJS
Título (inglés):	Development of a trusted gamification platform for employee incentivization based on Blockchain and ReactJS
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Resumen

Entre las tecnologías en auge en la actualidad, cabe destacar una de las más prometedoras, blockchain. Aunque es conocido popularmente por ser el pilar sobre el que se apoyan la criptomoneda Bitcoin, tiene muchas más aplicaciones. Es una tecnología disruptiva que nos permite crear aplicaciones descentralizadas, fiables, y seguras.

Por otro lado, estamos sobrepasando una era digital, en la que el ritmo de la innovación se ha acelerado de manera significativa. Esto impica una necesidad de actualizar de conocimientos con mucha más frecuencia que antes. Esto implica que una ventaja competitiva clave para el éxito de cualquier organización sea la capacidad de aprendizaje. Aunque cada vez mas empresas incluyen programas de formación y desarrollo, todavía existen muchas otras que no ven rentable de incorporarlo.

Para ello se propone una solución barata, y fácil de incorporar y seguir. El proyecto se centra en el diseño e implementación de una plataforma web de gamificación basada en blockchain y *ReactJS* para promover, a través de un token propio a modo incentivo, la formación de profesionales y entre profesionales dentro de las empresas.

Se presentan las pruebas realizadas sobre cada una de las partes individual del sistema implementado. Se ha creado un escenario de simulación para probar el sistema completo con el fin de comprobar que se cumplen los todos requisitos del sistema.

En las conclusiones del proyecto se exponen los resultados obtenidos y los problemas encontrados. A partir de esto y de las numerosas aplicaciones prometedoras de blockchain, se proponen interesantes líneas de investigación y desarrollo para el futuro que completarían útilmente esta plataforma.

Palabras clave: Formación y desarrollo de los empleados, Blockchain, *Ethereum*, Smart Contract, *Solidity*, Token, Tokenomics, *ERC-20*, Gamificación, *ReactJS*, *Redux*, Dapp

Abstract

Among the technologies on the rise today, one of the most promising is blockchain. Although it is popularly known as the mainstay of Bitcoin cryptomontage, it has many more applications. It is a disruptive technology that allows us to create decentralized, reliable, and secure applications.

On the other hand, we are moving beyond a digital era, in which the pace of innovation has accelerated significantly. This creates a need to update knowledge much more frequently than before. This implies that a key competitive advantage for the success of any organization is the ability to learn. Although more and more companies are including training and development programmes, there are still many others that do not see the profitability of incorporating them.

A cheap, easy to incorporate and follow solution is proposed. The project focuses on the design and implementation of a web platform for gamification based on blockchain and *ReactJS* to promote, through a token itself as an incentive, the training of professionals and among professionals within companies.

The tests carried out on each of the individual parts of the implemented system are presented. A simulation scenario has been created to test the complete system in order to check that all system requirements are met.

The results obtained and the problems encountered are presented in the conclusions of the project. Based on this and the many promising applications of blockchain, interesting lines of research and development are proposed for the future that would usefully complete this platform.

Keywords: Training and Development, Blockchain, *Ethereum*, Smart Contract, *Solidity*, Token, Tokenomics *ERC-20*, Gamificación, *ReactJS*, *Redux*, Dapp

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CHAPTER 1

Introduction

1.1 Context

In an ever-increasing competitive environment, companies need to get the best out of their employees. Several quite obvious factors directly affect the performance of these employees, such as the work environment, motivation, etc. However, there are also not so obvious factors, or at least, not as considered as they should be, that have been scientifically proven to be as important as those mentioned above. One of these and perhaps the most important is the training that a company provides to its workers[5][6].

A digital era in which change occurs considerably faster than before is currently underway. Human accomplishments are taking place at a significantly higher rate. This means that to live up to the task, training must constantly be updated. Therefore, the ability to learn will become the most valuable competitive advantage/necessity of any organization. In fact, in the United States of America, training expenditures have increased more than 48,7% since 2012 with a total value of 83 billion dollars in 2019 [7]. The market size of the workplace training industry in North America has increased more than 51,6% since 2008 with a present volume of 166.8 billion dollars [8]. The biggest firms feature this

strategy. This year alone, Amazon[1] has invested $700 million to provide in-service training programs[9]. But other corporations such as Google[2][10][11], Apple[3][12], Facebook[13], IBM[4][14], Microsoft[5][15], and LinkedIn[6][16] are no less and also carry out this practice[7].

Nonetheless, still to this day, numerous business owners tend to see employee development programs as optional rather than crucial because it is very often perceived as an expense over an investment. This viewpoint is understandable as it is generally approached in the wrong way. Many times this strategy is carried out without knowing well what results to expect or because the targeted results are not the ones they should be focusing on. Instead, more indirect but reliable results should be taken into account as they turn out to be the real benefits of this strategy[18].

Among these benefits the following stand out (more detailed explanation in [Chapter 2.2]):

- **Improved employee performance** – By acquiring better skills and knowledge, employees achieve greater potential and motivation, and thus, better results in their work.
- **Improved employee satisfaction and retention** – When a company takes care of its employees, it makes them feel more valued. This, of course, leads to a greater commitment but also a stronger loyalty to the company.
- **Enhances company reputation and profile** – Having a good business training program is one of the best advertisements. Attracting more applicants is the best way to improve the staff of the firm.

Although for each company this may apply in a particular manner, some must implement stronger or weaker programs, and others even both depending on their situation, absolutely all enterprises should create a learning and development culture as profitability is assured and does not necessarily require large costs (e.g., Googles' Whisper Courses[8]), it is essential for the long-term success of the company, and provides important advantages and significant profits.

[1] More info. at https://www.aboutamazon.com/working-at-amazon/upskilling-2025
[2] https://grow.google/intl/europe
[3] https://training.apple.com/
[4] https://www.ibm.com/services/learning
[5] https://www.microsoft.com/learning/
[6] https://learning.linkedin.com/
[7] IBM was top 3 in 2018 for enterprise-wide success as a result of employee talent development[17].
[8] https://rework.withgoogle.com/blog/whisper-courses/

A great way to raise awareness of these types of programs within the company and increase motivation to engage in them is through **gamification**[19], encouraging employees through incentives. Gamification is the process of transforming work activities, or other non-game related duties, into game-oriented ones by making such exercises more engaging and rewarding for employees[20]. The main reason why gamification works is that it harnesses the most influential motivators: recognition, sense of competition, and reward, making the process more enjoyable, and thus increasing employee engagement[21].

This technique implies more advantages within the main one mentioned above. Applied in the right way, one of these is that it can encourage employees not only to learn but also serve as a greater impetus to teach. Which at the same time significantly reduces costs. Once an employee has learned or already knows about a subject, the organization no longer needs to pay for those courses [Chapter 2.2.1].

Blockchain is a disruptive technology famously known for Bitcoin cryptocurrency, although the reality is that it has many more applications. Specifically, blockchain allows us to create decentralized applications, commonly referred to as DApps. Currently, there are numerous blockchains on which these Dapps can be implemented. Some of the most famous are: Ethereum[9], Corda[10], Hyperledger Fabric[11], OpenChain[12], EOS [13] y Stellar[14]. This type of application can be created by means of *smart contracts*, in which rules are defined in a programmatic and deterministic way. These rules must be fulfilled by everyone involved, these blockchain programs make sure that they are met. As it is known this technology offers several strengths. It grants greater transparency, enhanced security, improved traceability, increased efficiency and speed, and reduced costs, in addition to many others[15]. But a particular advantage, which complements the gamification technique very well, is the use of tokens. This way, blockchain can help to build incentives in a secure fashion, and consequently generating real and reliable rewards[22].

[9] https://ethereum.org
[10] https://www.corda.net/
[11] https://www.hyperledger.org/projects/fabric
[12] https://www.openchain.org/
[13] https://eos.io/
[14] https://www.stellar.org/
[15] https://www.ibm.com/blogs/blockchain/2018/02/top-five-blockchain-benefits-transforming-your-industry/

1.2 Motivation

Out of the breakthrough technologies of the 21st-Century, one that has been given the most attention in recent years is blockchain, and rightly so. It is a very interesting technology and although many dispute its applicability because of the challenges it must face, the truth is that this technology will solve many problems in the future[23].

During the last academic year, a cursory glance of this technology was imparted in a cybersecurity class, and more in-depth knowledge of web technologies was taught (these included ReactJS and Redux). For this reason, it seemed interesting to undertake a project combining both, and through which this knowledge would be applied while learning more about it in the process.

Initially, one compelling idea was to develop a project that sought to solve the problem of employees' dedication to their work. The idea was a blockchain-based application that, through the gamification of the employees' work processes, would somehow quantify the tasks completed, the efforts made, and the performance achieved, which would provide them with an improvement in all these aspects.

It was also proposed to design a system that would provide incentives for interdepartmental assistance in organisations. But finally the decision was taken to postpone this option because, although it would favour aid between employees, a study carried out determined that, although improvement could be made, the lack of interdepartmental support was not a very serious problem, and therefore the solution would not be sufficiently demanded. It can be implemented as a complement to the system in the future (See 7.2. Future Work).

As we have already mentioned in the context, employee training in companies is increasingly necessary. In addition to this, it brings very good benefits among which are the productivity and dedication that the employee has at work. Therefore, carrying out a project that focuses on employee training would allow us to solve the main concern we had when the first idea was raised, motivation and dedication at work. But it turns out that this approach also leads to more improvements such as efficiency, better quality of the work they perform, etc. For these reasons it was decided to combine these attractive technologies together with a technique called Gamification, for a greater promotion of the system and a greater incentive to train, in order to put a proper solution to this problem.

1.3 Project goals

The aim of this project is to design a system to encourage training among employees through incentives and to implement a functional PoC (Proof of Concept) with a web interface for users.

To achieve this, a blockchain will be used to support the smart contracts needed to create the incentives and *the academy* that will manage them. In parallel, a front-end will be developed, and the remaining back-end, supported by the web technologies previously mentioned. And then, both parts will be joined. Thus, the **project goals** can be enumerated as follows:

- To provide an easy to use and appealing web application accessible from most popular browser.
- Gain agility in the execution of training actions, from the request for training to the completion of the course.
- Increase the degree of decentralization in the management of training, which is usually responsibility of the human resources staff, to reduce these costs as well as the maintenance costs of traditional platforms.
- Provide greater autonomy to the employee when deciding which courses to take. And give them the oportunity to teach in whatever fields in which they have experience.
- Increase the culture of knowledge transfer within the company, as well as motivation, engagement, satisfaction and performance of employees in the workplace.

And reach these goals, the main **project tasks** to be undertaken include:

- Study the state of the art of business training programs, gamification and blockchain.
- Study the system use-cases to have firm and clear requirements.
- Design the complete system architecture and from this, build a data model that separates the data to be stored in the blockchain and the data to be stored externally.
- Create a token (smart contract) following the ERC-20 standard.
- Design and implement a second smart contract to handle courses, users and tokens.
- Develop the client side.

- Develop the necessary scripts for the correct interconnection of the smart contracts and the web application.
- Create a fictitious scenario to check that the requirements are met.

1.4 Structure of this document

In this section we provide a brief overview of the chapters included in this document. The structure is as follows:

Chapter 1 introduces the project. It provides the context in which the project is developed, reasons that have led to a work on this subject, and what the main goals of the project are.

Chapter 2 gives some relevant background investigation as well as a brief state of the art. Proposal statement.

Chapter 3 explains the technologies that have been used to support all the work and the reason why they have been chosen.

Chapter 4 describes a series of use cases of the product. Functional and non-functional requirements are presented.

Chapter 5 describes the architecture of the project including the multiple modules it is composed of and how it was implemented.

Chapter 6 describes the test performed including the fictitious scenario created for the PoC demo.

Chapter 7 presents conclusions, goals achieved, and problems encountered, as well as purposes future development lines for the project.

CHAPTER 2

Background and related work

2.1 Introduction

In this chapter, a series of background knowledge relevant to the project and a brief state of the art will be presented. As this project does not exist in its entirety as such, this chapter is divided into parts in which there a more defined background. The best examples of each of the sections are presented. These have been chosen mainly for their convenient functionality and for having a better fit with our solution. At the end of this chapter, a proposal that brings together the characteristics of each of the projects is presented.

2.2 Training and development

In the context [Chapter 1.1], a brief outline of the data on training in enterprises was given. This section provides a more in-depth analysis of the benefits of introducing this feature as well as some interesting existing approaches for it.

The need to implement it is set out in the following data:

– A growing trend of incorporation of these programs seen in increasing spending by

companies, more and more companies are incorporating it [Figure 2.1]

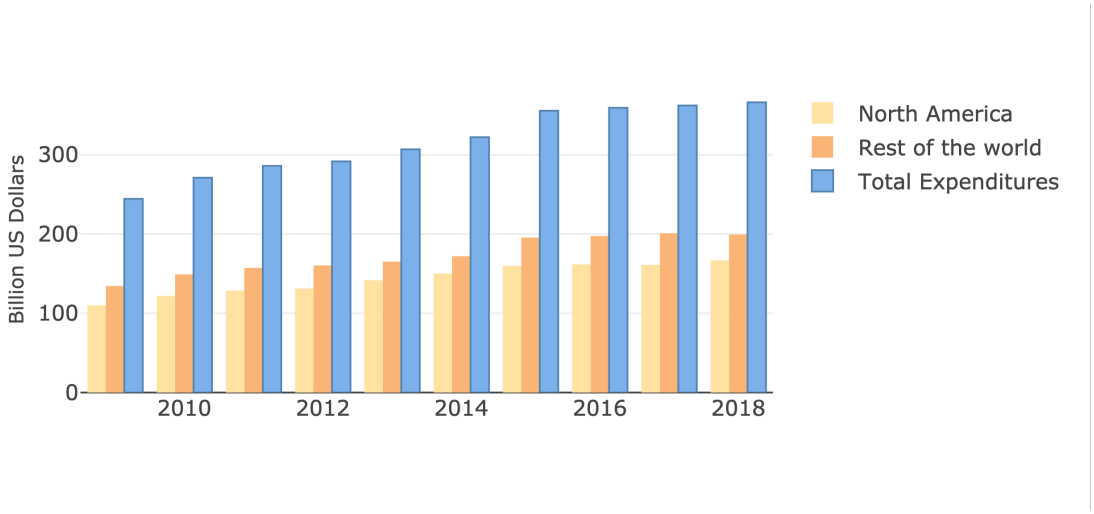


Figure 2.1: Growing Spenditures For the las 10 years[1][2]

– Increased demand for employee learning programs. Employees consider it is considered one of the most important features. Also, the lack of it is the number one reason why employees quit their job [Figure 2.2].

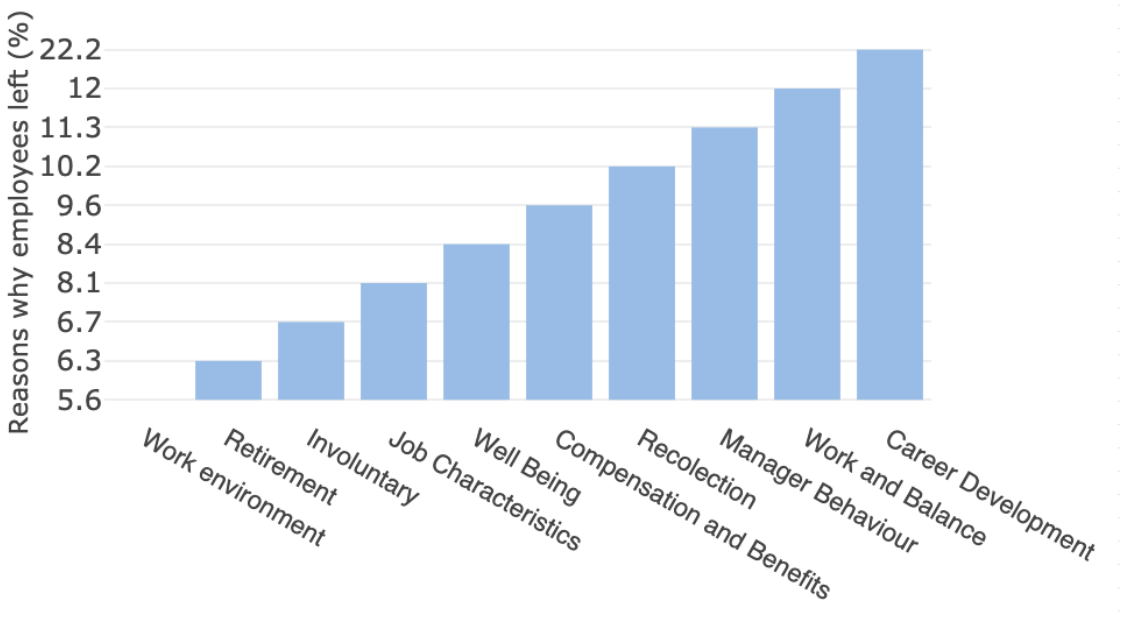


Figure 2.2: Why do employees quit their job [3]

– A multitude of articles that support the benefits provided. These are described and

justified below[1].

Among these benefits of incorporating an apprenticeship program in a company[2] [36][37], the following stand out:

- **Improved employee performance** – The employee who receives the corresponding training has a better performance in their job. It allows strengthening those skills that each employee needs to improve as it provides them with both soft and technical skills that their job may require. Those employees who are more skillful are more capable if their knowledge and abilities are constantly renewed as being conscious of the changing industry standards at all times allows them to better maintain and improve the position of the company towards the rest of the market competitors. Knowing their possibilities of developing themselves and, thus, the ones getting promoted are higher, gives a stronger motivation. Also, a greater understanding of their responsibilities within their role is obtained and, in turn, these employees build increased confidence which enhances overall performance. As far as the company is concerned, it is in its best interest that the basic policies and procedures of the company are known since, for obvious reasons, it is necessary that all employees are aware of what they can or cannot do, how it is normally done and also of the expectations within the corporation. Additionally, these programs may serve to balance the knowledge and skills of employees by reinforcing those with poorer skills which at the same time helps to reduce the weak links in the company on which others depend to complete basic tasks of their work. A This can only benefit the company as increased efficiencies in processes result in financial gain. Further, helping workers expand their career competencies leads to greater job satisfaction. [5] [6] [18] [38] [39] [40] [41] [42] [43]

- **Improved employee satisfaction and retention** – As mentioned above, if an employee understands well what their job is and how to do it, they gain confidence. This confidence improves their work meant, its importance, but also increases their happiness performing it. Also, the company investing in them makes them feel more valued, especially if it allows them can access training that they would otherwise not be able to access or would not have known. *Employees who feel appreciated and challenged through training opportunities may feel more satisfaction toward their jobs*[18]. This results in higher loyalty to the company and, therefore, reduces employee resignations. A report presented this year by Work Institute stated that the first reason why

[1]To see the studies that support this information go to the citations and footnotes provided.

[2]Based on articles from major magazines: "Entrepreneur": [24][25]; "The Economist": [26]; "Forbes": [27][28][29][30][31][32][33][34]; "Fortune":[35]

employees quit their jobs is because of the lack of training and development opportunities with a percentage of 22%[3]. With a quality, well-oriented training program, companies can retain their employees, including the top ones, as they can develop themselves, promote within the company, and see no need to go anywhere else to expand their skills. This, coupled with reduced recruitment costs due to lower employee turnover, conducts a growth in profits. Research conducted by the Massachusetts Institute of Technology showed that "companies that moved from a low level of employee engagement in the first year to somewhat engaged the following year showed a 19% average increase in earnings per share and companies that moved from a moderate level of employee engagement to the highest level of engagement showed a 132% average increase in earnings per share"[44][3]. [18] [41] [42] [43] [48] [28]

- **Enhanced company reputation and profile** – The number one job for companies is to attract the right employees. The more competent these are, the better the effectiveness it is reached. Having a sound learning and development strategy boosts the employer brand and makes the firm a compelling choice for job seekers. Plus, this makes the firm more attractive for those who seek to improve their skills and opportunities associated with those. Higher demand for jobs in the company and by more diligent applicants raises the competitiveness. Such out-turn allows for better quality employees and, consequently, further enhancement of the corporate image, which also gives good publicity for the company and attracts more customers at the same time. In the end, it all sums up to a higher gain for both the company and its employees. [18] [42]

2.2.1 Existing approaches

2.2.1.1 Learning Management System (LMS)

A learning management system (LMS) is an electronic web-based platform that is used to administer contents, distribute and control the corresponding training activities of an educational program for an organization[49].

The tools and functions vary depending on the software. Most allow you to manage, administer, organize, coordinate, design and deliver learning programs, taking into account the specific needs of each organization.

They can range from applications based entirely on e-learning and whose contents are

[3]See more relevant statistics at [45][46][2][47] and https://blog.smarp.com/employee-engagement-8-statistics-you-need-to-know

exclusively digital, to applications that serve to manage rooms in which the face-to-face courses will be deliver, student assistance, etc.

A well-known platform is **Moodle**[4]. This application provides students and teachers with a system for creating customised learning environments.

2.2.1.2 Social Learning

Social learning can be identified as knowledge and skills acquisition utilizing methods that are collaborative, immediate, important and presented in a personal work context. Compared to traditional learning techniques, *Social learning* integrates 3 main features: the interaction with work companions to learn and acquire skills right on the spot while receiving live feedback; gamification; and advanced on-the-job methodologies.

The main steps to follow in to incorporate social learning in an organization are:

- **Recognize** the potential of user-generated learning content.
- **Create** organizational social media platforms to harness the power of interactive learning.
- **Understand** that the line between working and learning is becoming increasingly permeable. Learning is becoming more important with the pace of knowledge creation.
- **Following** the *70-20-10 methodology* that purposes that 70% of learning should be attained through on-the-job activities, 20% should be acquire through, and only 10% through traditional learning systems.[50]

One of the most important existing projects is **Docebo**[5]. And among the main features Docebo claim to have we encounter:

1. *Automate learning management: manage and organize learning activities, while creating beautiful experiences that employees, customers, and partners will keep coming back to.*
2. *Facilitate social learning in the flow-of-work: Reverse the forgetting curve by facilitating social learning as it happens, in the flow of work.*
3. *Gamification: Include exciting elements like points, awards, badges and more.*

[4]https://moodle.org/
[5]https://www.docebo.com/

2.2.1.3 Peer-to-peer learning

Peer to peer learning is a kind learning program that allows the teaching of one to each other. That is, as a student you also have the option to teach courses, and vice versa. In the context of a company, it is the employees who pass on knowledge to each other.

Google

Google deployed an employee-to-employee learning platform called "g2g" (*Googler-2-Googler*). And, believe it or not, of the training courses that have been provided, 80% are delivered through this platform. And it has more than 6000 volunteer googlers to impart their knowledge. The famous company even provides a guide to create a platform like this one[6] [Figure 2.3].

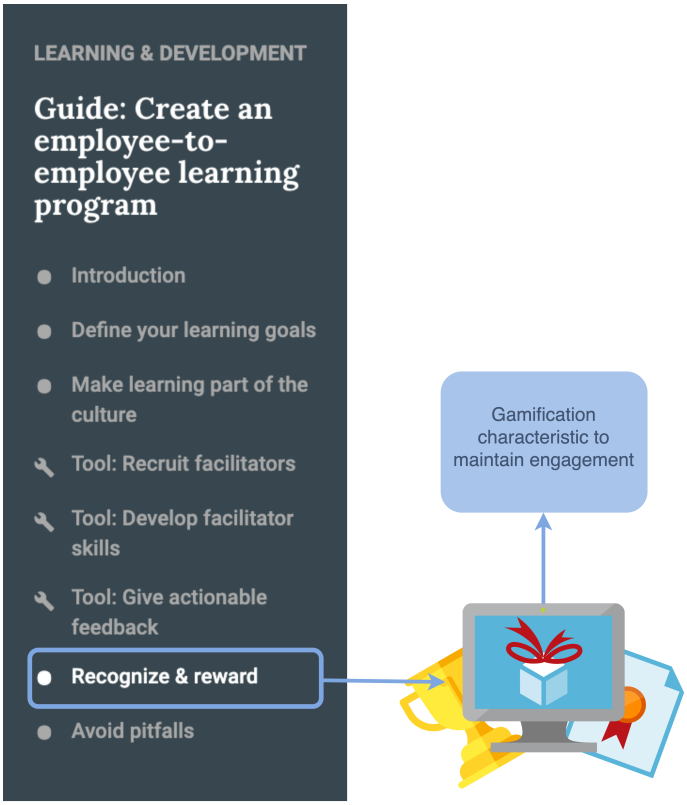


Figure 2.3: Google's guide includes gamification features [1][2]

[6]https://rework.withgoogle.com/guides/learning-development-employee-to-employee/steps/introduction/

2.3 Gamification

As it has been already mentioned, the use of electronic based loyalty programs is progressively greater as it is being proven to be a helpful technique for people implication. Gamification has become a buzzword in recent years [Figure 2.4[7]].

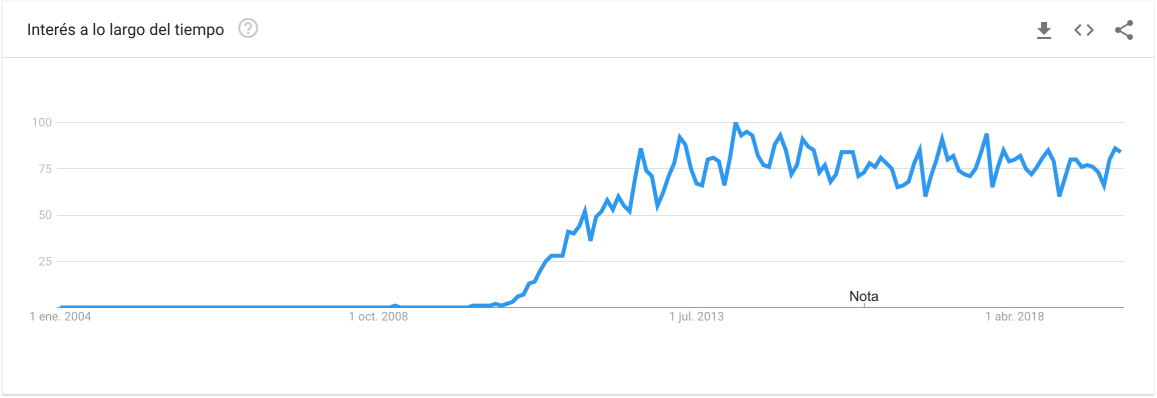


Figure 2.4: Interest on Gamification trend

In the following section, a series of statistics based on surveys are presented to emphasize the benefits of gamification among which lie improved productivity, motivation and employee dedication.

2.3.1 Gamification at work

The most important benefits of applying gamified solutions in a work context (not necessarely training) [4]:

Productivity: More than 89% of employees feel more productive when gamification is applied in a specific task as *it makes them feel more competitive and eager to complete it.*

Motivation and engagement: More than 84% of employees feel more motivated as gamification provides a greater sense of belonging and an improved sense of purpose while working.

Happiness: 88% of workers stated they felt happier when using gamification in software at work.

When employees were asked which application they wanted to gamified the most, an interesting event happened. To summarize, the top 3 ranking was: third place, customer re-

[7]https://trends.google.es/trends/

lationship software with 15 percent; second place, communication software with 30 percent; and first place, **training** program applications with 33 percent [Figure 2.5].

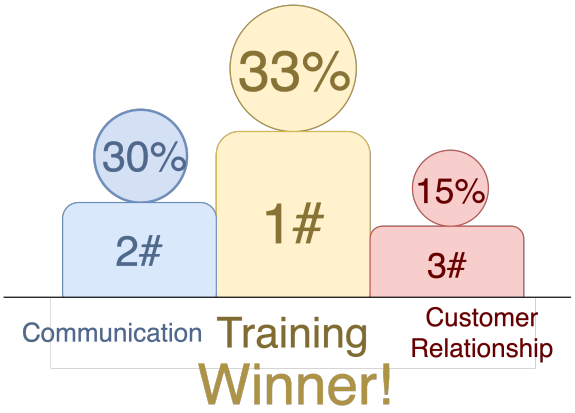


Figure 2.5: Training is the most wanted gas a gamification platform[4]

2.3.2 Gamification in training

All above-mentioned can also be applied to training. It has very similar benefits. A survey made by Talent LMS with more than 900 participants in which they asked how would they feel while taking a training (With gamification vs without gamification. From the obtained results the most important are displayed in Table 2.1.

	Non-gamied	Gamied
Motivated	28%	83%
Bored	49%	10%
Unproductive	11%	3%

Table 2.1: Demonstration stream 1

A good example of gamification in training would be: SAP Cloud Platform Gamification[8][51].

[8]https://www.sap.com/products/cloud-platform/capabilities/digital-experience.gamification.html

2.3.3 How to design a gamified solution

An step-by-step solution would be:

1. To be aware business outcomes and success metries
2. Identify the target audience
3. Identify layer goals
4. From there, design an engagement Model
5. Locate a game space
6. Build a game economy
7. Play, test and iterate

Top motivating gamification elements according to employees[52]

- Rewards
- Badges
- Points
- Leaderboards
- Levels

2.4 Blockchain

Although at the moment it is a technology that has yet to mature, its usefulness is undeniable. In fact, although in an unstable way it follows a growing trend. Not only the financial world, but also many other applications among which is lifelong learning. The use of blockchains for the implementation of decentralized applications [Figure 2.6[9]] has grown significantly since its creation. And an increase is foreseen with the launch of Ethereum 2.0.

The name blockchain describes very well how it works. It is called like this because the blocks are *chained* together by a hash, placed in the header of the present block, that

[9]https://etherscan.io/

Figure 2.6: Ethereum number of transactions since its creation (2015-2019)

summarizes the information from the previous block. This way, it results very difficult to change the information as you wouldn't get the same hash. This string of blocks is distributed to all the nodes equally, like a "distributed ledger", and it is these that decide whether the next block is valid and accepted or has been corrupted and must be discarded. which is stored in the header of the next block. A block is closed by mining, and for users to close blocks they are given an incentive which is usually the cryptocurrency that that blockchain offers. To achieve overall system reliability when breaches occur, the use of consensus is essential. These are the rules governing the blockchain to complete a block and there are different approaches depending on the blockchain.

There are many blockchain and each one has its own particularities. These characteristics are: security that it uses in its hash algorithm, consensus, currency price, gas, the possibility of developing smart contracts, etc. Depending on the features needed for the applications you want to carry out we will choose one or the other. In enabling technologies we will briefly explain why Ethereum is chosen over the other blockchain for this project.

Characteristics of Blockchain Technology [53]

- Traceability: It is the ability to track a specific transaction within the blockchain network.

  When a transaction is made within the blockchain network, the traces of such transaction are stored. Thus, inspecting the block detailed information can reveal useful information needed to track the said transaction. This is caused by blockchain's time-order arrangement, meaning that each block is connected with other close by blocks.

- Transparency: This characteristic related to the veracity of the transactions, permitting all members within the blockchain to control them.

  Once a transaction has been inputted, it is broadcasted and publicited to all members. For this reason, all members within the network have the ability to detect and, more importantly, reject distrustful transactions. This possibility grants a sense of openness, transparency and security. So, as it can be inferred, information on the blockchain cannot be altered if the rest of the participants do not consent it, therefore making it less susceptible against internal or external attacks through mutual trust, reliability and durability.

- Decentralization: Each node within a decentralized network is independent of the others. This helps keep the network secure, while also ensuring relatively democratic governance.

  Decentralization allows data processes (input, transmission, verification, update and storage) on the blockchain network to be established according to the distributed structure. This transfers the risk and responsibility of program execution and data processing from centralized systems to decentralized blockchain networks. In the latter, trust between the network nodes is ensured through strong encryption and decryption techniques.

- Immutability: "The inability of a block to be deleted or modified once it is in the blockchain".

  Although the blockchain network is not fully tamper proof, it is tamper evident, meaning that data cannot be tampered with, without it getting noticed. Immutability property ensures that the data and logs of transactions within the blockchain are always consistent. Moreover,validated transactions or committed blocks cannot be modified or deleted.

Advantages of Blockchain technology

From the mentioned characteristics of blockchain, we can derive some advantages of using blockchain in education.

- Reliability: Decentralization of the blockchain implies that the failure of a single node will not affect the whole network. This increases the reliability of the system as opposed to centralized ledgers, because it removes infrastructural single points of failure.

- Trust: All characteristics mentioned above contribute to the trust that the blockchain network provides. Contrary to the established system, where a few institutions are in charge of educational data, for which trust is commonly taken for granted, blockchain technology, as mentioned before, allows all network nodes to act as trust bearers with decentralized ledgers.

- Security: The blockchain removes any apparent relationship between the input data and the actual data stored in the network. This is the benefit of using a hash functions, which changes a string with any arbitrary length into a fixed-length binary sequence. Also, the hashing process is extremely hard to reverse, since the binary output can not be traced back to the variable-length input. Besides, the newly generated nodes have to follow a linear sequence of time in the chain, thus contributing as well to its security.

- Efficiency: Efficiency is improved by reducing the number of intermediaries involved in the addition of data, since all data added to the blockchain must undergo a set of predefined procedures.

- Authenticity of information: The blockchain allows for educational documents like certificates, transcripts and skills records to be authenticated and validated, since the transactions within the blockchain network are legal and protected against fraudulent manipulation.

- Reduced costs: The decentralization characteristic of the blockchain, along with its transparency, indirectly reduce the costs associated with the deployment of a system, since the maintenance, hosting, data storage and redundancy, and privacy necessities are smaller.

2.4.1 Blockchain and learning

Two good examples found for blockchain and learning are:

- A Learner-Centred Approach for Lifelong Learning Powered by the Blockchain [54]. This projects proposes to provide reliable and official badges, and real certificates from official entities and that these last forever.

- Distributed learning logs across multiple institutions caused by the use of independent disconnected LRSs [55]. Managing lifelong learning records through blockchain.

2.4.2 Blockchain and gamification

There are many possible approaches, an example would be the creation of reliable and permanent certificates over time. But this project will focus on a different approach,**Tokenomics** (Token Economics).

Some successful approaches combining gamification and blockchain are set out in Figure 2.7.

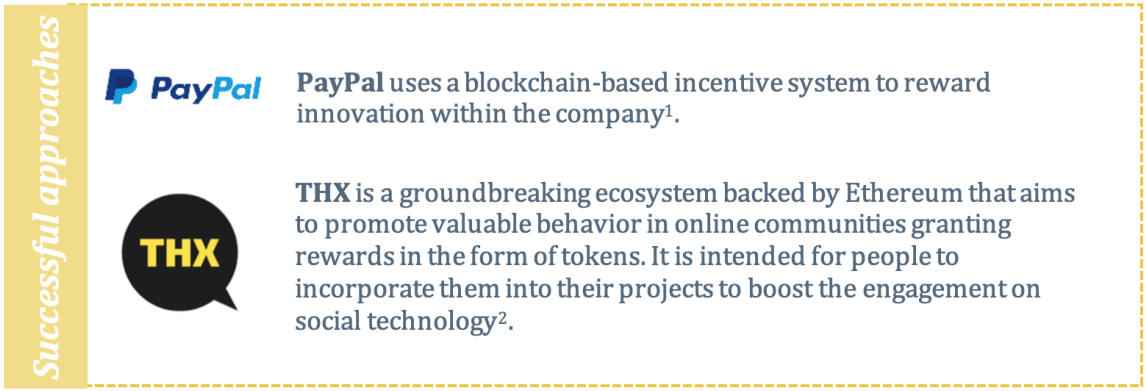


Figure 2.7: Very good examples of a Blockchain Gamification Platform

2.5 Proposal

The proposal is to bring these three elements together by combining the discussed approaches to build an LMS application, which allows employee-to-employee learning, i.e. both providing courses to be taught and having the possibility to sign up for those to be taught by other employees. The use of the blockchain will make the application more secure, self-maintained (reducing costs), and will also provide more reliable and realistic incentives (*Tokenomics*, "Token economics"). Directing those incentives as a gamification will help employees get extra motivation. These tokens could be redeemed for whatever the company wants. To put an example, it can be traded for more training, days off, checks, gifts, financial incentives, cryptomoney, experiences, etc. In turn, achieve greater agility in the implementation of training actions, from the request for training to the implementation of the course, to provide greater autonomy to the employee when deciding which courses to take and to increase the culture of knowledge transfer within the company. But also, the most important reason to build this application on blockchain is to provide a base for this type of applications, which will sooner or later be implemented in our society because of their usefulness, practicality, security, etc. [Chapter 7.4].

CHAPTER 3

Enabling Technologies

3.1 Introduction

In this chapter, the technologies that have been used for the construction of the project are presented. These will be grouped into two main sections, one presenting blockchain related technologies (main framework, IDEs, APIs, and libraries); and the other one showing JavaScript libraries for the development of the front-end platform that connects to the blockchain back-end.

3.2 Blockchain

3.2.1 Ethereum

Ethereum is one of the most used and well-known blockchain technologies to this day. The extremely extensive documentation and the fact that it is so popular in the blockchain development scene (offering a huge list of questions answered and problems solved by the community), are the main reasons why it was chosen as the blockchain upon which the presented project has be built.

> Ethereum is an implementation of blockchain technology that can run smart contracts. The Ethereum virtual machine is Turing complete and can run arbitrary computation directly on the blockchain network. Whereas Bitcoin has a limited set of commands, an Ethereum contract allows an application developer to specify exactly what transactions can be performed on a contract. Simple smart contracts can be thought of as a Finite State Machine (FSM) with a set of custom transitions.

An Ethereum network can be depoloyed as a private network by changing the text block. This is the first block of the block chain. In its configuration, certain parameters determine which particular ethereum blockchain it will connect to. There is the main one, and many other so-called test nets whose ETH currency has no monetary value and are used for testing. In this project, one of the test nets used is rinkeby but the most famous is ropsten. For example, by changing the parameter *chainid* in the *genesis block*. In short, ethereum allows us to change where we deploy our contracts between ethereum main net, other test nets, or a reserved and isolated network in an effortless way.

3.2.2 Solidity

Solidity is an object-oriented, high-level language for implementing smart contracts. It has been designed and compiled in bytecode, with the focus on creating and developing the smart contracts that will execute on the Ethereum Virtual Machine. Also, it is considered to be a 'Touring Complete' language, as the EVM is considered to be a Universal Turing Machine, meaning the ability of the software to solve any computational problem defined by the developer and use complex rules such as loops. However, this characteristic requires the definition of a mechanism like 'Gas'. 'Gas' is the way Ethereum calculates the cost of transactions, which is simply the computational cost associated with processing a transaction or a smart contract and its storage needs. Solidity's syntax is quite similar to JavaScript, one of the most popular programming languages to this day.

3.2.3 Remix

Remix is a Solidity IDE used to write, compile and debug solidity code. One of the advantages of using this IDE is that it offers both web and native applications, so it can be easily accessed.

3.2.4 Ganache-cli

Gnache-cli is a component of the Truffle suite of Ethereum development tools, and is a command line version of Gnache (a personal blockchain for Ethereum development). According to Ganache-CLI proyect page [1],

> Ganache CLI uses ethereumjs to simulate full client behavior and make developing Ethereum applications faster, easier, and safer. It also includes all popular RPC functions and features (like events) and can be run deterministically to make development a breeze.

3.2.5 Infura

Infura is an Ethereum Blockchain network API that provides developers with a variety of tools with the purpose of connecting their desired applicatins to the Ethereum network. This tools make it possible to handle short-term fluctuations such as the ones related to token launch and also eliminate the need for developers to

Its main features include, amongst others, TLS-Enabled Endpoints (public endpoints for Infura's Ethereum Mainnet) and IPFS Gateway (decentralized storage containing custom reliability features), Portable Ethereum Interface (designed to be compatible with standard JSON-RPC API), Ferryman Service Layer (providing advanced routing requests, load balancing...) and Multi-Client backend (featuring both Parity and geth nodes as peers).

3.2.6 Metamask

Metamask is a plugin for web browsers that acts as wallet to manage Ethereum private keys. These are stored in the browser and are not sent anywhere. allows users to interact eaily and securely with DApps from Ethereum blockchain. It acts as a bridge between DApps and browsers, providing users an easy-access though most common browsers, supporting Firefox, Chrome, Opera and Brave.

In September of this year he released a mobile application in beta version. Very useful for making transactions through the scanning of QR codes or your browser. This makes the platform more fun and processes.

[1] https://github.com/trufflesuite/ganache-cli

3.2.7 OpenZepelin and ERC-20

As it is defined on OpenZepelin official webpage[2],

> OpenZeppelin is a library for secure smart contract development. OpenZeppelin Contracts helps minimizing risk by using battle-tested libraries of smart contracts for Ethereum and other blockchains. It includes the most used implementations of ERC standards.

The most important smart contracts[3] for the creation of the token are listed below:

- **ERC20Detailed.sol**
- **ERC20Burnable.sol**
- **ERC20Mintable.sol**

Other important contracts used for the creation of the service contract are Ownable.sol: Used to grant exclusive access specific functions using the onlyOwner modifier in your solidity functions to restrict their use to the owner.

SafeMath.sol: It provides with secure and optimal math operations.

Others like Crowdsale.sol would allow to add a real monetary value to this token by buying it through the ether currency, an application that could be considered in the future.

3.3 JavaScript Libraries

DApps are the frontend apps which interact with these blockchain over an API. For Ethereum, this API is a JSON-RPC layer called the Ethereum Web3 API.

JSON-RPC is a stateless, light-weight remote procedure call (RPC) protocol using JSON for payload. Unlike RESTful APIs which are resource-centric, RPC APIs like JSON-RPC are procedural and can be more tightly coupled than RESTful APIs. Frontend apps communicate with the Ethereum cluster using JSON-RPC. Web3 is the Ethereum compatible API and bindings which is built using the JSON-RPC spec.

Any decentralized app must use a Web3 SDK such as Web3.js or Web3.py for browser based DApps.

[2]https://openzeppelin.com/contracts/

[3]https://docs.openzeppelin.com/contracts/2.x/

3.3.1 NodeJS

NodeJS is a multi-platform, open-source, runtime environment for server side (though not limited to it) based on ECMAScript programming language. It is asyncronous, with I/O data and event-oriented architecture, and based on Google's V8 engine.

3.3.2 Web3JS

As they state in WEB3JS documentation webpage[4],

> WEB3JS is a collection of libraries which allow you to interact with a local or remote ethereum node, using a HTTP or IPC connection.

3.3.3 WebpackJS

As they state on their website [5],

> At its core, webpack is a static module bundler for modern JavaScript applications. When webpack processes your application, it internally builds a dependency graph which maps every module your project needs and generates one or more bundles.

3.3.4 ReactJS & ReduxJS

React is an open-source JavaScript library designed to create user-interfaces with the objective of easing the development of single page web applications. It is maintained by Facebook and a wide community of individuals.

Redux is a pattern for data architecture that allows to handle the state of the application in a predictable way. It is designed to reduce the number of relations between application components and to keep a simple data flow. It is helpful for developing applications that behave consistently, are able to run on diverse environments (server, client and native), and are easy to test.

[4] https://web3js.readthedocs.io/en/v1.2.4/
[5] https://webpack.js.org/concepts/

3.4 Other important technologies

The use of a few other technologies has been crucial to the achievement of this project. The most important ones are presented below.

3.4.1 JSON Server

JSON Server is a node package used to simulate databases. JSON Server will take a JSON file and turn it into a RESTful database with all the right routes.

While working on the project, it was discovered that it was not efficient to store all data on the blockchain because it required a lot of Gas. So, as the original planning of the project did not include the design and implementation of a database, and it was not either necessary to reach the objective of the PoC, it was decided to use this tool, which does not require a lot of configuration.

3.4.2 Truffle

Truffle is an Ethereum development framework. This framework makes a lot easier to implement and test smart contracts, and to unite these with the client side.

Between the main features we find:

- Smart Contract Life-cycle Management
- Automates Contract Testing
- Sriptable Deployment and Migrations
- Powerful Interactive Console

CHAPTER 4

Requirement Analysis

4.1 Introduction

In this chapter, the requirements of the proof of concept are presented and divided into 3 sections: Functional requirements, non-functional requirements and restrictions. A set of diagrams and tables will be used to further illustrate and explain these.

4.2 Functional Requirements

The functions or characteristics that describe what the system should be able to perform will be established. To do this, the first thing to do is to locate the main actors and roles in the system by generating user stories [Tables 4.1 & 4.2].

In order to be able to execute these actions more actors and roles are required. For the final system, these functionalities will be fully available and these user stories will go along with the ones mentioned above.

However, for the sake of simplicity, for the prototype we will limit ourselves to making these functionalities accessible only from a terminal. Although it does not have to be a

User stories		
As a...	I shall be able to...	Traceability
Student	browse through the course catalog.	1.1
	view a list of courses I am currently enrolled in.	1.2
	submit a teacher's evaluation of a course I have participated in.	1.3
	receive tokens for the courses I have participated in and submitted teachers' evaluations.	1.4
Teacher	browse through the course catalog.	2.1
	see which courses I have created.	2.2
	see how many students have enrolled in my courses.	2.3
	submit the student's attendance.	2.4

Table 4.1: User Stories

requirement of the user interface, its implementation is necessary for the functional system and to obtain a valid proof of concept [Table 4.2].

User stories		
As a...	I shall be able to...	Traceability
User	Create a course (and then, become a teacher) for other employees to benefit from it.	3.1
Employee	Sign up to the platform, while automatically generating an Ethereum Account (and then become a user)	3.2

Table 4.2: More User Stories (Accessible from a Terminal)

Note that adding a user not only requires to sign up to the web app but also to the blockchain by acquiring an Ethereum account and register in the *smart contract* side of the system [Table 4.2].

4.2.1 Use cases diagram

A use case diagram has been made in order to summarize the most important actors and activities and clarify the functionalities that this platform offers [Figure 4.1].

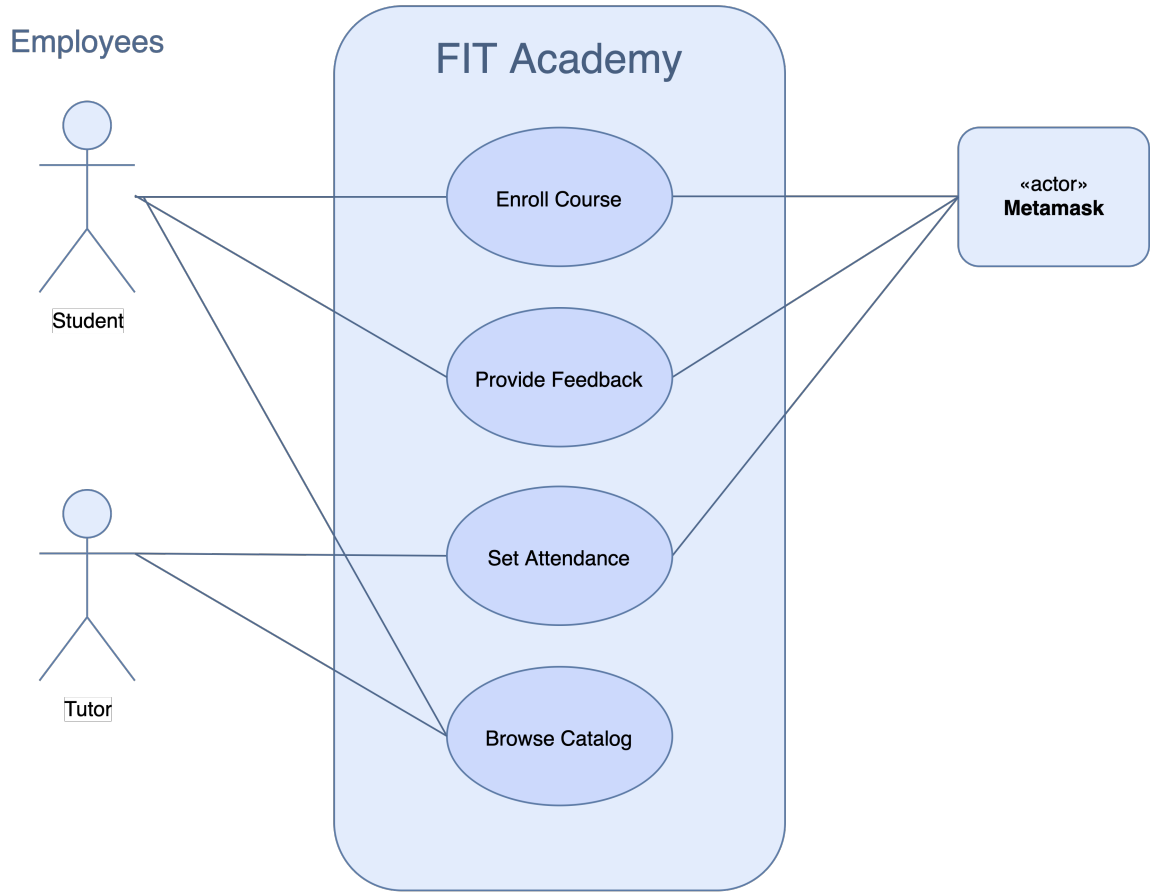


Figure 4.1: Use cases diagram

4.3 Non-Functional Requirements

The following are the non-functional requirements according to the ESA-SRD (System Requirements Document-European Space Agency[56]) industry standards. These are divided like so:

- **Portability** – Requirements to facilitate the execution of the system on different computers and operating systems. These should be satisfied as follows: availability on the computer and the mobile whenever you have a browser or the Metamask application installed.
- **Performance** – The fact that the system is based on blockchain, can make the application work very slowly. As a non-functional requirement we need to reduce these times as much as possible.
- **Interfaces** – These specify hardware, software or database elements with which the system, or system component, must interact or communicate:
  - The private blockchain network
  - JSON Database [Chapter 3.4.1]
  - Metamask Wallet
- **Operation** – Users will have no need to install the application since it is web based accessible from a browser. However, they must have a wallet. It is recommended to install the Metamask extension because of its ease of use. However, they must definitely have a wallet. It is recommended to install the Metamask extension because of its ease of use and the advantage of being able to use it from the mobile phone.
  - Accessible, at least, from browsers:
    - Google Chrome
    - Mozilla Firefox
    - Brave
    - Opera
  - Transactions can be made from the mobile phone with Metamasks' help scanning a QR-code, for example, to enroll courses.
- **Resources** – The only resources needed for for the use of all the functionalities of the application are the the work computer and the means to access internet normally provided by the company.

- **Reliability** – As this is a prototype, the upper limits regarding number and rate of system failures and availability will be the necessary to determine that the project is viable. This means a proper usability. It is expected to have a 0.95 reliability.
- **Maintainability** – One of the project objectives is to require less maintenance. Nevertheless, the system must be implemented taking into account that future application will be added to the project.
- **Safety** As valuable assets are not uploaded . As for the tokens and fake ether the entire network (all nodes) would have to go down in order not to be able to recover the data. This is very unlikely to happen.
- **Verification** – Requirements regarding tools and procedures to be used to check system correctness: simulation, testing environment, facilities for logging and diagnosis, etc.
- **Acceptance tests** – There will not be acceptance tests as is not going to be deployed for production yet Validation requirements at system level for a software product previous to deployment to production.
- **Documentation** – Standards, formats and documentation style to be used in technical documents and user and maintenance manuals
  - The system will abide by the ERC-20 security standards for the token implementation. In this way we guarantee safety in its use.
  - The system will follow other famous standards for the implementation of Ethereum smartcontracts such as Ownable and SafeMath.
- **Security** – System requirements to protect the system against information security threats: confidentiality, integrity, availability, authentication, authorisation, etc.

4.4 Domain Rules

The domain rules applicable to the system as explicitly included in the system description above, as the source of functional and non-functional requirements are:

- The system will implement security and privacy mechanisms to conform General Data Protection Regulation 2016/679 (GDPR) para la parte fuera de la blockchain.
- Most common company policies for most companies are considered for compatibility with all of these.
- Specifications imposed by the Ethereum blockchain protocol are followed, among these are:
  - For the generation of blocks, the SHA3-256 hash algorithm is applied.
  - The system will be governed by the current Ethereum consensus mode, Proof-of-Stake mining and Ledger leveled.
- The system will use the recommendations established in the yellow paper the Ethereum[57] for the optimization algorithms, and minimization of the gas expense. The lowest gas limit necessary for the operation of the system shall be established.

CHAPTER 5

Architecture

5.1 Introduction

In this chapter, we cover the design phase of this project, as well as implementation details involving its architecture. Firstly, we present an overview of the project, divided into several modules. This is intended to offer the reader a general view of this project architecture. After that, we present each module separately and in much more depth.

5.1.1 Overview

The architecture that has been designed to materialize everything exposed until now tries to disassociate as much as possible the content management, facilitated as we normally saw by an LMS [Chapter 2.2.1.1], from everything that has to do with the access to those contents. In our case, is going to be managed through blockchain tokens. This way, the aim is to build a kind of training aggregator that functions as a meeting point to manage access to different types of training in a decentralised manner. In the catalogue, there would appear both the courses submitted by the employees and those of another LMS with which the company interacts to show those courses but manage from ours the gamification process [Figure 5.1].

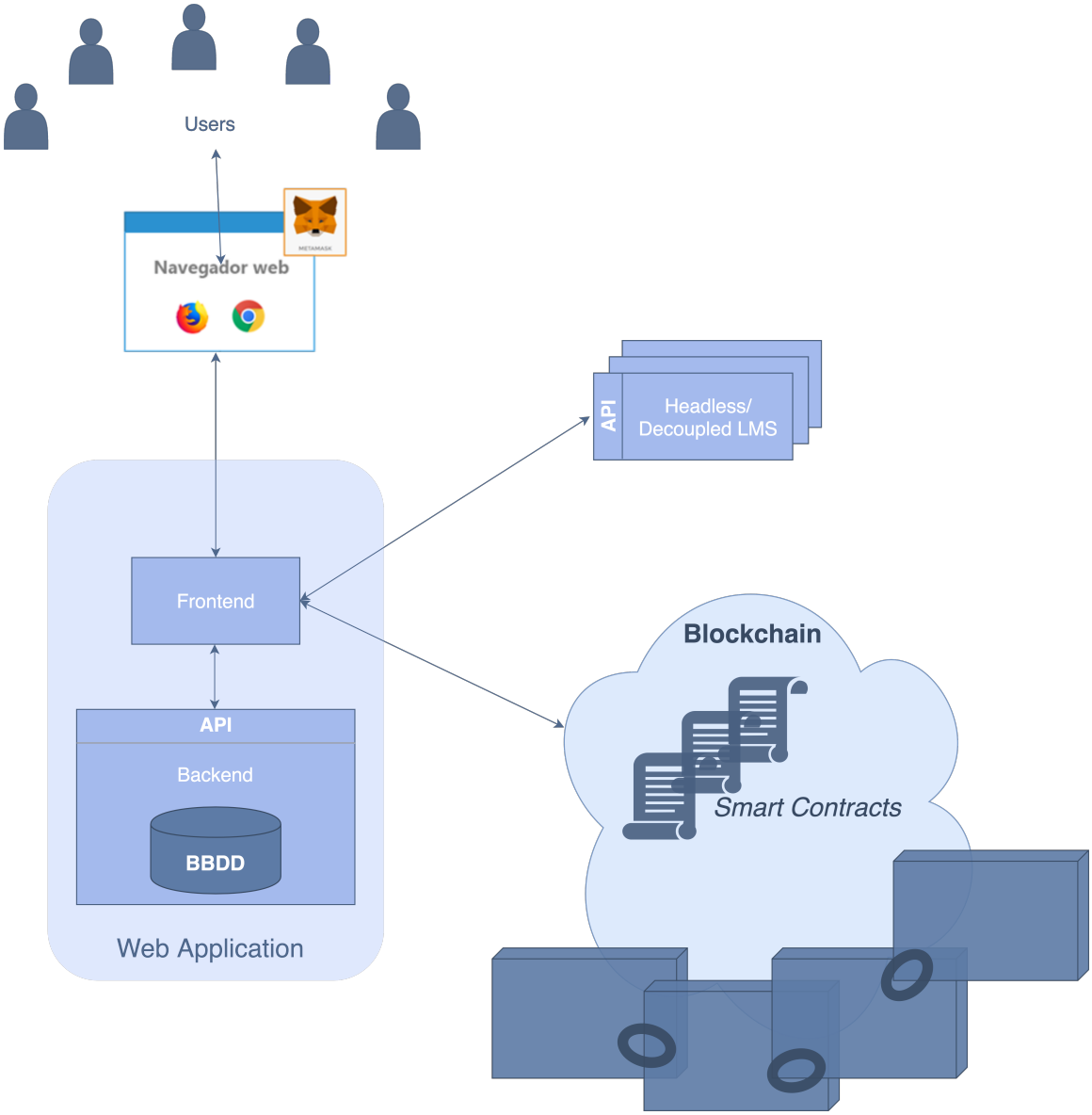


Figure 5.1: Architecture

With this approach, the frontend component will be responsible for capturing data from the different available platforms in order to present them in an appropriate and uniform way in the web interface. As we can observe in the diagram, course information is collected from various sources.

1. On the one hand, the course information of the external platform(s) would be accessed through APIs (headless LMS). This information would be composed only of light data, i.e. the videos would not be accessed in case of e-learning courses. Only data such as: course name, description, teacher's name, etc. would be accessed.

2. On the other hand, the information of the employee-to-employee attendance based courses is stored separately in the blockchain through the *smart contracts* and in the database which is in the backend. We will try to make these data as less redundant as possible to avoid synchronization errors, so both elements are required in order to access the information of one of these courses.

In addition, we see that in the frontend, users interact with Metamask. This allows them to sign the transactions for the administration of the courses with the different *smart contracts* of the blockchain.

Based on these components, and looking for the minimum viable product (MPV), for the PoC it has been decided to simplify the architecture as follows [Figure 5.2]:

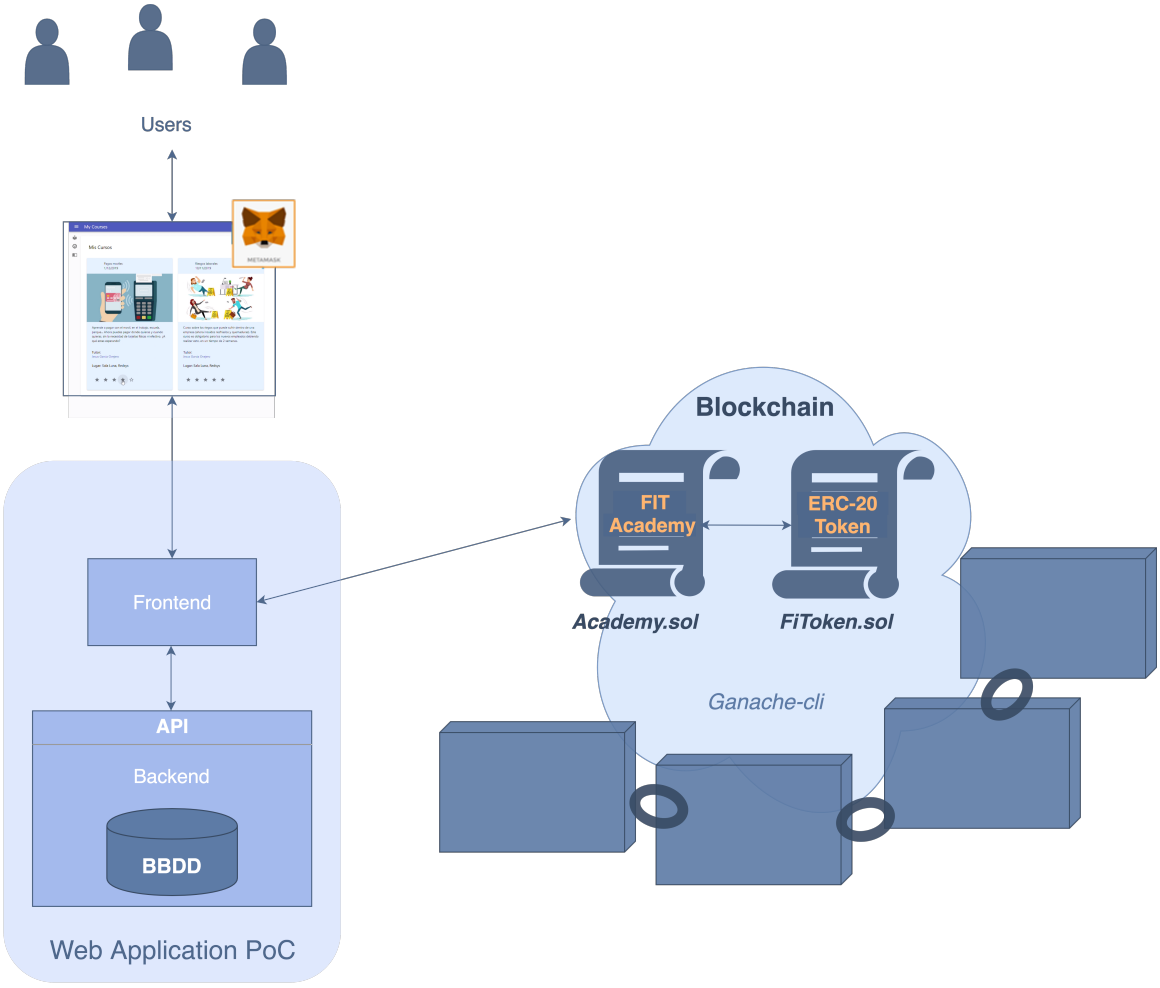


Figure 5.2: PoC Architecture

- Due to its greater simplicity, in the PoC it has been decided to focuse on internal training in a face-to-face format, so LMS systems are no longer taken into account.

Although, developments have always been carried out taking into account possible extensions that are compatible with other training modalities (e.g. e-learning) for future work.

- The access to the course information is done through the API of a backend server (json-server), in a similar way as it would be done through the API of a headless LMS.
- The *smart contracts* through which users interact are specified: Academy.sol y Fit.sol.

5.1.2 Data model

Initially, an idea was put forward to have all the data stored in the Blockchain. However, collecting this meant much more computing. This implied more gas, and consequently a greater expense and a notably greater slowness when interacting with the blockchain. There would be no problem with the expenses when dealing with a private network, since it is possible to lie at the beginning the amount of ether that is considered appropriate. The same happens with the testnets since the ether has no real value. In these, the transactions are very very slow and do not consider making a functional Dapp. Only as its name indicates to make tests. However, if you wanted to deploy it on the Mainnet for reasons seen in future work (7.4), this would mean a very big expense.

For these reasons it was decided to split the data and use an external database to store most of it, while maintaining security. And these are divided in the following way [Table 5.1].

As mentioned in enabling technologies 3, a *fake-server* will be used which will be implemented in JSON format. Bearing in mind that this model will be changed when the database technology used changes. For the time being, this will be the architecture in the JSON server [Figure 5.3]:

5.1.3 Smart contracts

Smart contracts are the most crucial components of the system architecture, it will be used in all processes in the system. The two smart contracts implemented are:

- Fit.sol
- Academy.sol

Data on the Database	Data on the Blockchain
- userAddress	
- userName	
- courseAddress	
- courseName	- userAddress
- courseTutor	- value = duration (in h)
- courseDescription	- attendance
- courseDate	
- courseLocation	
- courseStudents[]	

Table 5.1: Splitting the data in JSON server and Blockchain

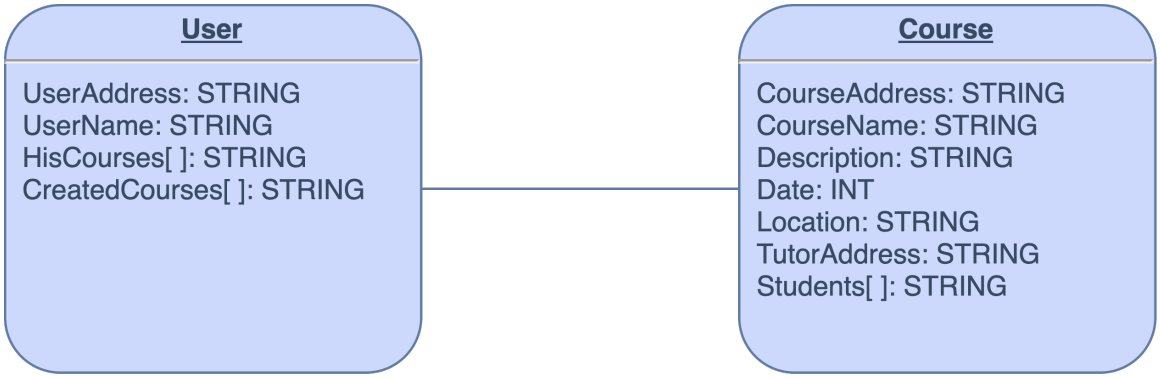


Figure 5.3: Data Model JSON Server

Whenever a user conducts a transaction through the application, that is to say, managing courses, the system will interact with both contracts. The flow they carry out in order to achieve a successful payment is the one shown in Figure 5.4

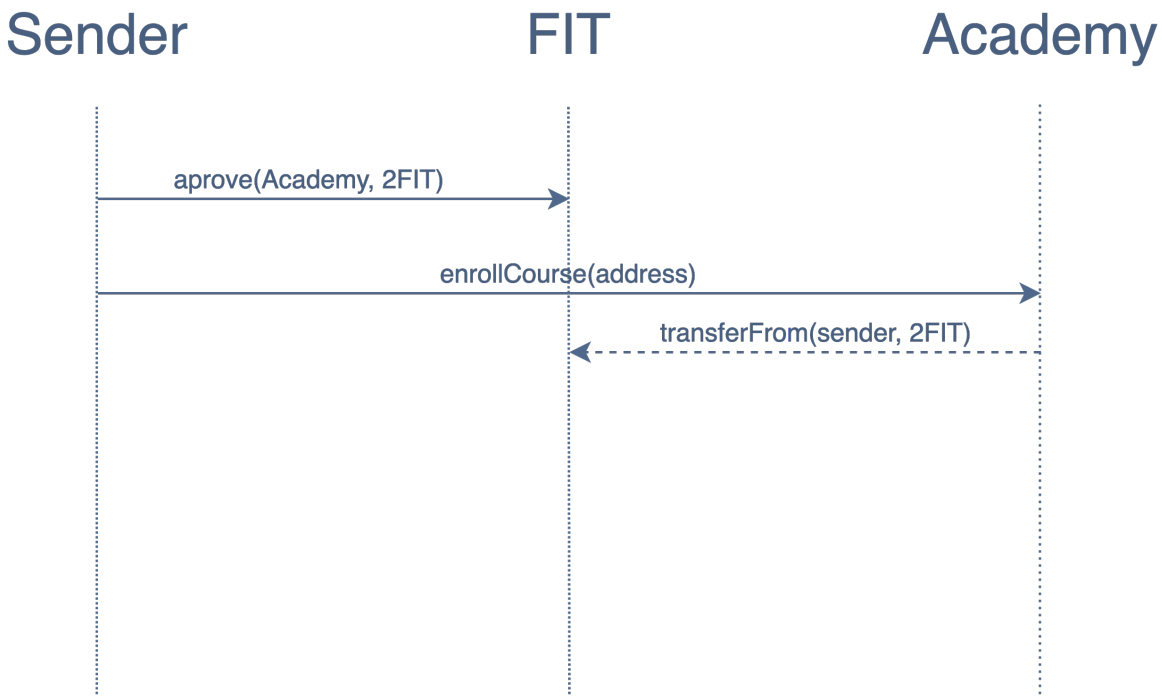


Figure 5.4: Aproving a payment for a service contract

5.1.4 User Interface

5.1.4.1 FIT Token

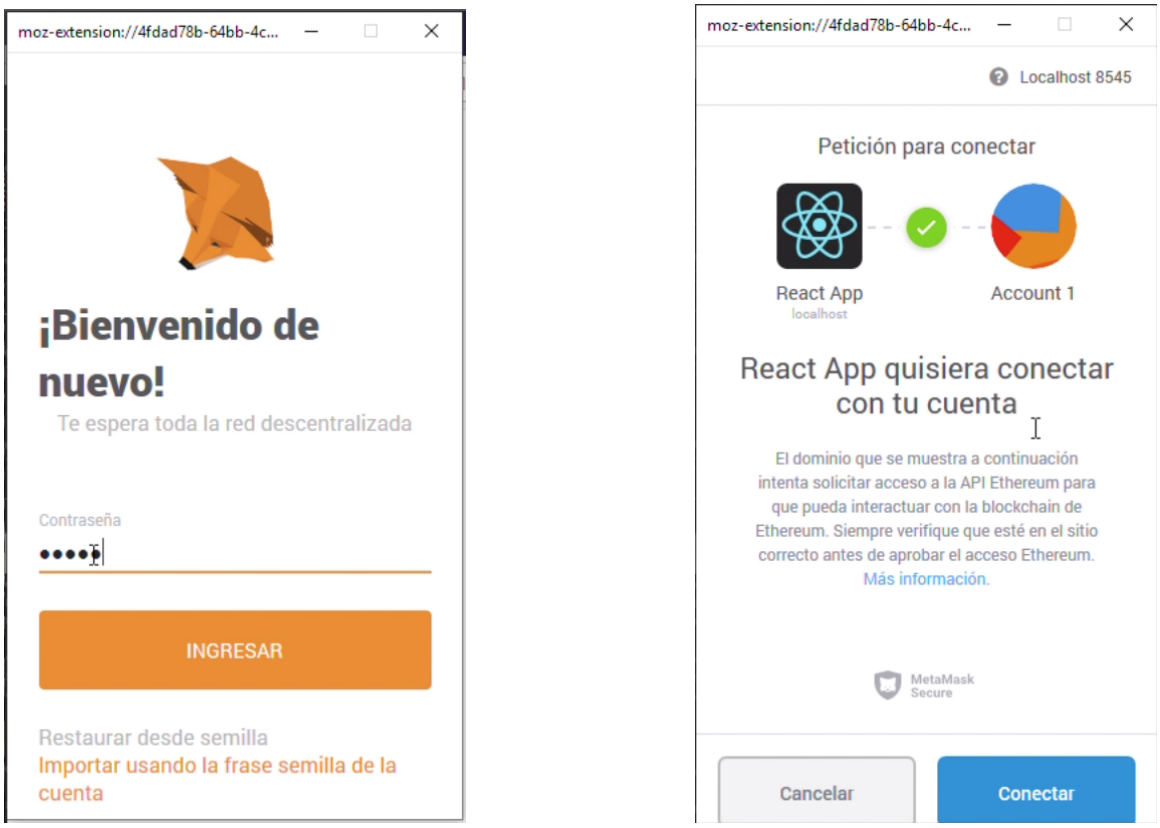
Figure 5.5: "Formation Incentive Token"

5.1.4.2 FIT Academy

Figure 5.6: FIT Academy, Get your mind in shape

5.1.4.3 Metamask

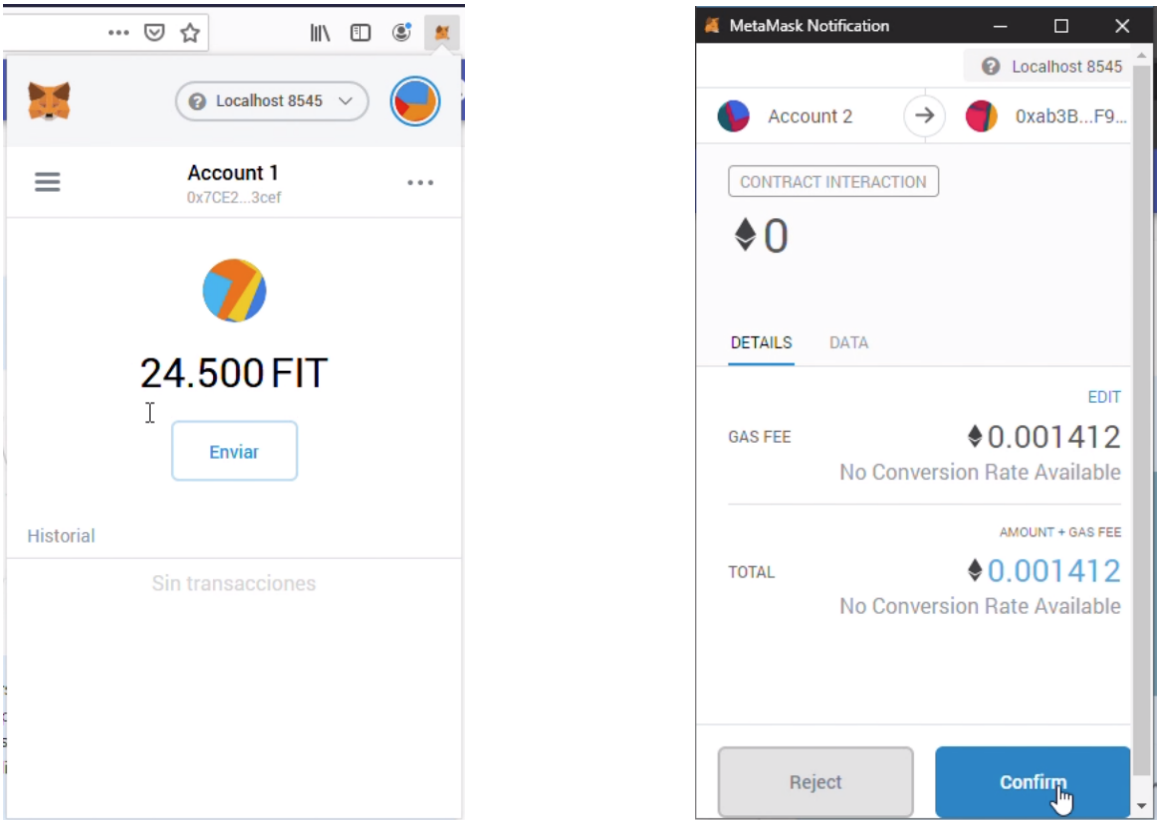
User will require of a wallet to manage its transactions. Metamask interacts with our smart contracts.



(a) LogIn Metamask

(b) Conecting React

Figure 5.7: Connecting with Metamask



(a) Transaction Overview

(b) Transaction details and Confirmation

Figure 5.8: A transaction with Metamask

5.1.4.4 Web interface

One example of the web interface is provided here bellow [Figure 5.9].

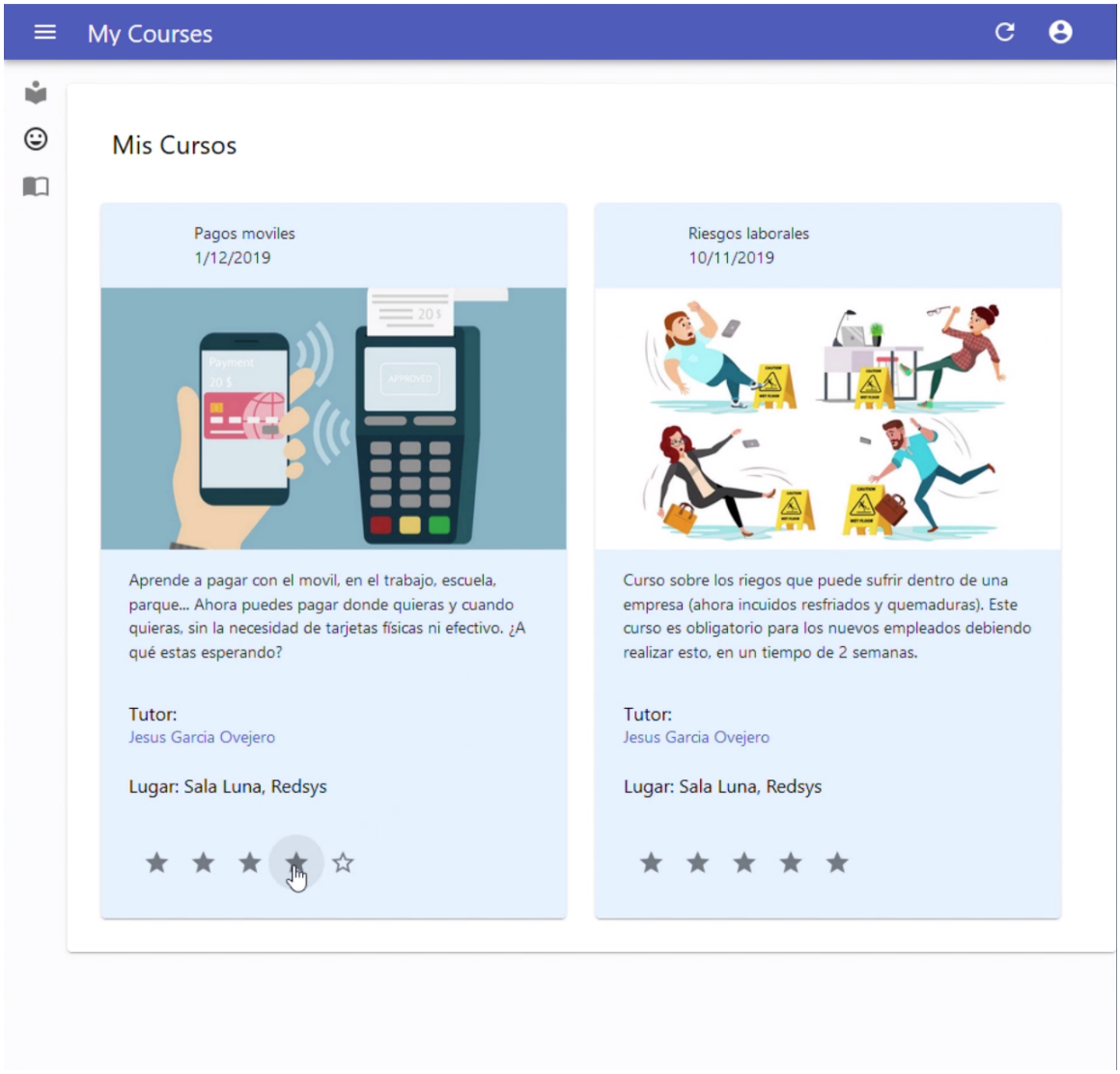


Figure 5.9: Appearance of the web interface

CHAPTER 6

Tests performed

6.1 Introduction

In this chapter we are going to describe a set of tests perform in the hopes of showing the platform behaviour and consistency.

6.2 Testing Smart Contracts

Apart from debugging the code with remix tool, a series of tests were carried out with Visual Studio Code, Truffle framework and the help of JS libraries among which are mochaJS, chaiJS, etc., to check that each solidity function worked correctly. An example of a successful terminal response is shown in Figure 6.1.

Also, for greater manageability, to test modules composed of a larger set of functions have been tested by making javascript scripts with logs executed in the windows powerwhell using node [Figure 6.2] .

At the same time, when the blockchain was successfully deployed with ganache, a process kept in operation visible on the console from which you executed the command. During

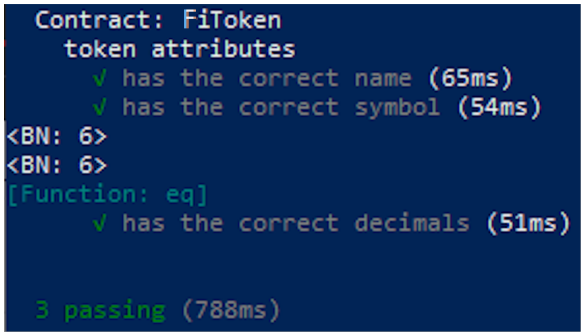


Figure 6.1: Testing FiToken contract using Truffle Framework

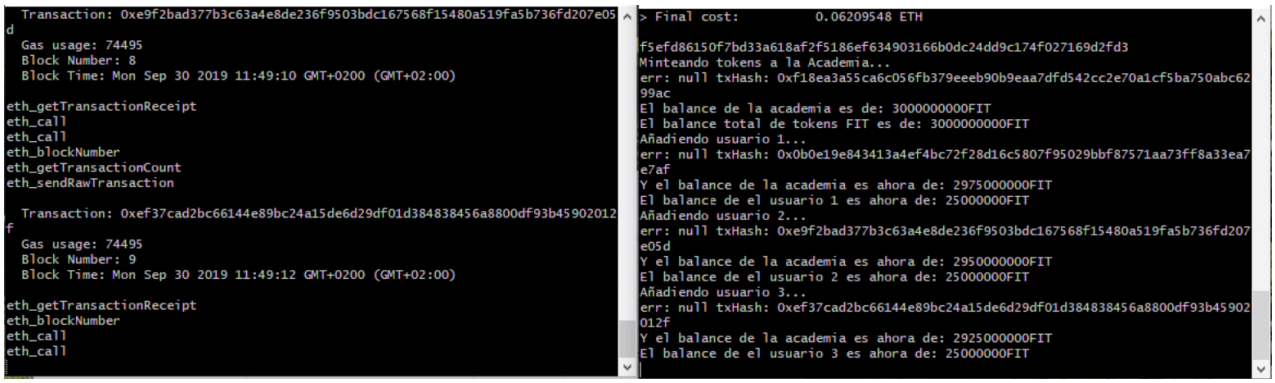


Figure 6.2: Testing FiToken.sol contract using Truffle Framework

the other processes, it provided us with real-time data. It facilitated things like the correct deployment of a contract, a successful transaction, the gas used, etc. A great example would be output logs when deploying the entire testing scenario [Figure 6.2].

6.3 Demonstration scenarios

We defined two streams or demonstration scenarios to show how the Proof of Concept works:

1. Course enrolment
2. Automatic token distribution. This one includes:
   (a) Course score
   (b) Attendance confirmation

To carry out these scenarios, we start from an assumption in which the smart contracts

have already been deployed and there are 3 registered employees and 3 published courses [Table 6.1].

	Price	Miguel	Jesus	Andres
User assets	Tokens	24 FIT	22 FIT	20 FIT
Introduction to Blockchain	3 FIT	TUTOR	STUDENT	STUDENT
Mobile payments	2 FIT		TUTOR	STUDENT
Occupational risks	1 FIT	STUDENT	TUTOR	

Table 6.1: Initial state of the scenario

Each user leaves with a starting balance of 25 FIT, so the table above reflects the number of tokens each user has after registering for the different courses.

In this regard, it should be noted that it is assumed that none of these courses have been completed, so attendance has not yet been resolved and no ratings have been provided.

The following subsections detail the flows followed (user journeys) in each of the two demo scenarios.

6.3.1 Demonstration stream 1: Course enrolment

Miguel logs in to the FIT website. He consults the course catalogue and decides to sign up for one of the courses on "Mobile Payments", which is given by his partner Jesus. When he proceeds to register, he receives a notification from the wallet installed in his browser indicating that he needs to confirm that he wants to spend the 2 FIT tokens that that course costs. After confirming this, Miguel goes to the list of courses in which he is registered and checks that he has indeed acquired the right to access the course [Table 6.2].

6.3.2 Demonstration stream 2: Attendance confirmation

The face-to-face course on "Mobile Payments" has already taken place. Jesus, the course tutor, wants to receive the tokens he has so richly earned for creating, organizing and delivering the training. To do so, Jesus proceeds to log in to the FIT web application. Then he accesses the section that lists the courses in which he plays the role of tutor, and fills in and sends the attendance form for the "Mobile Payments" course. Your wallet,

	Price	Miguel	Jesus	Andres
User assets	Tokens	22 FIT	22 FIT	20 FIT
Introduction to Blockchain	3 FIT	TUTOR	STUDENT	STUDENT
Mobile payments	2 FIT	STUDENT	TUTOR	STUDENT
Occupational risks	1 FIT	STUDENT	TUTOR	

Table 6.2: Demonstration stream 1

integrated in the browser, will ask you to confirm the sending of this information. Now all you have to do is wait for the students to evaluate the training.

Miguel has just returned from the "Pagos Móviles" training that Jesus gave. Enter the FIT application and access the course in the panel where those he is enrolled in are listed. Fill in the form that requests the evaluation of the course "Pagos móviles". Since you liked the course quite a bit, you decide to give it a 3 out of 4. Once you send the form, the browser wallet asks you for confirmation. Miguel accepts and, a few seconds later, notices that he has received 2.5 FIT in his wallet[1].

Jesus wants to check if his students in the "Mobile Payments" course have started providing feedback, so he opens his wallet in the browser and checks if his balance has increased. Jesus checks that at least one of his students has indeed provided feedback, as his balance has increased by 1.5 FIT [Table 6.3] .

[1]It should be noted that the values will be calculated according to the following formulas:

- Tokens received by the tutor for each student = course value * feedback / 4, where feedback can go from 0 to 4
- Tokens received by the student for attending the course = course value * 1.25

	Price	Miguel	Jesus	Andres
User assets	Tokens	24.5 FIT	23.5 FIT	20 FIT
Introduction to Blockchain	3 FIT	TUTOR	STUDENT	STUDENT
Mobile payments	2 FIT	STUDENT	TUTOR	STUDENT
Occupational risks	1 FIT	STUDENT	TUTOR	

Table 6.3: Demonstration stream 2

CHAPTER 7

Conclusions and future work

In this chapter we will describe the conclusions extracted from this project, and the thoughts about future work.

7.1 Conclusions

As a general conclusion, it is important to mention that Blockchain was potentially the best technology that could have been chosen for the development of this project. Moreover, it has been proved that taking on projects like the presented, real-life ready and at a bigger scale is perfectly feasible. The future of the world's gamification and collaborative learning is huge and full of opportunities, so more projects should be promoted.

7.2 Achieved goals

In principle, all the presented goals have been achieved with the development of this project, in the form of fulfilment of both functional and non-functional requirements.

The main goal that can be extracted from the process of this work could be the achieve-

ment of greater agility in the implementation of training actions, from the request for training to the implementation of the course, to provide greater autonomy to the employee when deciding which courses to take and to increase the culture of knowledge transfer within the company.

7.3 Problems encountered

- Wordpress

  Wordpress is a nice option, and it even includes elements for blockchain interaction. However, these were not very permissive, which really restrained the available design and it supposed very limited room for customization.

- WEB3 Versions

  The fact that the version had been upgraded just this year implies that tutorials and forums showed different ways of implementation. Being true that it has a very extensive and complete documentation, it could turn into a really tedious job. For instance, when trying to execute the *Keccak 256 Hash* on the data for a transaction, there was needed to incorporate additional modules because, for security reasons, the upgraded version of WEB3 did not allow to do it.

- Moodle

  Although Moodle is a really useful tool for LMS projects, it was a very complex one to use and would have required more time. Also, constraints were found using the Moodle's API so it would not have been possible to achieve the correct functioning of Fit Academy.

7.4 Future work

One of the purposes of this project was to provide a versatile blockchain solution able to incorporate interesting elements that are in a state of development today. In this subsection , we discuss possible future lines of work, especially approaches with blockchain technology.

- Cross-platform: *Platform is a foundation or a place where theoperating system works, or it is the foundation in whichprocesses run, while the term 'cross' means literally.Cross platform is a term in the technology of informa-tion about software or application that can be executedin a variety of operating systems and hardware types,i.e.*

smartphones, standalone PCs and other gadgets. The development of cross-platformsoftware consists of several cycles, one of which issystem validation done by users who do not have aninterest in the development of the application (Frede-rick, 2013).

- E-learning with IPFS: Inter Planetary File System does not use blockchain, but a different combination of technologies (Distributed Hash, Tables, Torrent, Git...)

- Login through blockchain : Decentralized Identity (DID): Some application such as uPort, Sovrin or Civic are already implementing it, and the matter is being widely studied. It consists on signing the transactions that confirm the login with a wallet. It could be useful for accessing not only to this page, but to every other that need it, which removes the burden of having to log in every site and having multiple logins. Besides, it would obviously present a more secure way of logging in.

- More DID applications: DID is not only useful for login, but also for storing certificates provided by official organizations that also possess a self-sovereign identity (SSI). It would be cryptographically verifiable trough an SSH Key or any other official data such as an ID, driving license,etc. And, of course, it would only be needed to provide one identity at a time.

- ERC-20 Token and Crowdsale: Although it would be pretty simple to incorporate, it would not be such an easy change for corporations, because taxes come in. The fact that it would suppose real value outside of the company (just like a bonus or an extra pay), would make it mandatory to apply taxes. For that reason, enterprises may not consider it a viable option for the time being. That said, when this type of technology penetrates into daily life, it could present a really good option and turn into a significantly more powerful incentive.

Important notice

It is important to clarify that this project was initially thought and designed to be deployed on a private company network. This does not mean that it could not be deployed publicly, but it would require a significantly high real cost of using Eth. The fact that it would be deployed on a private network does not hamper the implementation of the improvements presented above, although it could make it harder. For example, the implementation of DID, which works on a public network, would require a separate application through which one should log into the proposed application.

APPENDIX A

Impact of this project

This appendix reflects the possible social, economic, environmental and ethical impact or implications of the developed project.

A.1 Social impact

The purpose of this project is to provide enterprises with a solution for employee development at a low cost. This also helps employees to work better and be happier at work. A greater learning culture, as well as helping culture is promoted.

As these technologies evolve, more and more people will study these subjects. Therefore, the future impact of the project is promising and the affected groups will increase.

Overall, as it is a platform very easy to use, a greater agility in the processes of training actions. It is an application that can help many companies and employees.

A.2 Economic Impact

In this section the economic impacts of the incorporation of the platform to enterprises is viewed.

For employees, it does not require any cost at all, as the currency used as an incentive has not a real value. These ones can be traded for real rewards. This implies more profit for the employee.

For companies, the costs depends on the size of the company, but as seen in the introduction 1 and background 2 it implies greater benefits and reduces costs like maintenance for other LMS platforms, etc.

A.3 Environmental Impact

This section aims to define the main environmental impact of the development this system.

Computers and other information technology infrastructures consume significant amounts of electricity, adding a huge charge on our electricity networks and contributing to greenhouse gas emission. In addition to this consumption, the energy required for the cooling system associated with this equipment must also be added, which is the second main reason for the consumption of this equipment.

The main environmental impact of this project is the high consumption of office and all the computers and servers used for it.

A.4 Ethical Implications

In this section we will evaluate the ethical implications of such a project.

Employee development is a key for company progress and well being. For one reason, because knowledge is a really important part of any professional life, which leads to more efficiency at work and thus increases revenue. For another reason, if employees feel taken care of at a firm, they are more likely to stay there, their quality life gets higher, and their satisfaction and mental health is overall improved. Also, the offer of rewards for this matter is an added value which at the end of the day just benefits one's life.

APPENDIX B

Economic budget

This appendix details an adequate budget that is required for the execution of this project.

B.1 Physical Resources

The complete budget of physical resources used in order to carry out the development of this project includes the computer used for research and programming purposes and its peripherals. The estimated costs of each element is shown at the list bellow:

- Computer: 1300€ considering desktop, screen and peripherals.

Therefore, the total cost in material that the project required was 1300€.

B.2 Human Resources

The salary of a person developing a project like the one proposed is based on the scholarship within which this project was designed and carried out. The company scholarship of 500 hours, with a value of 2750€ was the total budget for human resources.

B.3 Licenses

This section should evaluate the cost related to software licenses that had to be purchased in order to develop and implement the scenario. However, all the software used throughout the project is open-source, so this section does not represent any cost.

B.4 Taxes

The developed project forms part of the department of research and innovation of the company, so it is not intended for selling the final product to another company. However, this idea and the platform that was built from it, could actually be registered and provided to an interested investor. Taking that into consideration, the sale would be bound to a 15% tax over the price of the product, as it is defined in Statute 4/2008 of Spanish law.

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