Masters Thesis

A gamification-based approach for learning IoT

Tatiane Escobar Gava

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Examiner: Prof. Dr. Stefan Wagner
Supervisor: Dr. Ana Cristina Franco da Silva  
Dr. Pascal Hirmer

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Abstract

In recent years, gamification has been employed in several domains, including in IoT applications, to improve, for example, human engagement, performance and sustainability. Such an approach aims to increase human motivation by employing gamified elements (e.g., badges, points) in non-game contexts. To support the learning process, a gamification approach was developed in the scope of this master thesis to teach IoT concepts within IoT platforms. To achieve this goal, several gamification-based frameworks have been analyzed. Based on this analysis, a generic gamification-based approach to learn IoT concepts was designed and prototypically implemented. To verify the effectiveness of the elements, a user experience evaluation was performed with 10 participants, which verified the learning growth in IoT and the behaviours generated with the gamified elements. This evaluation proved that the participants learned the main concepts of IoT and that all the elements implemented in the prototype proved to be important for the user’s journey in learning. In conclusion, the goals of this master thesis were achieved through proofing of IoT knowledge growth and that the gamified elements proved to be important throughout the journey, as pointed out by the user evaluation participants.
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1 Introduction

The Internet of Things (IoT) has grown significantly in its daily use by consumers, moving from futuristic scenarios to the reality of home, sports or security routines. As can be seen in the survey conducted by the company Deloitte about smart home consumers [Del18], on average 16% of consumers in Germany currently use smart home solutions across all ages – this corresponds to a significant increase compared to the smart home survey carried out by Deloitte in 2015 [Del18].

Due to the decreasing costs of smart home devices, the proportion of smart home users also increases. However, the aforementioned survey shows that 38% of the participants say that IoT solutions are still too expensive, and 21% say that these solutions complicated to install and use.

The configuration and management of IoT environments and applications is challenging and complex, and furthermore, require expert knowledge to be successfully conducted. In order to make IoT also accessible for end users that do not have a consolidated background in computer science, approaches to facilitate the learning of IoT concepts and the subsequent development of IoT applications are still needed. For this reason, the research motivation for this master thesis is to provide an approach within IoT platforms to motivate non-expert end users to learn IoT concepts. Furthermore, this master thesis also aims to ease the development of open-source IoT platforms by end users.

To support the learning process, a gamification approach was developed in the scope of this master thesis to teach IoT concepts within IoT platforms. In recent years, gamification has been employed in several domains, including in IoT applications, to improve, for example, human engagement, performance and sustainability [AN19]. Such an approach aims to increase human motivation by employing gamified elements (e.g., badges, points) in non-game contexts.

The main goal of this master thesis is increasing the motivation and learning curve of end users by introducing gamification mechanisms to common IoT platforms. The results of this master thesis have been evaluated through a user study based on a proof-of-concept implementation, integrated in the open-source IoT platform MBP [FHS+20], which has been developed by the University of Stuttgart.

To achieve this goal, several gamification-based frameworks have been analyzed. Based on this analysis, a generic gamification-based approach to learn IoT concepts was designed and prototypically implemented.
1 Introduction

1.1 Research Questions

This master thesis aims to answer two main questions, which are related to answer two questions related to the gamified elements and learning process:

- Question 1: Do gamified elements support the IoT knowledge improvement of people without any previous knowledge in IoT and IT?
- Question 2: Do gamified elements stimulate behaviours that assist in the learning process of people without any previous knowledge in IoT and IT?

1.2 Outline

The remainder of this master thesis is structured as follows: Chapter 2 gives an overview of the Internet of Things and Gamification, which are essential topics to comprehend this work. Chapter 3 presents related work. Chapter 4 presents the analysis of three gamification frameworks and explains which of them were used in this work and why. Chapter 5 presents the conceptual design and prototype development. Chapter 6 evaluates concepts and prototypical implementation through an user experience evaluation. Finally, Chapter 7 summarizes this work and describes future work.
2 Background

To achieve the goals of this work using gamification concepts to motivate non-expert end users to learn IoT concepts and ease the development of IoT applications, the following topics are important for this work: IoT, gamification and User Evaluation. Moreover, for a better understanding and visualisation of the results, the concepts of this thesis were implemented in the MBP IoT platform, which is an IoT platform that was designed and built in collaboration at the University of Stuttgart.

2.1 Internet of Things

The Internet of Things (IoT) [FRS+13] is an emerging technology for enabling smart environments, such as smart homes, smart factories, and smart cities. The IoT generally refers to the networking of heterogeneous devices, which are equipped with sensors and/or actuators. This heterogeneity allows the creation of adaptive, flexible IoT environments that are able to recognize and react to certain conditions as soon as possible.

There are many definitions of IoT mentioned by different researchers. The term was first defined by Kevin Ashton in 1999 and was later defined as “The Internet of Things allows people and things to be connected Anytime, Anyplace, with Anything and Anyone, ideally using Any path/ network and Any service” [PZCG14]. The IoT promises to bring to the society “a better world for human beings” [PZCG14], where devices know us very well: what we want, what we like, and what we need – and can even make decisions without the user requesting it [DMD+10].

The IoT was built to connect multiple nodes and through these connections to send information about interactions between a device and another device or a device and a human (user). These devices should send data in real time to be processed and as soon as possible make decisions based on the data. Furthermore, IoT products collect valuable data for companies, which allow the generation of great knowledge about the users or clients using, e.g., their shopping habits, walking patterns, etc.

The IoT ecosystem is extremely complicated and fragmented. It involves many different devices, technologies, vendors, and configurations. Platforms for configuration and management of IoT ecosystems tend to be extremely complex and difficult to manage, especially over time as the number of system devices grows and the usages demanded of these systems increase. According to Statista, a German company specialized in market
2 Background

and consumer data, there were in 2018 around 22 billion Internet of Things (IoT) devices connected devices and in use around the world and its projection suggests that by 2030 around 50 billion of these IoT devices will be in use [Sta19], as depicted in Figure 2.1, increasing each year even more the complexity of IoT ecosystems.

![Number of devices in billions](image)

**Figure 2.1:** Number of Internet of Things (IoT) connected devices worldwide in 2018, 2025, and 2030 [Sta19]

Furthermore, according to some researches [Glo19] [IoT20], there were in the end of 2019 officially 620 IoT Platform companies on the open market, up to 260 IoT Platforms companies in 2015, and a 2.4 times growth (as depicted in Figure 2.2 ). This shows that the IoT ecosystem is getting harder to manage mainly because a user does not want to use only one vendor, or because this vendor does not have all best devices in price or quality. For this reason, IoT platforms need to be flexible enough to configure and manage as much vendors as possible. Users do not want to have many disconnected platforms to control a single environment, or are not be able to connect devices from different vendors.
2.2 Gamification

Gamification has become a trend and popular practice in business [WH12]. The term means using elements of games in order to engage people to achieve a goal. There is no consensus in the definition of the term "gamification", although the most widespread definition of it clearly comes from Deterding et al. [DDKN11a], as “the use of game-design elements in non-game contexts”. Gamification improves learning motivation by inserting game elements in the in the middle of instruction processes. [Rah19]. Gamification has a wide application to domains, such as, healthcare (to encourage more exercise, e.g. Nike+, Fitbit [TL18]), education (facilitate learning, e.g., MinecraftEDU, Khan Academy), commerce (make exercise more fun, e.g., Fitocracy [HHT15]), marketing (create a competition between customers, e.g, [HH17]), logistic ([WKM+20]), employee management (encourage collective effort [SRV13]), customer relationship (customer engagement, e.g., reactive customer engagement in product returns [EMFD19]) and research (improve treatment protocols and develop drugs, e.g., [Ant17]) [SF15].

Figure 2.2: IoT Platforms Competitive Landscape Database 2020 [Glo19] [IoT20]
Different terminologies have appeared from the interaction between games and education, such as gamification and serious games, although many researches differentiate between these terms. Gamification consists of using techniques, strategies, and game design in other contexts that are not necessarily associated with the games themselves [Cho15]. It encourages engagement, productivity, and determination, making it easier to achieve goals and objectives in any context, always focusing on user enjoyment [WH12]. However, it is important to note that gamification does not mean a whole game itself, it only uses elements from games that support the goals from a task in non-game contexts [TL18] [Cai01]. This diverses from the concept of serious games, which use the designed game as a whole game with goals related to non-entertainment purposes, as depicted in Figure 2.3 [DDKN11a].

**Figure 2.3:** Difference between gamification and serious games [DDKN11a]

Elements, such as points, badges, and leaderboards (PBL) are common game elements used in Gamification. It helps the users to track their progress, compare themselves with others and collect achievement symbols for excellence [WH12]. Nonetheless, some research shows that gamification does not return the expected benefits. Thomas Leclercq [LPH17] listed some poor results with the use of gamification in projects around 2017 and 2019, such as: no effect on user behavior, conflicting interactions, stress, and user disengagement [LPH20]. According to Werbach [WH12], the main problem in these cases is the diversion into user-centric and fun.


2.3 The MBP

The Multi-purpose Binding and Provisioning Platform (MBP) is an open-source IoT platform developed at the University of Stuttgart – to manage devices, and allowing non-IT users to create rules for IoT environments in a simple way. The MBP connects devices, sensors and actuators allowing to visually create smart environments (e.g., smart homes, smart industry, smart office, etc.) and reducing their complexity in installing and controlling sensors and actuators [FHS+20].

The essence of the MPB platform is to enable a secure connection of a huge amount of heterogeneous sensing and actuating technology devices. Furthermore, it reduces the amount of manual tasks required to set up an IoT environment with sensors, actuators, devices, and rules. Figure 2.4 shows how MBP represents IoT components and how they interrelate with each other in the platform.

![MBP IoT components](image)

**Figure 2.4:** MBP IoT components

According to the concepts presented in figure 2.4, a device is connected to or contains sensors and actuators. Sensors and actuators interact with the environment: sensors measure physical characteristics and actuators change these characteristics. To connect a device to a sensor or actuator and allow the communication between them and the MBP, a piece of software is required. This software extracts data from a sensor or activates an actuator and is called extraction or control operator. Another important entity of the MBP is a rule, which is an event-condition-action statement. Rules allow users to specify how their IoT environments should react to pre-defined events based on sensor data.
3 Related Work

This section addresses the related work either in terms of market products or in terms of research projects that focus on similar concepts as those of this work.

The goal of this work is to apply gamification so that people without knowledge in IT or IoT can quickly learn how to use residential IoT platforms. In the learning process, the user gets to know basic IoT concepts and applies them directly to the platform, in this thesis, the MBP IoT platform. This learning aims at facilitating the use of less user-friendly tools, such as Raspberry Pi, which do not have platforms aimed at users with low IoT knowledge.

Gamification is a methodology applied widely in several domains, such as in healthcare, education, energy, or marketing [HKS14]. This work, however, as it aims at the learning process in IoT tools, focuses on studies of applications in IoT for health activities or residential controls and in learning using gamification.

Khan introduces the Khan Academy [Kha06] system, which targets learning almost anything for free [Tho11]. Students are able to learn math, science, and economics with videos on, which one can never see the instructor – only the voice can be heard and the material can be read or watched. In addition, it uses gamification to motivate the students with badges, points and progression. Khan says that with his application, the learning is more human and it also allows students to advance at their own pace. Moreover, he believes students only understand a new subject, for example, math, if they discover each principle on their own. He gave Isaac Newton’s example, who would have never invented calculus learning from textbooks. Considering this last statement, we can assume that it is easier to learn IoT topics already in an IT environment, and not only on a learning website. In this master thesis, users can see real results and during the process earn rewards, which could engage them even more.

Raharja University introduces the iDu software [Uni01], which is an online learning method to ease the students’ access to the lecture material, making the collection of independent tasks become easier and efficient [Rah19]. iDu has enormous benefits as a social network between teacher and student, which can be monitored by parents. This platform tries to motivate the student in progressing the learning process and completing the task independently online. To achieve this goal, the following elements are applied: individual points, badges, achievement leaderboards and levels. It has the same disadvantages as Khan Academy, since it depends on what should be learned, for IoT, this is the case. For math, maybe not.
Khasianov et al. [KSG16] introduce the Kazan Federal University, a learning gamification platform. Every course has certain credits, and students have a target credit value for the courses in their curriculum. It has badges for complex tasks, and students ratings. As almost all learning platforms, the learning process does not include doing the tasks and seeing how it works. It is an independent course, which requires the user to learn and apply separately.

The INLIFE platform, which is built in the INLIFE project [pro20] and is funded by the H2020 EU programme. The INLIFE platform supports the development of e-health services and applications by combining IoT and gamification. The main idea is to exploit the addiction to games in order to incentive them to change their behavior and act as desired [KKD+18]. This project combine 3D games with actions in the real life and IoT. For example, the ALMA project used APIs of the INLIFE platform to create a game for children, teenagers and adults with disability (autism and mental retardation), aiming at their psychosocial improvement and integration in a society with IoT devices, such as RFID in toys. The INLIFE platform focuses on controlling mainly health behaviors and not on managing IoT devices. What differentiates this master thesis is that the user learns how to install and use IoT devices, and not only use them as they are.

Nike+ users are measured via sensors in Nike sports shoes and Apple iPods or iPhones, documented on the Nike+ platform and converted into NikeFuel points [Nik21]. Nike’s Fuel Score, trophies and different kinds of measurements are in use to provide training feedback. These elements help to understand and highlight the key points of the workout and support the progression over time [TL18]. In this situation, it is not necessary to understand how sensors work to install or control them, mainly because there is more than one sensor, which will be controlled. This master thesis focuses on connecting different devices and configuring them, what is not possible in Nike+.

Félix García [GPP+17] introduces the GOAL, an application of gamification in Software Engineering Team. It sets challenges that need to be fulfilled, for which some skills, and mainly much collective effort, are required. It clearly enables the company to introduce gamification in its work environment, achieving a quality solution with appropriate design and development effort. This tool allows project managers to create projects, define teams and introduce tasks. GOAL is more focused on project management, and not in increasing knowledge or learning. It is more a competition to finish tasks, and this work has the objective to increase the motivation and also learning a new topic.

Papaioannou et al. [PKB+17] introduces the ChArGED, an IoT-enabled gamified approach to alter consumption behaviors in public buildings. ChArGED focuses on energy consumption, energy efficiency and reductions of wasted energy in such buildings. It uses low-cost devices (NFC or Bluetooth Beacons) to improve energy efficiency and (consequently) reduce wastage at device, area, and end-user level. In this example, users do not need to implement anything. They are able to learn how to save energy and see a dashboard about the improvements made. Similar to ChArGED, this thesis aims at the possibility for the
user to manage his domestic energy consumption, however, not by checking consumption dashboards, but by learning IoT and managing rules to turn off devices when they are not needed.

Casals et al. [CGM+20] introduce another energy application, the CodeGreen Energy App that enables to view and analyze Energy scores of buildings and to share building performance statistics on social media networks such as Facebook and Twitter. The CodeGreen Energy App has the same limitations as ChArGED.

The main contribution of this master thesis to solve the problem of IoT learning by non-IT users is the design and implementation of a gamification approach integrated in an IoT platform where users can learn IoT and also implement what they are learning at the same time, which means learning by doing.
4 Gamification - Methodologies

An essential task of this master thesis is the analysis and consequently the choice of one or more suitable gamification frameworks, which will be the base to develop the gamification project design.

There is an increasing number of academic papers about the concept of gamification being published from 2010 [HKS14]. However, whether gamification is effective is still an on-going debate. There are many knowledge gaps on the issue if gamification is effective or if it is only a hype. For this reason, this master thesis investigates if some of the gamification elements are indeed effective to learning IoT.

4.1 Gamification vs Game Inspired Design

Gamification is part of the daily life, for example, collecting airline miles to exchange for tickets, collecting points on the credit card to exchange for products, earning points on Waze, browsing on eBay or LinkedIn, etc. They all have elements of gamification. They encourage loyalty, increased use and motivation to execute tasks [MHWA17].

More specifically for this work, gamification in education comprises the idea of adding game elements, mechanics and logic to engage people in the purpose of learning [LH16]. It is possible to use the content that was usually presented in a lecture and add gamification elements, such as quest, leaderboard, progress, or avatar and create a game itself.

In order to make the distinction between games concepts clearer, Marczewski has made a framework one can use to define what type of game it is, which can be seen in Figure 4.1. Marczewski breaks games in five types: game, serious games, simulation, gamification and game inspired design [Mar13].

This thesis aims for gamification since its focus is to motivate and engage and it is not intended to be a game, it just to contains elements of gamification.
4 Gamification - Methodologies

Figure 4.1: How to define if an application uses gamification or has a game inspired design [Mar13]

4.2 Frameworks

This work comprises a gamification approach. All gamification frameworks are composed of one or more basic themes for implementing it, which are: Design Process, User Motivation, Player Journey, Player Types, and Monitor and Measure [WH15]. In the following sections, these topics are presented in three famous frameworks, highlighting their advantages and limitations. The framework are Octalysis, 6D and MDE.

4.2.1 Octalysis

This section is written based on [Cho15].

Yu-Kai Chou is a gamification pioneer. He started his career as a game designer but today he works as consultant, teaching large companies to gamify their products and services, e.g., Google, Porsche, Ebay, Lego, etc. Octalysis, Chou’s gamification framework, has this name because the author, based on his years as a game designer and on what he studied in psychology, came to the conclusion that gamification tactics are organized into 8 Core Drives, which motivate users towards a variety of decisions and activities.

The Octalysis visually has an octagon shape in which the core drives are depicted in each corner, which is named as the Level 1. The right-hand drives reflect the creative, artistic and social aspects, while the left-hand drives reflect the rational and intellectual
4.2 Frameworks

Figure 4.2: The Octalysis Framework [GB17]

aspects. Chou says, if there are none of those 8 Core Drives behind a desired action, there is no motivation, and consequently, no action takes place. In addition, he addresses the significance of knowing that either extrinsic (motivated to perform a task to earn a reward or avoid punishment) or intrinsic (motivated to perform a task to own benefit) motivation is preferred by these drives. Some of them make the user feel powerful, but do not create urgency, while others create urgency, obsession, or make the user feel bad.

Figure 4.2 shows the Octalysis Framework and its 8 Core Drives.

The Octalysis framework triggers logical and emotional reactions. The left side concerns extrinsic motivations to reach a specific result. One is driven to action by logic, because the user will be rewarded in the end. The right side comes from intrinsic motivations and refers to emotional decisions, based on the person’s experience. One acts because he feels good or excited in doing so. The right side represents pleasant experiences, which do not need prizes in the end because they are pleasurable in themselves.

Another factor to note within the Octalysis Framework is that some Drives are considered positive motivations and others negative. This factor is called White Hat Gamification and Black Hat Gamification, which are respectively the top and bottom Core Drives of the framework, as can be seen in Figure 4.2. The use of these top elements makes the users express their creativity. It makes the users feel successful and encourages action. The bottom drives are not bad for causing negative feelings, it only brings the feeling of losing something if the user does not take action. For example, if one does not brush their teeth at night, they will not be able to eat a pie the next day.
Figure 4.3: Facebook Octalysis Framework [Cho15]

Figure 4.3 shows how Octalysis looks like for Facebook.

Chou believes that a successful gamification project needs to motivate users and, above all, keep users motivated, since user’s motivation from day 1 is totally different from day 100. This process can be divided into different stages and is commonly referred to as The Player Journey, and in the Chou Framework it is known as Level 2. Chou states that his work is inspired by Kevin Werbach’s theory, and consists of a discovery, onboarding, scaffolding and endgame phase. For example, most people discover a product because of two Core Drives: Unpredictability and Curiosity, as can be seen in Figure 4.4.

Furthermore, the Octalysis framework shows in Level 3 that player types are also a factor which impacts people’s motivation at different stages of the experience. Chou uses Richard Bartle’s Four Player Types which is the most recognized model in game design, which are Achievers, Socializers, Explorers and Killers. However, it is difficult to design something that pleases all user types. For this reason, he says that it is better to use the Level 3 to find weaknesses within the system and create improvement for motivation at various points.
The Octalysis framework is one of the most complete gamification frameworks. However, it is focused on psychological behaviors, it is almost a template, and has gaps in design implementation and in how to monitor and measure the system. For this reason, the development process of a gamification prototype or application requires the combination with other methodologies.

To summarize the Octalysis Levels a figure was created to understand the framework, as can be seen in Table 4.1.

**Table 4.1: Octalysis Level Overview**
4.2.2 6D Framework

This section was written based on [WH12] and [WH15].

Kevin Werbach, a professor at the Wharton School of the University of Pennsylvania, and Professor Dan Hunter, Executive Dean of the Faculty of Law, Queensland University of Technology (QUT), defined a six-step gamification design framework, which is depicted in Figure 4.5.

The framework represents a design process with the following six steps or premises:

- **Define business objectives:**
  
  In this step, it is detailed how gamification will benefit the business or achieve some other goal, such as motivating people to change their behavior. It is required to make an objective list as concrete as possible and rank them.

- **Delineate target behaviors:**
  
  In this step, the expected behaviors and how to measure them are detailed. For this reason, it is needed to specify the tasks, then define the success metrics, the win states for every task (e.g.: encourage people to invite friends with metrics as social network share and new users) and, finally, define how to measure these win states, e.g., Daily Active Users (DAU) / Monthly Active Users (MAU) ratio and virality.

- **Describe your players:**
  
  In this step, the users, skills levels, demographics (such as age and gender), psychographics (such as their values and personalities), or Bartle’s player types as used in Octalysis Framework, are defined. The system design needs to address the groups defined, so one should define different elements, different mechanisms for each type, in order to motivate them.

- **Devise your activity loops:**
  
  In this step, two kinds of activity loops in a game are defined, called engagement loops and progression loops. Engagement loops operate at the micro level, individual user actions. Progression loops operate at the macro level, broader structures of activities. The Engagement Loop is the constant process in the whole game: motivators appearing, the game giving the user something to do, some reason to be motivated, user taking the action and winning the challenge, as depicted in Figure 4.6.
4.2 Frameworks

It is also necessary to check how the gamified system moves forward. The player’s evolution in the game from a newbie, a novice, to a master, and typically the way this is done in games is through rising and falling action, as depicted in Figure 4.7. The difference to Chou’s approach is that instead of discovery, Werbach Hunter (2012) present an Identity phase. This is the phase where the user, for example, creates an account for the gamified system. Chou’s (2015) player journey starts at the discovery phase, where the user first discovers and learns about its existence.

• **Don’t forget the fun:**
  In this step, it is defined which aspects could continue to motivate players to participate even more in the game. It is certain that PBLs (Points, badges and leaderboards) are not necessarily fun. The challenge is to make sure that if gamification elements are going to be used, they will provide strong commitment and fun to the user.

• **Deploy the appropriate tools:**
  The final step in gamification design is to describe the game feedback, elements and the whole interactions. Once the 5 steps above have been evaluated and all questions are answered, it is time to think about the different options and the different techniques and tools that can be used to handle the challenge. Moreover, it is important to iterate and test and iterate again, and keep improving the system to get something
that works for the business objectives and to achieve the defined metrics. To evaluate the software, the best way to start is to build a prototype that costs little time and money, and let potential players try the system out and give feedback.

6D framework is not a precise and strictly detailed template. However, it is one of the most complete guidelines to help the gamification process as it covers all the basic topics. The framework does not always have to be used in its entirety. It is possible to choose which steps are needed to design the application. On the other hand, since it is only a guideline, there is the need to combine it with more gamification studies to be able to execute the proposed steps.

### 4.2.3 MDE Framework

MDE is a framework adapted from another framework called MDA (mechanics, dynamics, and aesthetics) [HLZ04], which is a tool used to analyze games, as depicted in Figure 4.8. In game design, aesthetics defines the emotional reactions that players elicit as they engage with the game (e.g., fantasy, submission, friendship, discovery) [RPK+15b]. These aesthetic reactions are mostly video game-specific, for this reason, in the MDE Framework the word used is *emotions* as it relates closer to the effects of interaction that corporations can obtain from staff and consumers [RPK+15b]. Moreover, the MDE Framework takes an important initial step towards highlighting the importance of emotional experiences in motivating human behavior and includes a two-way relationship between the parts. The player’s emotions and the dynamics developed when interacting with the system should shape the part of the mechanics that controls the overall play of the gamified experience [MS20], as depicted in Figure 4.7.

![Figure 4.8: MDE framework of gamification [HLZ04]](image-url)
Mechanics describe the setups or rules and components that encourage users to take an action. Dynamics describe how the mechanics between user input and interactions work. Emotions describe the emotional response from a dynamic or mechanism when users interact with the gamified system.

The MDE Framework is more a guideline to the relationship between gamification parts and how they impact each other [BDNC]. It does not go deep in Design Process, User Motivation, and Monitor and Measure. For this reason, MDE by itself is not enough to implement a gamified system. Additional methodologies are needed to support the development.

### 4.2.4 Summary and Comparison of Frameworks

All the above mentioned frameworks are a great inspiration and give a deep insight on gamification in learning IoT. As it has been shown, the frameworks listed in this work are not applicable alone. There is no framework which covers all basic topics, as depicted in Table 4.2. A combination of methodologies and frameworks is necessary to implement a gamified system according to the project’s objective.

What is worth mentioning is that all frameworks show the importance of the relationship between emotions and actions. The project has to focus on psychological actions to achieve its goals. For this reason, a gamification project is not simply a system implementation project, but rather involves investigations of mechanisms and their capability of generating the expected results, finally followed by their implementation.
## Frameworks Summary

<table>
<thead>
<tr>
<th>Framework</th>
<th>Summary</th>
<th>Advantages</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Octalysis</strong></td>
<td>The framework is based on 8 Drives which motivate users towards a variety of decisions and activities.</td>
<td>It is one of the most detailed gamification framework with huge amount of examples. It can be considered as a template to be followed.</td>
<td>It has gaps in design implementation and in how to monitor and measure the system.</td>
</tr>
<tr>
<td><strong>6D</strong></td>
<td>The framework represents a design process with six steps or premises.</td>
<td>It is one of the most complete guidelines to help the gamification process as it covers all the basic topics.</td>
<td>It is not a precise and strictly detailed template.</td>
</tr>
<tr>
<td><strong>MDE</strong></td>
<td>The framework focuses in mechanics, dynamics, and aesthetics, which is a tool used to analyze games.</td>
<td>A guideline to the relationship between gamification parts and how they impact each other.</td>
<td>It does not go deep in design process, user motivation, and monitor and measure.</td>
</tr>
</tbody>
</table>

**Table 4.2: Frameworks summary**
A majority of gamification implementations fail due to poor understanding of how to successfully design gamification elements [SF14]. This gap typically manifests as modest gamification designs, commonly only consisting of simple mechanics, such as points, badges and leaderboards [HKS14] [Lan19]. Gamification requires a lot of effort in the design process [MHWA17]:

- Gamification is complex, multifaceted, and therefore it is hard to design the life cycle, rules and progressions in diverse environments [HDL+16] [RPK+15a]
- Gamification involves motivational information system design, which involves understanding what the relevant motivations for users are [HKS14] [HDL+16] [Lan19]
- Gamification needs to affect user behavior which adds yet another layer into the scope of gamification design [HDL+16] [Lan19]

In this chapter, the design process of enhancing an IoT platform with gamification methods is detailed step by step. It is presented how each element included in the design was supported by gamification methodologies, or motivated by common errors documented in previous research.

When surveying the existing literature on gamification, it can be found that most of the research focusses on the gamification elements’ varying levels of abstraction, but actually misses a combination between a software design methodology and gamification elements. These approaches focus mostly on: game mechanics, interface design patterns and motivational information system design. Even Werbach [HDL+16] [Lan19], who has developed a six step process for implementing gamified applications, does not include the stages of the design process on it. As this master thesis aims to introduce gamification elements into an IoT platform, this work requires the use of a design methodology to guide the gamification design. Thus, the Garrett method [Gar10] is used, which is divided into five steps, as depicted in Figure 6.11: Strategy, Scope, Structure, Skeleton, and Surface.
Figure 5.1: Interrelation between Garret Method, 6D Framework and Octalysis Framework
[Gar10] [Lan19] [Cho15]
The following sections are based on the Steps to Design a Website [Gar10] by Garret. In each section, the step’s objective and methodology used are presented, as well as the defined results based on gamification methods explained in Chapter 4 – Gamification - Methodologies.

### 5.1 Strategy

This plane’s objective is a successful user experience. The first step in the development of the project is to precisely to summarize the strategy to be adopted and define user needs and software system objectives. The plane’s objective also includes success metrics, which indicate whether the business goals were reached.

In this master thesis, two definitions have been made to meet the users’ needs. It has been defined that the IoT platform to be further developed should motivate non-expert end users to learn IoT concepts, with the main objective to ease the development of IoT applications and users’ use of IoT devices. Furthermore, even though this master thesis focuses on low cost and open-source devices and platforms, such as Things.io, MBP platform, Arduino, Raspberry, BeagleBone, or LaunchPad, proprietary IoT platforms can also benefit of this work. In this case, however, the work’s results should be adapted and applied more directly to their needs.

The two definitions above definitions about this work’s focus are based on the information from a Smart Home Consumer Survey from Delloite [Del18], which shows that 38% of the participants say that IoT is too expensive, and 21% say that it is complicated to install and use, as depicted in Figure 5.2.
As already stated, in order to achieve the learning objective of this work and enhance user motivation, the use of gamification strategies has been chosen. To support the definitions needed in the Strategy plane, the 6D Gamification Framework, explained in Chapter 4, has been selected, whose three first steps have been used:

- Define business objectives
- Deliberate target behavior
- Describe your players

### 5.1.1 Define business objectives

There has been a further refinement of the definition of the business objectives. The application has the objective to teach basic IoT concepts to non-expert end users and perform activities to facilitate their understanding with small incentives and interactivity, which will facilitate the development of IoT applications and the user utilization of IoT.
5.1 Strategy

devices. Thus, throughout this stage, it sought to understand the needs of future users and
to determine which IoT platforms the system developed in this thesis would support.
In order to do so, several platforms have been examined to extract a list of concepts that
end-users are required to know. 15 IoT platforms were investigated and supported the
understanding of the topics to be focused on: DeviceHive 1, FIWARE 2, Home Assistant
3, OpenHAB 4, OpenMTC 5, ThingsBoard 6, hinger.io platform 7, openremote 8, MBP 9,
IFTTT 10, AWS IoT 11, Google Cloud IoT 12, Samsung SmartThings 13, Philips Hue 14,
Bosch IoT Suite 15, thethings.io 16.

This investigation results in the following main IoT concepts: sensor, actuator, device, rule
and code to connect sensors and actuators to devices.

This work focuses on non-proprietary software, which implies low cost to users compared
to proprietary software.

5.1.2 Deliberate target behavior

In order to achieve the system’s goals, some behavior need to be encouraged during the
learning process. According to Werbach [WH15], behaviors should be measurable. The
metrics should provide feedback to the system designers, letting them and also the users
know when they are successfully engaging in the intended behaviors.

In this work, the objective is to encourage people to try out new concepts and encourage the
desire to learn. Therefore, what needs to be measured is the knowledge acquired. There are
two methods of measuring student learning: summative or formative assessments [Kea10].
Summative assessments are, for example, tests, quizzes, and other graded activities that
are used to measure student performance. Consequently it makes it possible to measure

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1Device Hive: https://devicehive.com/
2FIWARE: https://www.fiware.org/
3Home Assistant: https://www.home-assistant.io/
4OpenHAB: https://www.openhab.org/
5OpenMTC: https://www.openmtc.org/
6ThingsBoard: https://thingsboard.io/
7hinger.io platform: https://hinger.io
8openremote: https://openremote.io/
9MBP: https://github.com/IPVS-AS/MBP
10IFTTT: https://ifttt.com/
11AWS IoT: https://aws.amazon.com/de/iot/
12Google Cloud IoT: https://cloud.google.com/solutions/iot
13Samsung SmartThings: https://www.smartthings.com
14Philips Hue: https://www.philips-hue.com/de-de
15Bosch IoT Suite: https://www.bosch-iot-suite.com/
16thethings.io: https://thethings.io/
individual knowledge. Formative assessments measure student learning on a daily, ongoing basis. It is more about the interaction between instructor and student, who gets feedback about their interactions and insights into their own learning.

Considering the nature of the application, it makes no sense to have formative assessments, because there is no interaction which can be monitored. For this reason, metrics based on summative assessments are used in this work.

5.1.3 Describe your players

It is important to understand what sorts of game elements and other structures are likely to be effective for the users. For this reason, it is necessary to understand who the users are. Since the user evaluation is conducted in Germany, the user target was defined based on a Smart Home Consumer Survey from Delloite [Del18] in Germany, which presents an overview about the Smart Home consumers and what their interests are.

According to the study, approval for smart home products is particularly high in the age group between 25 and 45 years, as depicted in Figure 5.3. Moreover, even though costs for smart home hardware have recently fallen, the different levels of acceptance in the income groups show the high prevalence in the high-income segments, as depicted in Figure 5.4.

![Figure 5.3: Smart Home Users Age [Del18]](image-url)
5.1 Strategy

**Figure 5.4:** Smart Home Users Income[Del18]

Furthermore, the expectation for 38 percent of the participants in the study is that these systems will reduce electricity and heating costs. However, it is not only financial, but also ecological aspects that count: for 20 percent, the resulting positive effects on the environment are a good reason to switch to a smart home, as depicted in Figure 5.5.

**Figure 5.5:** Reason to use and interest in smart home [Del18]
5 Conceptual Design and Prototype

It has also been asked in the survey about the motives for not using and lacking interest in smart home offers. 22 percent of those surveyed doubt that the technology is mature and 21 percent perceive commissioning as too complicated, or do not see any added value that would justify its use, as depicted in Figure 5.2. This shows the need to focus on the concepts of the technologies behind the smart home devices.

5.2 Scope

The Scope step aims at defining the characteristics of the product. After understanding the wishes and needs of users, the definition of the functional boundaries of the application begin effectively in this step. Here, it must be defined how the user’s needs will be met. It should be noted that, as important as to make clear what is part of the project, it is to define what is not.

In the Scope phase, it is first defined which main concepts would be taught to the users, as well as the game elements and the behaviors expected based on Core Drives from the Octalysis Framework [Cho15].

5.2.1 IoT Concepts

A study from the Institute of Architecture of Application Systems – University of Stuttgart, Germany [GBF+16], defines an IoT reference architecture as described in Figure 5.6. It presents the IoT components and their intercommunication based on a comparison of different platforms. Simplified, the architecture is composed of seven concepts: Sensor, Actuator, Drive, Device, Gateway, IoT Integration Middleware, and Application.
These concepts were also verified in the 15 tools participating in this research, thus, leading to the same core IoT concepts. The important information to be emphasized in this topic is that the terminology from the concepts can change from platform to platform. However, the constancy of meaning and use is always the same. For example, in Philips Hue, drives are called skills and in MBP they are called operators, that is, different names but the meaning is the same. To facilitate the understanding in the scope process, the nomenclature introduced by Guth et al. [GBF+16] is used.

From these seven concepts listed in 5.1, some of them have direct impact in using IoT environments by novice users and some do not. For this reason, it was analyzed in the 15 tools participated in the research what is necessary to a beginner to learn to be able to use an IoT platform and manage IoT devices. The following concepts have not been selected in this work as they have no direct use for beginners in IoT platforms: Gateway and IoT Integration Middleware. They are more necessary for advanced users, or applications which are not so user friendly, and this project considers tools with more friendly installations, or provided as a service. The concepts considered in this work are: Sensor, Actuator, Drive, Device, and IoT Integration Middleware.

Moreover, as part of the project’s strategy to be more illustrative and teach IoT concepts more clearly, the application Multi-purpose Binding and Provisioning Platform (MBP) has been defined to support the user learning process, on which the user can install a real IoT device and see it working. The Multi-purpose Binding and Provisioning Platform (MBP)
5 Conceptual Design and Prototype

project, developed at the University of Stuttgart, is an IoT platform developed for easy management of IoT environments. The MBP\textsuperscript{17} enables users to create rules for the IoT environment in a straightforward and event-condition-action fashion.

As aforementioned, not all IoT platforms have the same terminology for the IoT concepts. For better understanding, as the MBP platform is used in this thesis to evaluate the gamification concepts, the same nomenclature used in MBP is used from this point on. For this reason, it is necessary to understand the names and the meanings for each concept used in the MBP. The comparison can be seen in Table 5.1.

<table>
<thead>
<tr>
<th>Concepts</th>
<th>MBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor</td>
<td>Sensor</td>
</tr>
<tr>
<td>Actuator</td>
<td>Actuator</td>
</tr>
<tr>
<td>Driver</td>
<td>Control Operator</td>
</tr>
<tr>
<td></td>
<td>Extractor Operator</td>
</tr>
<tr>
<td>Device</td>
<td>Device</td>
</tr>
<tr>
<td>Application</td>
<td>Rule</td>
</tr>
</tbody>
</table>

\textbf{Table 5.1:} Nomenclature from IoT reference architecture based on Guth et al.[GBF+16] and MBP

From this name comparison, the one with a slightly greater difference is the drive concept, which is divided in two in MBP. MBP separates drives for Actuators and drives for Sensors in different variables, even when the meaning and use is the same: a piece of software to connect the device to the sensor or to the actuator, as depicted in Figure 2.4 in Chapter 2 - Background. Control operator is the drive in the actuators and extractor operator is the drive in the sensor.

5.2.2 Gamification Elements

In this step, based on the needs and behaviors expected from the users, it has been defined which Core Drives from Octalysis Framework would be included and which gamification elements would have the desired effects in the application. At this stage,

\textsuperscript{17}https://github.com/IPVS-AS/MBP
gamified applications were also studied in the scope of this master thesis. However, they did not bring any new insight compared to the gamification frameworks and their examples studied in this work.

Product Gamification is about making a product more fun, engaging and motivational [Cho15], it is not only about including functionalities. For this reason, first, the expected Core Drives were defined and then the corresponding functionality. From the 8 Core Drives defined by the Octalysis Framework, all of them were included in the scope of this thesis, as all of them impact the learning process and the motivation to continue playing the game. However, the Core Drives do not need to have the same quantity of game mechanisms, some are more important for an IoT Platform’s purpose than others. The following points depict how each Core Drive was identified as necessary and the importance of it to the learning process:

1. **Epic Meaning & Calling**
   - **Objective:** This is the drive which defines that people are motivated because they believe they are engaged in something that is bigger, not only their own learning, but they are helping also others, it turns them into heroes [Cho15].
   - **Motivation for the IoT Platform:** As in the Smart Home Consumer Survey from Delloite [Del18], two main expectations or motivations for the Smart Home users are saving costs and ecological aspects. Then, the Epic Meaning & Calling for the game is Saving the World and Costs. The gamification should teach the users how IoT can help them save resources and consequently lower their costs.
   - **Importance:** This drive is important, because if the system demonstrates deep and sincere passion towards a higher vision, facing challenges during the learning process will not make the user give up.

2. **Development and Accomplishment**
   - **Objective:** This is the drive which makes people have the sense of growth towards a goal and accomplishing it [Cho15].
   - **Motivation for the IoT Platform:** The learning process needs to show to users that they are overcoming challenges they can be proud of. This drive is about progressing in the game and developing new skills. It is simple to be implemented with goals and rewards, so it is widely used in gamified applications.
   - **Importance:** This drive is effective, because in the learning process it is necessary to have the sense of growth towards a goal and accomplishing it.

3. **Empowerment of Creativity and Feedback**
• **Objective:** This drive is responsible for bringing the real feeling of playing. This is where users need to solve problems. Also important is the recurrence of feedback so that the users maintain their interest on the game [Cho15].

• **Motivation for the IoT Platform:** This drive helps in retaining users for the long haul, how that freedom of creativity can fuel their motivation to take action.

• **Importance:** For the first strategy of the application, this drive has low importance because the activities are quite fixed and without a lot of creative opportunities.

4. **Ownership and Possession**

• **Objective:** This is the drive where users are motivated because they feel like they own something. The feeling of owning makes the home user want even more [Cho15].

• **Motivation for the IoT Platform:** This drive helps making users spend a lot of time in the game accumulating things and taking care of their possessions. This is mainly due to the feeling of losing certain desirables if they are not playing.

• **Importance:** This drive is important, because it makes users spend more time exploring the application to make more and more possessions and consequently learning, even if it is hard or boring, because they will increase their possessions at the end.

5. **Social Influence and Relatedness**

• **Objective:** This drive relates to social elements that drive people, including: mentorship, acceptance, social responses, companionship, as well as competition and envy. Almost every user urges to be able to “Invite His Friends” for sharing their accomplishments with others [Cho15].

• **Motivation for the IoT Platform:** The learning process is an individual process, however, it is also a comparison between students and a competition of those who understand more about the topic or are ahead. This drive brings a lot of interest to go ahead of the game and learn more.

• **Importance:** For the first strategy of the application, this drive has low importance because the activities are quite individual, and the MBP does not yet have mechanisms for sharing information with other users as it is still a tool installed locally without publication or connection with other applications.

6. **Scarcity and Impatience**

• **Objective:** This is the drive of wanting something because you cannot have it. It motivates users because they are either unable to obtain something, or because it is hard to obtain it, therefore, making it more precious [Cho15].
5.2 Scope

- **Motivation for the IoT Platform:** The learning process is sometimes tricky. Some activities need to be done, however, they are quite hard and the users want to skip or give up because they only see the high effort spent on the activity. On the other hand, when they are given the feeling of preciosity and the time to do it, they will at least try it.

- **Importance:** This drive is important to the learning process, because it makes users try hard on complex tasks seeing that they are having more benefits and not just losing their time.

7. Unpredictability and Curiosity

- **Objective:** This is the drive about wanting to find out what is coming next.

- **Motivation for the IoT Platform:** The learning process is always preparing one for the next task or having curiosity about what is going to be learnt next. This work’s application also brings the feeling whether in the end the user will be able to implement an IoT device and see it working.

- **Importance:** This drive is important for the user’s desire to go to the next step, not only because they will gain points, but also because they want to know what is coming next.

8. Loss and Avoidance

- **Objective:** This Core Drive is based upon the avoidance of something negative happening, for example, losing points, going back stages, investment of time, effort, money, or other resources. This drive encourages the user to do the activity with more passion and effort [Cho15].

- **Motivation for the IoT Platform:** This drive brings the feeling of steps back, thus, making users work hard to not waste their learning effort.

- **Importance:** This drive is highly important to test users if they are really learning or only passing through the content. It is possible to show to the users that they will lose chances if they do not do their work right.

After analyzing the drives, the gamified elements that can cover the objectives listed above were defined. For this, examples of applications have been used, which already use gamification for each drive listed in the work of Chou and Werbach [Cho15] [WH12] [WH15]. Finally, nine gamified elements have been created, as depicted in Table 5.2.
In order to delimit the scope of this master thesis, it has been decided which points should be part of a first prototype and which activities are to be considered as future work. The decision was taken based on having all Octalysis Framework Drives in the functionalities, except the 5th Core Drive, due to the lack of current applicability and since individual tests are performed, with no possibility of comparing results. From the nine gamified elements defined, five of them are implemented in the prototype. Consequently from the eighth Core Drives defined by the Octalysis Framework, seven will be implemented in the prototype. The elements implemented are: Story behind the game, Points, Progress, Store and Quest.

### Table 5.2: Gamified elements defined

<table>
<thead>
<tr>
<th>Gamification Element</th>
<th>Octalysis Framework Drives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Story behind the game</td>
<td>1</td>
</tr>
<tr>
<td>Avatar</td>
<td>4</td>
</tr>
<tr>
<td>Points</td>
<td>2, 4</td>
</tr>
<tr>
<td>Progress</td>
<td>2</td>
</tr>
<tr>
<td>Bagdes</td>
<td>2</td>
</tr>
<tr>
<td>Leaderboard</td>
<td>2, 5</td>
</tr>
<tr>
<td>Feedbacks, Curiosities and Challenges Message Area</td>
<td>3, 6, 7</td>
</tr>
<tr>
<td>Store</td>
<td>4, 7</td>
</tr>
<tr>
<td>Quest</td>
<td>2, 3, 6, 7, 8</td>
</tr>
</tbody>
</table>

5.3 Structure

Garret’s proposal in the Structure phase is to plan the structure of the system, which consists of organizing the hierarchy of the screens and the flows between them. The focus of this phase is to create the organization of the system, especially about how the parts interrelate.
In Gamification Design Structure, the game flow must be defined. The two frameworks studied in this work in Chapter 4 (Octalysis and 6D) show the importance of loops, which can help the users to have an overview of their progression and journey. For this reason, there is the need to think in small progression and about the journey which the user will go through.

As shown in Chapter 4 in Figure 4.4, the level 2 from Octalysis tries to optimize the user journey throughout all four phases of a player's journey [Cho15], which are:

- Discovery: reason why the user would want to start the journey in learning IoT
- Onboarding: explanation about the rules and tools used to play the learning IoT game, and motivation of the user to go through the next phases
- Scaffolding: journey of repeated tasks towards the goal in learning IoT
- Endgame: journey to the end without losing the user engagement and achievements

The fourth task of the 6D Gamification Framework, the Activity Loops, divides the loops in two types: engagement loops and progression loops. The engagement loop is the one that motivates the player; the game provides a motivation (e.g.: feedback, or points) for users to take an action to do something and overcome a challenge [WH15]. The progression loop corresponds to the progress through the entire gamified experience. To prevent the users from not seeing their progression, there should be a rest point before they start moving on to a higher level. Progression loop breaks the challenge in small parts, bringing the feeling of a journey [WH15].

Based on the decisions of the previous phase, and taking into account the inputs of the gamification frameworks studied in this work, the elements and mechanics of the system can be more clearly defined as shown in Figure 5.7. The Discovery phase basically corresponds to the Core Drive Meaning, which brings to the user the feeling of saving the environment: first, because using IoT can help the environment, and also because all points accumulated in the game will become an action to help the environment.

The system is divided in three levels as sub-challenges. The user can choose at the end of each challenge to take a quiz and test the acquired knowledge, gaining points in case of success. Each level has some concepts which should be learned, as shown in Figure 5.7. The levels were created to provide the feeling of improvement as in progression loops, and points were used as engagement loops with each task or quiz taken, the user gets more points. The quizzes are used as Summative Assessments as explained in the Strategy phase. They consolidate the knowledge improvement.
5 Conceptual Design and Prototype

Each level has a number of tasks and a quiz to be taken. Each of them provide an amount of points, which increase with the activity’s difficulty. The only activities that can be skipped are the quizzes. If the users decide to take it and correctly answers more than 50% of the questions, they get extra points. If the users decide to not take the quiz, they get no extra points, but also do not lose points. On the other hand, if the users take the quiz and correctly answers less than 50% of the questions, they lose points. This rule brings the Core Drives Avoidance and Ownership to the game: the user does not want to lose the effort made until this point of the game, but also does not want to lose points. This makes them pay more attention to the content to guarantee more points. Level 1 tasks and points can be seen in Figure 5.8, level 2 tasks and points are depicted in Figure 5.9, and level 3 tasks and points in Figure 5.10.

Figure 5.7: Game flow and Loops

Figure 5.8: Level 1 Tasks
Moreover, the points and gifts are strategically defined to encourage the user to take all activities and thereby win the best prizes. The chosen scores and items can be seen in Figure 5.11 and Figure 5.12.
In this stage, the contents of the tasks and quizzes were also created. To each task, a presentation with the task content has been created, which is included in the system as a PDF file.

The tasks, quizzes, and answers can be seen in the Appendix A.1 in JSON format.
5.4 Skeleton

In the Skeleton phase, all user interfaces for the application are designed. Design exists to facilitate and make the user experience pleasant. For this objective to be achieved, it is necessary to consider different elements that are part of the application’s requirements. Some authors say that the biggest mistake of gamified application is forgetting to focus on the goal of a game, which is for the user to have fun [Lan19] [WH15].

The fifth task of the 6D Gamification Framework is *Don’t forget the fun*, which focuses on the engagement and fun in the gamified application. This is an important aspect, which considers how the game would function without any extrinsic rewards. The game needs to have more than only prizes, it needs to have aspects that motivate players to participate even without rewards [WH15]. For this reason, to support the learning process, a robot mascot has been created to help users’ studies. It has been named MBPchen, MBP from the application which is used in this work and chen comes from the diminutive of nouns used in the German language, as depicted in Figure 5.13.

Figure 5.13: MBPchen, the IoT teacher

Following, a draft of the system screen has been drawn with all the elements defined in the Scope phase. Wireframes have also been created based on other gamified applications, as depicted in Figure 5.14. Moreover, sketches have been made to describe the specifications and what it would look like in terms of structure, as depicted in Figure 5.15.
5.5 Surface

The Surface stage refers to what is seen by users, focusing on the visual aspect of the system. Essentially, the surface plane refers to the sensory user experience of the product they are interacting with, considering all aspects of visual design provided to users.

The 6D Gamification Framework has a sixth task, named "Deploy the appropriate tools", which focuses on the implementation of all defined functionalities [WH15]. In this stage, all the elements needed by the application are drawn and implemented. The design depends directly of the used technology in the application. In this work, an extension in the MBP’s
frontend, which uses Angular, has been created to present the gamification elements. Furthermore, an extension in the backend, which uses Spring and MongoDB, has been developed, as depicted in Figure 5.16.

![Figure 5.16: MBP architecture extension](image)

The first definition is how the user should access the game. For this purpose, two possible accesses were created: one through the standard navigation menu of the tool and another through the welcome message from the Home Page, as depicted in Figure 5.17.

![Figure 5.17: Home](image)
As defined in the scope, some of the elements are not going to be implemented. However, they have been drawn and created as a fixed area only to provide a game visual, as depicted in Figure 5.18. Moreover, the tasks, or quest area, can be collapsed to reduce information to the user in the screen.

Figure 5.18: MBP Gamification View

To facilitate the user’s understanding of the activities that have already been performed and those that are yet to be done, two states have been defined: Pending and Done. Pending means the user did not perform it yet, and Done means the user already did the task, as depicted in Figure 5.19 and in Figure 5.20.

Figure 5.19: Pending Tasks
The store has been implemented as a list of gifts, which the user can choose at the end of the game, as depicted in Figure 5.21. The gifts were planned to be real, to test all the drives listed for this element.

Each activity has a presentation in PDF, which has explanations of the game, IoT subjects, and the step-by-step to follow on how to configure an IoT device in MBP, as depicted in Figure 5.22. All the content is supported by MBPchen, the robot mascot designed to bring the fun to the game, as depicted in Figure 5.23, 5.24 and 5.25.
Figure 5.22: Content

Figure 5.23: MBPchen explaining the Rules
5.5 Surface

Figure 5.24: MBPchen explaining the MBP Tasks in Intermediate Level

Figure 5.25: MBPchen explaining how to use IoT to help save the environment in Beginner Level

The quizzes have been implemented interactively, that is, the users know their grade and the correct answers when they finish it. This also helps users to learn from mistakes, as depicted in Figure 5.26 and Figure 5.27.
Figure 5.26: Quiz Grade
To facilitate the reusability of the application, the quest area and quizzes have been created as a JSON file, which can be easily read by humans and changed, as depicted in Figure 5.28 and Figure 5.29. This eases changes, for instance, if there is a new functionality in the MBP which needs to be explained, or if a new task or quiz is required. The complete JSON can be seen in the Appendix A.1.

```
{
    "quests": [
        {
            "id": 1,
            "sequence": 12,
            "level": "Beginner",
            "type": "quest",
            "title": "T1",
            "description": "How does this game work?",
            "content": "QA_Content/task1.1.pdf",
            "points": 100
        },
        {
            "id": 2,
            "sequence": 28,
            "level": "Beginner",
            "type": "quest",
            "title": "T2",
            "description": "Understand the Internet of Things (IoT)?",
            "content": "QA_Content/task2.1.pdf",
            "points": 100
        },
        {
            "id": 3,
            "sequence": 13,
            "level": "Beginner",
            "type": "quest",
            "title": "T3",
            "description": "IoT Applications",
            "content": "QA_Content/task3.1.pdf",
            "points": 100
        }
    ]
}
```

Figure 5.27: Quiz Answers

Figure 5.28: Json Task
At the end of the conceptual design, an interactive prototype of a gamified application has been developed. With this prototype, the user can test functionalities and understand the general principles of the application, such as doing tasks or quizzes. In addition, the interactive prototype allows the visualization of the progress levels, the accumulation of points and supports the configuration of new IoT devices in a real system.

Figure 5.29: Json Quiz
6 User Experience Evaluation

User experience evaluation (UXE) involves observing representative users while they perform tasks with a hardware or software system and discovering how they perceive this system. The artifact which is tested can be a wireframe, a paper sketch, a storyboard, an UI mock-up, a prototype, or a product in development. During user experience evaluation, users seek to complete the tasks while, in parallel, the UX specialists monitor reactions, such as clicks on the screen, comments made by the user or even body signals, and write down information considered important [RC11].

User experience evaluation highlights the strengths and weaknesses of the hardware or software system. However, there is no absolute methodology, that is, each UX evaluation needs to be adapted to the tasks which are to be tested. There are at least 96 different UX evaluation methods [VLR+10], such as performance measures to improve systems, analysis of usability problems, or creation of recommendations in order to eliminate problems and improve the usability of the product.

User experience evaluation consists of five primary phases accordingly to Jeffrey Rubin [RC11]:

- Planning: develop the user experience evaluation plan, find and select participants, and prepare user experience evaluation materials
- Pretest or pilot: set up a user experience evaluation environment
- Test sessions: run the user experience evaluation
- Post-user experience evaluation or debrief: debrief the participant and observers
- Analysis, interpretation, and presentation of the results: analyze data and observations

The following sections are divided according to Jeffrey’s phases to detail the whole user experience evaluation conducted in the scope of this master thesis. Besides, a new phase of research objectives and focus has been added to introduce the main objective for this chapter.
6.1 Research Objectives and Focus

The goal of this user experience evaluation is to evaluate the gamified elements and content implemented in this work. The evaluation focuses on whether the elements impact on learning increase and user behaviour. The focus of the user experience evaluation is on the gamification content, and not on the MBP tool as a whole.

6.2 Planning

In the planning phase, the strategy for the user experience evaluation is developed and prepared. The evaluation plan, content and rules are defined in this stage, aiming at achieving more reliable results.

6.2.1 User experience evaluation plan

In this work, the objective is to encourage people to try out new concepts and encourage the desire to learn. For this reason, two hypothesis have been defined:

- **Hypothesis 1**: Gamified elements support the IoT knowledge improvement of people without any previous knowledge in IoT and IT
- **Hypothesis 2**: Gamified elements stimulate behaviours that assist the learning process of people without any previous knowledge in IoT and IT

Therefore, what has been measured to validate the design of the gamified elements was the knowledge and behaviours. To validate the two aforementioned hypothesis, summative evaluations have been used. Summative evaluations describe how well a design performs, often compared to another design, state or process [Kea10].

The two hypothesis have been divided in two different summative assessments:

- **Summative assessment 1**: to test the knowledge improvement, quizzes have been used as summative assessment. These quizzes have been developed in Chapter 5 - Solution Design. To compare the learning improvement, an initial questionary has been created, which contains questions on previous knowledge about IoT and can be compared with the quizzes’ results.
- **Summative assessment 2**: a questionary has been designed to test the general view of the users about the gamified elements, behaviour impacts and the user journey.
6.2.2 Participants

The number of participants varies based on the type and purpose of the user experience evaluation. Different user experience evaluation techniques require different numbers of participants, as explained by Ginny Redish [JR99] and depicted in Figure 6.1.

<table>
<thead>
<tr>
<th></th>
<th>BENCHMARK METRICS</th>
<th>DIAGNOSTIC (FORMATIVE) EVALUATION</th>
<th>SUMMATIVE TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How many?</strong></td>
<td>8-24 users</td>
<td>4-6 users</td>
<td>6-12+ users</td>
</tr>
<tr>
<td><strong>Metrics and Measures</strong></td>
<td>Focus on metrics for time, failures, etc Tests current process or product</td>
<td>Less formal Increased focus on qualitative data</td>
<td>More formal Metrics based on usability goals</td>
</tr>
<tr>
<td><strong>Why</strong></td>
<td>Establish baseline metrics</td>
<td>Find and fix problems</td>
<td>Measure success of new design</td>
</tr>
<tr>
<td><strong>When</strong></td>
<td>Before a design project begins or early in development</td>
<td>During design</td>
<td>At end of process</td>
</tr>
<tr>
<td><strong>How often</strong></td>
<td>Once</td>
<td>Iterative</td>
<td>Once</td>
</tr>
</tbody>
</table>

**Figure 6.1:** Recommended Number of Participants by Testing Technique [JR99]

This work focuses on summative testing, therefore, it has been defined to have 10 participants to conduct the user experience evaluation. To control confounding external factors which cause errors in the measurement, the participants were selected by IT knowledge level to support the hypothesis. These participants have been chosen from 2 groups: without any previous IT or IoT knowledge and with previous IT or IoT knowledge. From the group without previous knowledge, 6 participants from different professional areas have been selected. From the group with previous knowledge, 4 participants have been selected: 2 with deep knowledge in IoT and IT, and 2 with IT background but low level of IoT knowledge.

6.2.3 Scenario

The user experience evaluation has been designed as within-subjects (or repeated-measures): the same participant tests all the conditions (i.e., all the user interfaces) [CGK12]. Due to the need to test all the knowledge acquired during the journey, having participants testing only parts would not provide an overview of the knowledge improvement. Therefore, only one scenario has been tested, which was testing the three implemented user journey levels.
6.2.4 User experience evaluation materials

The user experience evaluation material developed consists of the following: previous knowledge questionnaire, gamified elements questionnaire and debrief.

The previous knowledge questionnaire is composed of questions about the user (User Overview) and questions about the IoT knowledge level (Pre-user experience evaluation). In order to not influence the journey experience, the pre-user experience evaluation has not been made exactly as the questions presented on the quizzes. However, the evaluation has been accordingly divided into the knowledge to be learned on the three levels, as follows:
**Previous knowledge questionnaire**

### User Overview
- What is your name?
- How old are you?
- What is your current occupation?
- What is the highest level of education you have completed?
- What is your educational background?
- Where have you born? (city/country)
- Where do you live now? (city/country)
- How do you rate your own knowledge computer use or IT? (Basic, Intermediate, Advanced or Expert)

### Pre User Evaluation

#### General
- How do you rate your ability to talk about IoT? (Basic, Intermediate, Advanced or Expert)

#### Level Beginner
- Have you ever heard about IoT? If yes, what does it mean?
- Do you have any IoT device in your home or day by day life? If yes, which one?
- Where do we can find IoT?
- How do you think the IoT can help in our environment?
- Smart home is an example of IoT?

#### Level Intermediate
- Can you list the elements existing in an IoT environment? If yes, which are they?
- Which element is responsible for collecting data from the environment, which are sent and sending it to the IoT platform?
- Could you tell what actuators and sensors are? If yes, what are they?
- What is the name of a numerical label assigned to each device connected to a computer network?
- What is the name of the code (computer program) executed on a device in order to connect its sensors/actuators to the MBP IoT platform?

#### Level Advanced
- Have you ever installed an IoT Device? Which one?
The *gamified elements questionnaire* is composed by questions about how each element influenced user behaviours and the user experience, as depicted in the following table:
## Gamified elements and debrief questionnaire

**Gamified elements**

<table>
<thead>
<tr>
<th>Gamified elements</th>
<th>In your opinion, do you think you have learned anything new?</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>Do you think your journey in the game was fun?</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>General</td>
<td>Do you think the game elements motivated you to finish the game?</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
</tbody>
</table>

- MBPchen (robot)
- Points
- Level/Progression
- Store/Gift
- Quest/Task
- Quiz
- Losing points Quiz

<table>
<thead>
<tr>
<th>Drive 1</th>
<th>Have you felt you could help &quot;the world&quot;? There is a meaning to play besides learning IoT.</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBPchen (robot)</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
<td></td>
</tr>
<tr>
<td>Points</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
<td></td>
</tr>
<tr>
<td>Level/Progression</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
<td></td>
</tr>
<tr>
<td>Store/Gift</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>---------------</td>
<td>-------</td>
<td>-----------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Quest/Task</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
<td></td>
</tr>
<tr>
<td>Quiz</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
<td></td>
</tr>
<tr>
<td>Losing points Quiz</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
<td></td>
</tr>
</tbody>
</table>

**Drive 2**

<table>
<thead>
<tr>
<th>Do you feel that you have reached your goal?</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBPchen (robot)</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Points</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Level/Progression</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Store/Gift</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Quest/Task</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Quiz</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Losing points Quiz</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
</tbody>
</table>

**Drive 3**

<table>
<thead>
<tr>
<th>Have you felt supported by feedback?</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBPchen (robot)</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Points</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Level/Progression</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Store/Gift</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Quest/Task</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Quiz</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
</tbody>
</table>
Drake 4

Did you feel motivated during the game? Did you feel that you were doing something good for yourself and also being rewarded for it?

- Strongly agree
- Agree
- Undecided
- Disagree

MBPchen (robot)

- Points
- Level/Progression
- Store/Gift
- Quest/Task
- Quiz

Drake 7

Have you felt any time curiosity about learning more?

- Strongly agree
- Agree
- Undecided
- Disagree

MBPchen (robot)

- Points
- Level/Progression
- Store/Gift
- Quest/Task
- Quiz

Losing points Quiz

Strongly agree

Agree

Undecided

Disagree
### Drive 8

Have you felt any time a bit scared of loosing point?

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
</table>

### New Gamified Elements

Should the following elements be included?

<table>
<thead>
<tr>
<th>Avatar</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Undecided</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badges</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Leaderboard</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
<tr>
<td>Feedback</td>
<td>Strongly agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
</tr>
</tbody>
</table>

### Debrief

- What was your overall impression of the game/learning?
- What was the best/worst thing about it?
- What would you improve the game?
- Do you have any IoT device in your home or day by day life? If yes, which one?
6.3 Pre user experience evaluation

According to Beywl and Schepp-Winter [Bey00], before the user experience evaluation starts, the whole evaluation scenario should be checked. For this purpose, the questionaries and the application have been tried out with one person under the same conditions as the participants are tested. The same material and place has been set up, as depicted in Figure 6.2.

After completing the user experience evaluation, it should be checked whether there is redundant information, the instructions are understandable, or the questionnaires are meaningful and easy to understand [Bey00]. The results from the pre-user experience evaluation gave inputs to rework some contents and questions to be able to start the user experience evaluation.

The gamified elements questionnaire and user experience questionnaire are used in the post user experience evaluation on which the participants can give their opinions and observations in more open questions.

Figure 6.2: User experience evaluation setup
6.4 User experience evaluation sessions

The user experience evaluation has been run with 10 users, as planned. The average run time for each test was 1:30 hours and the tests have been performed over the course of 3 weeks. All user experience evaluations took place completely and without any new confounding factor.

Throughout the user experience evaluations, participants were observed and encouraged to comment out loud if they found something interesting, important or confusing. Based on this, annotations have been made regarding reactions, feedbacks, and problems encountered by the participant along their journey. This process helps to store information that the participant might forget to inform in the debrief.

6.5 Post user experience evaluation or debrief

The debrief has been made as a casual conversation to discuss what did and what did not go well. For some participants, the conversation was uncomfortable, but they were encouraged to speak their opinion openly and give negative and positive feedbacks.

6.6 Results

This section is divided in five topics to better understand the results from the user experience evaluation, as follows: participants overview, quizzes’ results, gamified elements’ impacts, store gift choices and new elements to be included.

6.6.1 Participants Overview

Overview

The user experience evaluation had 70% of the participants between 31-40 years old, as depicted in Figure 6.3.
6.6 Results

Figure 6.3: Participant Age

**Previous IT Knowledge**

Mainly participants with low knowledge in IT and IoT have been chosen. However, also some participants with advanced knowledge have been included in order to check the content and get feedback about the overall work, as depicted in Figures 6.4 and 6.5.

Figure 6.4: Participant previous IT knowledge
6 User Experience Evaluation

**Figure 6.5:** Participant previous IoT knowledge

**Previous IoT Knowledge - Beginner Level**

The majority of the participants had already heard about IoT, however from this group only 40% said they have an IoT device at home, as depicted in Figures 6.6 and 6.7.

**Figure 6.6:** Share of participants who already heard about IoT
6.6 Results

Figure 6.7: Share of participants with IoT devices at home

The participants have been asked to give examples of IoT environment use cases and general IoT uses. Most of the answers focused on smart home, as depicted in Figures 6.9 and 6.8. The participants notoriously do not have the full picture of how and where to use IoT.

Figure 6.8: Examples and quantity of IoT use cases given by participants
6 User Experience Evaluation

Figure 6.9: Examples and quantity of IoT environment use cases given by participants

Previous IoT Knowledge - Intermediate Level

Participants have been asked about the meaning of 4 concepts: 90% knew what a Sensor is and 80% what an IP Address is. However, 60% did not know what an actuator means and 80% what an operator means, as depicted in Figure 6.10.

Figure 6.10: Participants who answered right about the meaning of the concept

Only 30% of the participants were able to list the elements necessary to create an IoT environment, as depicted in Figure 6.11.
6.6 Results

Figure 6.11: Participants who can list the elements existing in an IoT environment

Previous IoT Knowledge - Advanced Level

From all participants, only 40% have already installed an IoT device, as depicted in Figure 6.12.

Figure 6.12: Participants who have already installed a smart device

6.6.2 Quizzes' results

All participants have taken all quizzes, even with the possibility of losing points. Only one participant has failed in one of the quizzes. Only one question had more than 40% wrong answers and it was from the Intermediate quiz: “What is the name of the code (computer program) executed on a device in order to connect its sensors/actuators to the MBP IoT platform?”. One of those wrong answers was from an expert in IoT, which leads to the conclusion that the name (operator) is possibly complicated to be linked with its concept, and, thereafter, the participant does not memorize the concept.
With exception of the one mentioned quiz failure, all other results were satisfactory for learning, as depicted in Figure 6.13. Some of the participants went back to the content to verify the answers, and all returned on the correct task, which shows that they knew where the information was, only details were not memorised.

One of the participants had no proficiency in the English language, but even so they managed to pass all the quizzes. The participant understood the content by drawings in the presentations and key words. This shows that, for a better understanding, drawings are very important for the user and need to be included to support the learning process.

The youngest participant raised the need to have more videos and less reading, as his generation is more interested in videos than long readings.

![Figure 6.13: Point average in percentage for each Quiz](image)

### 6.6.3 Gamified elements' impacts

Overall, the elements had a significant impact in the participant behaviours and 90% said they have learned something new and had fun in the journey, as depicted in Figure 6.14. Moreover, 100% of the participants agree that the elements motivated them to finish the journey.
Figure 6.14: Overall user experience opinion
As described in Chapter 5, each gamified element has been defined according to the guidelines of the Octalysis Framework Drivers. The next six graphs validate or invalidate the definitions made for each gamified element defined in Table 5.2 and also the Mpbchen (robot). To assist the analysis, the user quest has been divided in tasks and quizzes, and the responses were grouped into agree and undecided/disagree.

The story behind the game is the “Drive 1 - Epic Meaning & Calling” defined in this work. When participants were asked about which element has made them feel they are saving the world, they could not name an element, as depicted in Figure 6.15. However, 60% of the participants felt behaviour in the journey, as depicted in Figure 6.14.

![Figure 6.15: Drive 1 answers](image)

The “Drive 2 - Development and Accomplishment” has been designed containing the following elements: Points, Progress, and Quests (Task and Quiz). As seen in Figure 6.16, the participants agreed, more than 69%, that these three elements somehow made them feel the direction of this Drive. Besides, the Mpbchen (robot) also helped them to feel that they have achieved their goal, mainly because of the “interaction” between the robot and the participant with positive messages.
Figure 6.16: Drive 2 answers

The “Drive 3 - Empowerment of Creativity and Feedback” has been designed containing the following elements: Quest/Task, and Quest/Quiz. Only 50% agreed that the design reached its goals, but 70% understood that it was the Mbpchen (robot) that helped in the feedbacks, as seen in Figure 6.17. During most of the evaluations, participants talked loudly to the Mbpchen, replying comments made by it.

Figure 6.17: Drive 3 answers
The “Drive 4 - Ownership and Possession” has been designed containing the following elements: Points, and Store. It has been asked if the participants felt they were being rewarded for their effort, and they said they have not felt the Drive in the Store element. Surprisingly, the elements Quiz and Task were actually the ones which triggered the behaviour in the participants, possibly by gaining knowledge and grades from the quizzes. In this Drive, Mbpchen also had an important impact in the participants, as seen in Figure 6.18.

![Drive 4 answers](image)

**Figure 6.18:** Drive 4 answers

The “Drive 7 - Unpredictability and Curiosity” has been designed containing the following elements: Store, Quest/Task, and Quest/Quiz. The participants agreed that the Quest positively influenced this Drive’s behaviour, however only 20% agreed that the Store influenced them, as seen in Figure 6.19.
6.6 Results

The “Drive 8 - Loss and Avoidance” has been designed containing the following element: Quest/Quiz. This element had a high impact in participant’s behaviour: 90% said it has influenced their behaviour. All participants were surprised at the possibility of losing points, and all wondered before starting if they were going to do the quiz or not. Many participants commented that, since the minimum pass grade is only 50% of the limit, then they would do it, as seen in Figure 6.20. None of the participants skipped the quizzes.
6.6.4 Store gifts

The participants, as shown on the previous figures, did not give much importance to the store. On the other hand, it was clear that the fact of the awards being real made a difference. In the end, all the participants were excited to be able to choose their gifts. Only two participants said that having a real store made the difference to the journey, but the store’s relevance could be seen on the excitement of all participants at the time of choice. The participant who missed one of the quizzes was disappointed because he could not get the best prizes.

The prizes were chosen as follows: 7 participants made donations, 2 participants chose the surprise and 1 chose prizes for themselves. The participants who chose the surprise were the youngest participants and for one participant it was his young daughter the responsible for deciding the prize. This shows that the age factor also influences the choice of the awards.

6.6.5 New elements

It was asked to the participants which element which has been designed, but not implemented on the prototype, should be implemented in future work. The Leaderboard achieved 90% of acceptance of importance for future work and 80% voted for Feedback and Badges, as seen in Figure 6.21.

![Figure 6.21: Which elements should be included in future works](image)
7 Conclusion and Future Work

This master thesis presented a gamification approach and a gamified prototype to support IoT learning, in order to motivate non-expert end users to learn IoT concepts and ease the development of IoT applications.

This research aimed to present the application of gamification elements in the design of an IoT learning journey on an IoT platform, in order to understand its applicability in the context of this type of teaching. The developed approach in this master thesis combined three gamification frameworks, and furthermore, this master thesis designed an IoT learning journey with basic concepts and the installation of a real device. The gamification approach contains nine gamified elements and a mascot to lead the journey and interaction with the user. The prototype contains five of the nine gamified elements designed, and these contain six of the eight drives defined on the Octalysis Framework, which triggers logical and emotional reaction.

As this work includes the development of a Design prototype, this master thesis was based on a design methodology. Thus, to design a gamified user interface, the well-established Garrett method was used, which is divided into five stages: Strategy, Scope, Structure, Skeleton and Surface.

To verify the effectiveness of the elements, an user experience evaluation was performed with 10 participants, which verified the learning growth in IoT and the behaviours generated with the gamified elements. This evaluation proved that the participants learned the main concepts of IoT and that all the elements implemented in the prototype proved to be important for the user’s journey in learning.

Losing points in Quiz proved to be important for users to make an effort to understand the topics. 90% of the participants said that they were afraid to lose their points, which made them return to the contents to answer the questions and better understand the topic.

The Quests (Quizzes and Tasks) proved to be very important for the journey, providing the feeling of development and curiosity in what was to come. In addition, the feeling of possession was surprisingly passed on to the participants, as they had the feeling of acquiring knowledge and status.

The Store was not an element that users gave importance to throughout the journey, but everyone was excited to choose their prizes, showing its importance indirectly.
Progression and Points proved to be important for the feeling of Development and Accomplishment, for the participants progression is more important than points. This shows that status is more important than earning points, but the two complement each other in importance.

In addition to the evaluation of the elements, the importance of the mascot along the journey was also questioned. All participants informed that the mascot and the contents were very important for learning and the feeling of fun.

As future work, it is expected to transform the high-fidelity functional prototype into a fully functional application, including three new gamified elements: Feedback, Leaderboard, and Badges. In addition, the importance of having better system usability was shown, including: integrating the content other than having it on separate screens, having the mascot on the IoT platform (not separately) to provide support, and automatically verifying software installation on IoT devices and closing quest tasks.

In conclusion, the goals of this master thesis were achieved through proofing of IoT knowledge growth and that the gamified elements proved to be important throughout the journey as pointed out by the user evaluation participant. However, the mascot for communication with the user and for fun proved to be just as important as the gamified elements.
References


References


References


References


A Appendix A

A.1 Task and Quizzes

The tasks, quizzes, and answers can be seen below in Json format, as it was used in the software.

```json
{"quests": [  
  {  
  "id":1,  
  "sequence":10,  
  "level":"Beginner",  
  "type":"quest",  
  "title":"1.1",  
  "description":"How does this game work?",  
  "content":"GF_Content/task1.1.pdf",  
  "points":100  
  },  
  {  
  "id":2,  
  "sequence":20,  
  "level":"Beginner",  
  "type":"quest",  
  "title":"1.2",  
  "description":"Understand the Internet of Things (IoT)",  
  "content":"GF_Content/task1.2.pdf",  
  "points":100  
  },  
  {  
  "id":3,  
  "sequence":30,  
  "level":"Beginner",  
  "type":"quest",  
  "title":"1.3",  
  "description":"IoT applications",  
  "content":"GF_Content/task1.3.pdf",  
  "points":100  
  },  
```
1.4
How can IoT help you save the environment?

---

Quiz
Test your knowledge: Level 1

Questions:

1. What does IoT mean?
   - Integration of Things
   - Interconnection of Things
   - Internet of Things

2. Integration of Things
   - True
   - False

3. Internet of Things
   - True
   - False

---

Appendix A
"question_text":"What are types of IoT devices?",
"answers":
[
  {
    "sequence":1,
    "answer_text":"Smart devices (e.g., smart TV, smart watch, smart bulb light) and sensor devices",
    "is_correct":true
  },
  {
    "sequence":2,
    "answer_text":"All non-smart equipment",
    "is_correct":false
  },
  {
    "sequence":3,
    "answer_text":"Any equipment in my house (smart or not smart devices)",
    "is_correct":false
  }
]
},
{
  "id":18,
  "sequence":3,
  "question_text":"What can sensor devices measure?",
  "answers":
  [
    {
      "sequence":1,
      "answer_text":"Temperature, humidity or light intensity",
      "is_correct":true
    },
    {
      "sequence":2,
      "answer_text":"They can not measure the surroundings",
      "is_correct":false
    },
    {
      "sequence":3,
      "answer_text":"Both answers above are wrong",
      "is_correct":false
    }
  ]
],
{
  "id":19,
"sequence":4,
"question_text":"Smart home is an example of IoT?",
"answers":
[
    {
        "sequence":1,
        "answer_text":"For sure not!",
        "is_correct":false
    },
    {
        "sequence":2,
        "answer_text":"Yes!",
        "is_correct":true
    },
    {
        "sequence":3,
        "answer_text":"I do not know",
        "is_correct":false
    }
],

"id":20,
"sequence":5,
"question_text":"Where can we find IoT?",
"answers":
[
    {
        "sequence":1,
        "answer_text":"Smart Homes",
        "is_correct":false
    },
    {
        "sequence":2,
        "answer_text":"Smart Factories",
        "is_correct":false
    },
    {
        "sequence":3,
        "answer_text":"Smart Cities",
        "is_correct":false
    },
    {
        "sequence":4,
        "answer_text":"Smart Buildings",
        "is_correct":false
]
A.1 Task and Quizzes

},
{
  "sequence":5,
  "answer_text":"All above",
  "is_correct":true
}
],
{
  "id":21,
  "sequence":6,
  "question_text":"How do IoT devices send data to IoT platforms?",
  "answers": [
    {
      "sequence":1,
      "answer_text":"Using communication protocols, such as MQTT or HTTP",
      "is_correct":true
    },
    {
      "sequence":2,
      "answer_text":"By email",
      "is_correct":false
    },
    {
      "sequence":3,
      "answer_text":"By cable",
      "is_correct":false
    }
  ]
}
],
{
  "id":12,
  "sequence":50,
  "level":"Intermediate",
  "type":"quest",
  "title":"2.1",
  "description":"Understand IoT Basic Concepts",
  "content":"GF_Content/task2.1.pdf",
  "points":200
}
],
{
  "id":6,
  "sequence":60,
A Appendix A

"level":"Intermediate",
"type":"quest",
"title":"2.2",
"description":"Configure a device",
"content":"GF_Content/task2.2.pdf",
"points":200
},
{
"id":7,
"sequence":70,
"level":"Intermediate",
"type":"quest",
"title":"2.3",
"description":"Configure an operator",
"content":"GF_Content/task2.3.pdf",
"points":300
},
{
"id":8,
"sequence":80,
"level":"Intermediate",
"type":"quest",
"title":"2.4",
"description":"Configure a sensor",
"content":"GF_Content/task2.4.pdf",
"points":200
},
{
"id":13,
"sequence":85,
"level":"Intermediate",
"type":"quiz",
"title":"Quiz",
"description":"Test your knowledge: Level 2",
"content":"
",
"points":200,
"questions":
[
{
"id":22,
"sequence":1,
"question_text":"Which element is responsible for collecting data from the environment, which are sent to the IoT platform?",
"answers":
[

```json
```

98
"sequence":1,
"answer_text":"Device",
"is_correct":false
},
{
"sequence":2,
"answer_text":"Actuator",
"is_correct":false
},
{
"sequence":3,
"answer_text":"Sensor",
"is_correct":true
}
],
{
"id":23,
"sequence":2,
"question_text":"What does an actuator do?",
"answers":
[
{
"sequence":1,
"answer_text":"An actuator is responsible for moving and controlling a mechanism or system",
"is_correct":true
},
{
"sequence":2,
"answer_text":"An actuator detects events or changes on its environment and sends the information to other electronic devices",
"is_correct":false
},
{
"sequence":3,
"answer_text":"An actuator is a piece of code to extract data from other elements",
"is_correct":false
}
]
},
{
"id":24,
"sequence":3,
"question_text":"What is the name of the code (computer program) executed on a device in order to connect its sensors/actuators to the MBP IoT platform?",
"answers":
[
  {
    "sequence":1,
    "answer_text":"Rule",
    "is_correct":false
  },
  {
    "sequence":2,
    "answer_text":"Operator",
    "is_correct":true
  },
  {
    "sequence":3,
    "answer_text":"Sensor",
    "is_correct":false
  }
]
],
{
  "id":25,
  "sequence":4,
  "question_text":"What is needed to configure a sensor in the MBP IoT platform?",
  "answers":
[
  {
    "sequence":1,
    "answer_text":"Device and operator",
    "is_correct":true
  },
  {
    "sequence":2,
    "answer_text":"Actuator and device",
    "is_correct":false
  },
  {
    "sequence":3,
    "answer_text":"Nothing",
    "is_correct":false
  }
]
],
{
  "id":26,
"sequence":5,
"question_text":"What is the name of a numerical label assigned to each device connected to a computer network?",
"answers":
[
  {
    "sequence":1,
    "answer_text":"Operator",
    "is_correct":false
  },
  {
    "sequence":2,
    "answer_text":"Sensor",
    "is_correct":false
  },
  {
    "sequence":3,
    "answer_text":"IP address",
    "is_correct":true
  }
]
]
},
{
"id":9,
"sequence":90,
"level":"Advanced",
"type":"quest",
"title":"3.1",
"description":"Install an Operator and Actuator",
"content":"GF_Content/task3.1.pdf",
"points":400
},
{
"id":10,
"sequence":100,
"level":"Advanced",
"type":"quest",
"title":"3.2",
"description":"Configure a Rule",
"content":"GF_Content/task3.2.pdf",
"points":400
},
{"id":11,
"sequence":110,
"level":"Advanced",
"type":"quest",
"title":"3.3",
"description":"Run it!!",
"content":"GF_Content/task3.3.pdf",
"points":500
],
[
"id":14,
"sequence":115,
"level":"Advanced",
"type":"quiz",
"title":"Quiz",
"description":"Test your knowledge: Level 3",
"content":"
",
"points":200,
"questions":
[

{"id":27,
"sequence":1,
"question_text":"What is needed to register and control a new actuator in the MBP IoT platform?",
"answers":
[

{"sequence":1,
"answer_text":"Install a control operator in a device.",
"is_correct":true
},

{"sequence":2,
"answer_text":"Only a device, then you will be able to control the actuator.
",
"is_correct":false
},

{"sequence":3,
"answer_text":"Only a control operator, then you will be able to control the actuator.
",
"is_correct":false
}
]
],
[


A.1 Task and Quizzes

"id":28,
"sequence":2,
"question_text":"How do users are able to specify how to react to pre-defined events that might occur within their IoT environments?",
"answers":
[
    {
        "sequence":1,
        "answer_text":"Defining Rules",
        "is_correct":true
    },
    {
        "sequence":2,
        "answer_text":"Creating Operator",
        "is_correct":false
    },
    {
        "sequence":3,
        "answer_text":"Creating Device",
        "is_correct":false
    }
]
},
{
    "id":29,
    "sequence":3,
    "question_text":"What are the components managed in the MBP to run a Smart Environment?",
    "answers":
    [
        {
            "sequence":1,
            "answer_text":"Device, Extractor Operator, Sensor, Control Operator, Actuator and Rule",
            "is_correct":true
        },
        {
            "sequence":2,
            "answer_text":"Rule and Device",
            "is_correct":false
        },
        {
            "sequence":3,
            "answer_text":"Device, Sensor and Actuator",
            "is_correct":false
        }
    ]
}
A rule definition in the MBP consists of:

- Rule condition
- Rule action
- Rule condition and a set of rule actions

Questions about your User Experience with iot jouney - 1000 points!!!
Declaration

I hereby declare that the work presented in this thesis is entirely my own and that I did not use any other sources and references than the listed ones. I have marked all direct or indirect statements from other sources contained therein as quotations. Neither this work nor significant parts of it were part of another examination procedure. I have not published this work in whole or in part before. The electronic copy is consistent with all submitted copies.

place, date, signature