INSTITUTO SUPERIOR DE ENGENHARIA DO PORTO
MESTRADO EM ENGENHARIA INFORMÁTICA




Diretrizes para Ludificação: Educação

GIL ESPINHEIRA MOUTINHO
Outubro de 2019

POLITÉCNICO
DO PORTO

Gamification Guidelines: Education

Gil Espinheira Moutinho
1130632

Dissertation to obtain the Master's Degree in Informatics Engineering,
Area of Expertise in Graphical Systems and Multimedia

Supervisor: Isabel Azevedo

Porto, October 2019

Resumo

Ludificação consiste na utilização de características típicas dos jogos em aplicações cujo propósito não é o entretenimento, de forma a melhorar a motivação e os resultados dos seus utilizadores. A implementação deste conceito conta com vários casos de sucesso, no entanto, o contrário também é observável, com os casos de insucesso a serem muitas vezes causados pelo *design* pobre dos sistemas ludificados.

Este trabalho tem como propósito a criação de diretrizes que ajudem a combater o problema do *design* pobre na ludificação. De modo a o tornar mais focado, decidiu-se analisar o mundo da educação, mais precisamente o ensino superior, para se perceber se um sistema de ensino ludificado é capaz de ajudar os alunos a terminarem os seus cursos sem contratempos.

Foram estudadas algumas das mais populares *frameworks* de apoio à ludificação, dando origem à criação de um conjunto de cinco diretrizes que juntam os pontos fortes de cada uma delas, enquanto colmatam os seus pontos fracos. Estas diretrizes foram usadas no desenvolvimento de um *plugin* para o Moodle direcionado a estudantes universitários, o "Gamification Banner".

Todo um sistema ludificado foi preparado, não só o *plugin* do Moodle, mas também o curso onde ele se insere. Este sistema foi testado por um grupo de voluntários que o avaliou, e da avaliação resultante comprovou-se que os estudantes são a favor da ludificação, embora não tenha sido possível provar que as suas notas são influenciadas positivamente, dado o curto tempo dos testes.

Conclui-se que vale a pena investir na ludificação do ensino superior, e que se deve continuar a estudar a possibilidade de as notas dos alunos serem influenciadas positivamente por sistemas ludificados. O sucesso do sistema desenvolvido espelha-se nas diretrizes que ajudaram a criá-lo. Estas demonstram potencial, mas precisam de serem testadas noutros cenários.

Palavras chave:
Ludificação; diretrizes para ludificação; ludificação na educação; *plugin* do Moodle.

Abstract

Gamification consists in the usage of typical game elements in non-entertainment applications in order to improve the motivation and results of their users. There are several success stories of the implementation of this concept, however, the opposite is also observed, with failed cases often being caused by a poor design of the gamified system.

The purpose of this document is to create guidelines that can prevent the problem of poor gamification design. In order to make it more focused, it was decided to analyze the world of education, more precisely college education, to understand if a gamified educational system can help students finish their courses without any setbacks.

Some of the most popular gamification design frameworks were studied, leading to the creation of a set of five guidelines that bring together their strengths while addressing their weaknesses. These guidelines were used for the development of a Moodle plugin aimed at college students called “Gamification Banner”.

A whole gamified system was prepared, not only the Moodle plugin, but also the course in which it is inserted. This system was tested by a group of volunteers who evaluated it, and from the resulting assessment it was found that students favor gamification, although it was not possible to prove that their grades are positively influenced given the short time of the tests.

It is concluded that it is worth investing in gamification in higher education, and that the possibility of grades being positively influenced by gamified systems should be further studied. The success of the developed system is reflected in the guidelines that helped to create it. These show potential but need to be tested in other scenarios.

Keywords:
Gamification; gamification guidelines; gamification in education; Moodle plugin.

Acknowledgments

I would like to thank Instituto Superior de Engenharia do Porto (ISEP) for educating me, and my supervisor Isabel Azevedo for being extremely helpful and patient.

I would also like to thank my company for giving me time to finish this document, and my friends and family for being there when I needed.

And special thanks to my parents, who never gave up on me, my lover, who never let me down, and God, who was always there for me.

Alone, I would never make it this far.

Table of Contents

Table of Figures

Table of Tables

Glossary

AHP	Analytic Hierarchy Process
AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
CRUD	Create, Read, Update, Delete
CSS	Cascading Style Sheets
DB	Database
EEEE	Enroll, Enthuse, Engage, Endear
ERD	Entity Relationship Diagram
FEI	Front End of Innovation
FFE	Fuzzy Front End
FURPS	Functionality, Usability, Reliability, Performance, Supportability
GAME	Gather, Act, Measure, Enrich
GPA	Grade Point Average
HTML	Hypertext Markup Language
ISEP	Instituto Superior de Engenharia do Porto
JSON	JavaScript Object Notation
LMS	Learning Management System
MDA	Mechanics-Dynamics-Aesthetics
Moodle	Modular Object-Oriented Dynamic Learning Environment
NCD	New Concept Development
PDF	Portable Document Format
PHP	PHP: Hypertext Preprocessor
RAMP	Relatedness, Autonomy, Mastery, Purpose
ROI	Return on Investment
SaaS	Software as a Service
SDT	Self-Determination Theory
TOPSIS	Technique of Order Preference by Similarity to Ideal Solution
UI	User Interface
URL	Uniform Resource Locator
UX	User Experience
XAMPP	XAMPP Apache + MariaDB + PHP + Pearl
XML	Extensible Markup Language

1. Introduction

This chapter contextualizes and presents the problem to be solved, the work objectives and motivations, and the used methodologies. It is expected that by the end of the chapter the reader fully understands the goals of this study and its importance.

This chapter closes with a section dedicated to explaining the structure of the rest of the document.

1.1. Context

Games have been an important subject for human culture since the dawn of mankind as they provide means for entertainment, relationship building, and skill improvement. Thanks to the development of technology, more and more activities have become digitalized and that naturally came together with the growth of digital games. This raise in popularity is not only strained to entertainment but also to other fields such as academic research and studies. Digital games are now part of our culture and their importance should not be underestimated.

As such, and based on the success of digital games, people have been trying to adopt their features into other applications and systems that are not made to be played in the hope that it will raise engagement. This process has been often called gamification [1]. While its first documented use takes back to 2008, with its rise in popularity occurring in late 2010, the idea behind it is not new, as badges and ranks are being attributed for decades in the military, for example.

A gamified application should not be confused with a serious or educational game since the former is merely the adoption of game elements into an application and not a full game which main purpose is different from entertainment [2]. The concept of gamification, however, is not perfectly clear among scholars, with some authors defining it as invoking the same psychological experiences as games and others defining it as using the same affordances present in games. However, what experiences and affordances are exclusive from the game elements is not perfectly stablished either [3].

This conceptual difference is responsible for the geneses of diverse gamification design frameworks. These different approaches need be analyzed and reviewed to validate their real usefulness in various contexts, as they may not compensate the effort of implementation and investment or even be counterproductive in some environments while returning good results in others [4]. The fact that different users have distinct preferences for digital games might be one of the causes of the oscillations in the results of these frameworks, since player preferences models are often applied into gameful design without real evidence if they fit in those contexts [5].

To make use of gamification design to its full potential, a reasonable amount of research shall be done. Poor design has led to many failures in the attempt to incorporate gamification in applications [6]. Those failures vanished much of the hype surrounding gamification as Gartner's Hype Cycle for Emerging Technologies from 2014 (the last one to contain "Gamification" as of this date) suggests (Figure 1).

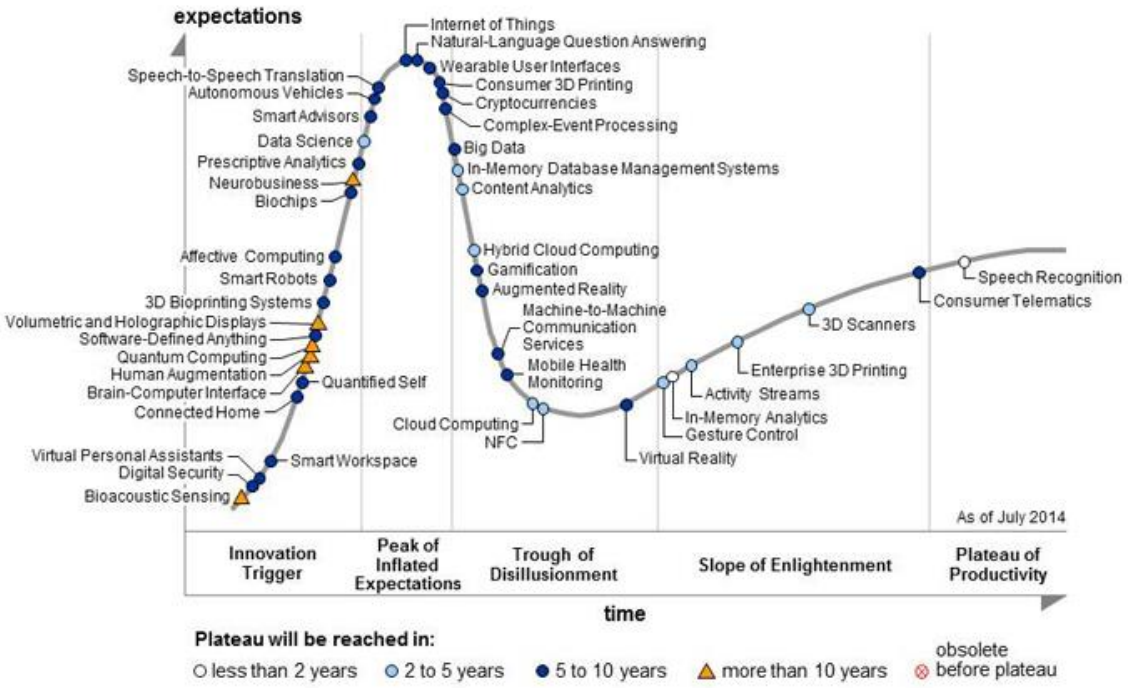

FIGURE 1 - GARTNER'S HYPE CYCLE FOR EMERGING TECHNOLOGIES, 2014 [55]

Judging by Figure 1, in 2014 Gamification was in the "Through of Disillusionment", that meant improvements had to be done in order to establish it as a viable practice.

Some successful adoptions of gamification, like Nike+, eBay, or Stackoverflow.com [2] show that this is an idea that has great potential and should not be deemed a trend and discarded after a half-hearted attempt of application, possibly leading to demise of gamification design altogether. Thus, the main problem to be addressed is **how to engineer gamified applications**, with emphasis on gamification design.

There are multiple fields and areas of study where gamification can be applied, such as computer science, engineering, and business economics. One of the most studied areas of application is education (corresponding to around 21% of gamification publications) [7], which is the focus of this document.

1.2. Problem

Although gamification has resulted in many cases of success, Gartner says that poor design will lead to the failure of 80% of the gamified systems [6]. That either means the existing gamification methods are not being applied correctly or that they provide insufficient information. Gamification needs a deep study to be applied successfully and should not fall victim of the common mistakes.

A frequent error seems to be when designers focus on adding meaningless game mechanics such as points, badges, and leaderboards without setting any clear mission or goal, sugarcoating the same unpopular actions hoping that users find them more engaging, which does not happen. Designers should put emphasis in understanding what really motivates players in a game like the presence of strategy, socialization, or challenge, and adapt the aforementioned mechanics to just bonus rewards [8]. In many cases, gamified applications can be even less enjoyable than the non-gamified versions because of the addition of a not welcome level of complexity [9].

According to the researcher on gameful design Sebastian Deterding [10], the main problems with the existing gamification design frameworks are the following:

- **Little formative research**, with the creation of user personas being mainly arbitrary and not based on investigation;
- **Reliance on player topologies**, with Bartle taxonomy of player types (originally created to describe the behavior of players in multi-user dungeon games) being the most common used typology. Over generalizing users while ignoring the context they are inserted and even the lack of evidence if those typologies work outside the setting they were created;
- **Appeals to motivational psychology**, with multiple methods being mixed into untested motivation models;
- **Inherent-additive, pattern-based approach**, using constantly the same game elements and assuming one-to-one pattern-effect relations;
- **Lacking guidance in game design pattern choice**, without giving any real advice on how to apply the recommended design patterns and what concrete gamification elements should be used for each case;
- **No iterative prototyping**, with the focus being in post launch increments but not on testing different design alternatives before the final product is formed;
- **Data-driven design**, with the data being suggested to use only after the deployment of the system and not during its development.

The conclusion reached is that most gamification design frameworks do not possess enough information, undervalue the research needed for user characteristics and gamification elements, discard the testing of alternatives before release, and lack advice for some areas of application.

To create reliable gamification guidelines, the main challenges that must be tackled are covering all the missing aspects of the existing gamification design frameworks while keeping what they do best. Also, the amount of research done to the characteristics and necessities of the system users in a given context, and to the gamification elements that are best suited to the developing system, must be quite extensive.

By analyzing the problems with current gamification approaches and having a formal method to evaluate user necessities and gamification elements, it is expected that the results of this work can provide more definitive advices on how to design a gamified system.

In the topic of education there are also problems that can be addressed. In 2018, almost 30% of Portuguese students abandoned college before concluding their courses, and only 46% concluded their courses without needing any extra years. This is aggravated the worse their grades are, as 54% of students who entered university with the lowest possible admission grade gave up in 4 years [11].

While this occurrence may be caused by many external factors, such as the economy, it is ambitioned that a gamified learning environment developed with the aid of this document could be motivating enough to reduce some of these negative numbers.

1.3. Objectives

The main goal of this study is to provide a set of guidelines that can aid designers in the adoption of gamification in learning environments, more specifically, for university courses.

The developed guidelines should use various concepts and ideas taken from regarded gamification frameworks and have them evaluated in order to create a reliable guide that can help designers create endearing learning applications. As such, this effort must be divided in smaller goals to be workable, namely:

- Identify the main challenges and problems related to gamification design;
- Compare and analyze different gamification design frameworks and approaches;
- Explore how to correctly engineer gamified applications to propose a set of integrative gamification design guidelines;
- Apply the guidelines in an application and analyze the results to improve and evaluate the proposal.

In order to have a more manageable environment to study and test, and to prevent the risk of losing objectivity and precision by trying to accomplish a wide-ranging study applicable to multiple areas, the focus of this document will be gamification in education. Essentially, **how to create effective gamification guidelines that can help designers form gamified learning environments capable of providing students with more motivation, engagement, and better results**.

Recapitulating, after a deep study about gamification is done, a gamified software module will be created to evaluate the reached outcomes. The chosen module is a **Moodle plugin**.

Moodle is a learning platform designed to provide users with a system in which they can personalize their own learning environments [12]. Therefore, it can be used to test gamification guidelines that are focused on education.

1.4. Methodology

This project was developed for a period of about a year and divided into two main stages, the research stage and the application stage. To complete each of those stages several specific outcomes were endorsed.

1.4.1. Research stage

In this stage, the first outcome was the interpretation of the problem. To achieve that, it was essential to examine the need for gamification design and possible difficulties with current approaches in gamified applications.

Then, existing knowledge and approaches to the problem of gamification design had to be investigated and synthetized. This was done by inspecting existing gamification design patterns and frameworks, along with their methodologies.

Finally, the different approaches to the problem were evaluated by comparing different gamification design patterns and frameworks and analyzing which of them were best suited to each area of application or problem and how could they be integrated.

1.4.2. Application stage

For this stage, firstly, a plan to the solution of the problem adopting informatic engineering best practices was needed. To accomplish that, the results of the research stage were used to delineate the best approaches to apply gamification using settled gamification design guidelines in a non-game application.

Then, the solution for the problem was assembled. The previously delineated gamification design guidelines had to be further assessed through their use in gamification initiative and integrated in a Moodle plugin.

Lastly, the implemented solution was evaluated. This outcome checked the validity of the effort applied in this project. To evaluate the solution, it was essential to identify and apply metrics used in the area, such as user engagement, time spent, return on investment, and quality [13], that were feasible for evaluation due to existing restrictions. Complementarily, test sessions occurred with recruited participants trying the gamified and non-gamified versions of the application. After that experiment, a questionnaire was used to collect the opinions of the volunteering participants.

With the results gathered, it was possible to find out how well the application of the proposed gamification guidelines succeed, and identify their comprehensiveness, limitations, scope for improvements, and what could have conditioned the results.

1.5. Document Structure

This document is divided in eight chapters:

1. **Introduction**: Contextualizes the readers and informs them about the problem and goals of this work.
2. **Value Analysis**: Analyses the importance this project will have to the various entities that may encounter it, and the cost of its development process.
3. **State of the Art**: Presents readers with concepts and solutions that exist for gamification design and describes them.
4. **Guidelines Proposal**: Analyses the previously presented solutions and then groups the gathered data into the set of guidelines this document proposes.
5. **Moodle Plugin Design**: Contains the planification and architectural design for the proposed gamified module and surrounding environment. Includes basic notions about Moodle development.
6. **Moodle Plugin Solution**: Details the production of the proposed module. This includes information about the components it uses, and its development process.
7. **Evaluation**: Contains the evaluation of the solution using predefined methods. Explains in detail how the evaluation was done and if positive results were accomplished.
8. **Conclusion**: Completes the document by determining the contributions the proposed solution gives to the problem of poor design and gamification in education, suggesting possible future work.

In the end of the document there are some annexes with complementary information.

2. Value Analysis

Value Analysis is the systematic analysis of designs, materials, processes, or systems to identify their best value alternatives. Its purpose is to reduce or even eliminate the cost of the product or service without diminishing its effectiveness, quality, and customer satisfaction [14].

This chapter starts with the innovation process applied by this project. Then, the value of the project is stated for each of the entities that may have contact with its results. Finally, a canvas summarizing the business is discussed.

2.1. Innovation Process

Innovation is the introduction of a new product or method in an industry, or the improvement of an existing concept or idea. It should use prudent processes to create viable solutions [15].

The innovation process can be divided into three parts: the front end of innovation (FEI), which is also called “Fuzzy Front End” (FFE); the new product development; and the commercialization.

The New Concept Development (NCD) model was created to provide a common language view of the front end. It divides the front end into three areas: the “engine”, which contains the vision, strategy, and culture that drive the FEI; the “wheel”, which defines five activities of the front end; and the “rim”, which consist of the external environmental factors that influence the other two areas [16].

The five activities of the “wheel” are [17]:

- **Opportunity identification:** The organization identifies the opportunities it wants to purse driven by business goals. The failure in gamification approaches caused by poor design means that gamification design guidelines are not being followed correctly or that they are not good enough. This presents an opportunity to propose a new set of guidelines that can be more helpful to designers that want to gamify a system.

- **Opportunity analysis:** Here, an opportunity is studied to validate if it is worth pursuing in a process that may involve making uncertain assessments. Market studies and experiments shall be conducted. In section 3.2 of this document, existing gamification design guidelines are presented, and in section 4.1, they are examined and evaluated. This investigation searches for failures and lacking information in the existing solutions to see if the prospect of creating a helpful gamification guide is feasible.

- **Idea generation and enrichment:** This activity consists in the birth, growth, and maturation of ideas. Ideas should go through many iterations and changes as they are discussed and examined. After the existing solutions are examined in section 4.1, the most effective features of each one are merged with notions based on personal experience to create possible new solutions to the problem being studied.

- **Idea selection:** Of all the generated ideas, only some should be pursued to achieve the most business value. There is some risk in this activity as no process will guarantee a good selection and ideas must advance to be possible to discover their true value. Opinions from

various people of different backgrounds were collected to perceive which ideas are more popular and thus, more viable.

- **Concept definition:** The final activity of the NCD is the one that provides the exit to the New Product Development. Here, innovators must create a convincing case for investment in their proposition. The case should vary depending on the nature of the concept and the attitude towards risk of the decision makers. With all the necessary information collected and examined, the development of the proposed gamification design guidelines was reasonable of being started.

These five activities are not linear and the results of each one should be interchangeable with the others [16].

2.2. Value and Perceived Value

2.2.1. Value

The meaning of value depends of the viewpoint of the observer and the context they are inserted in, but generally it is defined as being the result of overall performance minus the cost of something. Basically, the benefit something provides under specific circumstances [18].

Gamification design guidelines provide a way to successfully apply gamification to a given system and as it was noted, gamification when well applied can have great results for the company that applies it. However, poor gamification design with minor to no results is unfortunately very common.

In a succinct way, the correct use of gamification can lead to close relationships between organizations and system users. Users, by being motivated by the gamified system, can become fans of the organization and help spread the word about it while actively creating content for the organization and participating in all kind of events [19]. Students from an educational institution can even see their grades being improved alongside their engagement. So, creating reliable guidelines to apply gamification, whether for education or for other set-ups, can be very valuable to institutions and users alike.

2.2.2. Perceived Value

Companies that apply gamification to their products and users of the gamified product have different points of view about the value of the gamified system. Value from the viewpoint of users is often called “value for the customer”, and they usually care little for the production costs of the system. These differences in perceptions mean all products have a perceived value [20].

Next, the perceived value of good gamification design guidelines for general organizations (which includes educational institutions) that want to gamify their systems, and users of those gamified systems, are analyzed. Not only the benefits they may perceive, but also the sacrifices they might have to do.

Benefits to organizations: Good gamification guidelines can help organization designers develop a popular system capable of motivating its users. By motivating users, it is possible to improve their efficiency and results, make them more active in the organization (for example, participating in blogs and events, and spreading the word about the system [19]), and overall make them happier and creating a better environment. All of this can improve the profit of the organization and give it a better public image, attracting more investors and clients.

Organizations sacrifices: Organizations have to spend money hiring designers specialized in applying gamification to the desired system. Besides that, a reasonable amount of time must be spent to make sure gamification is well applied and the risk of failing is kept low. And finally, the gamified system should be constantly updated to be kept on par with the current needs of its users. Organizations must also take in account that is impossible to get approval from everyone.

Benefits to system users: If users like the gamified system, they can be motivated by it, improve their efficiency and results, have something more to talk about with colleagues and friends, and especially, be happier in environments that sometimes are stressful. Happiness makes people healthier and better for the ones around them. The increase in efficiency and improved results can also open room for users to create a better future for themselves.

System users sacrifices: Users need to spend some time learning how to use the new system and take full profit of it.

Table 1 summarizes this subsection.

	Organizations	**System users**
Benefits	Improved results More active community Better work environment Good publicity	Motivation Improved efficiency Happiness
Sacrifices	Money Time Possible resistance	Time

TABLE 1 - BENEFITS AND SACRIFICES OF EXPERIMENTING GAMIFICATION

2.3. Value Network

Value networks contain multiple roles played by individual participants, and value exchanges between them, generating specific kinds of values. The value exchanges can be tangible deliverables (goods, services, revenue, etc.) or intangible deliverables (knowledge and support offerings). Value networks can be adapted from any activity and allow the discovery of the different kinds of value that are being converted from one to another, and possible failure points in the network [21].

The purpose of this project is only fulfilled if its results are used by gamification designers or software developers, and organizations that want to gamify their systems. So, to demonstrate how gamification design guidelines, designers, organizations, and users interchange value between them, the value network model from Figure 2 was developed. The continuous lines represent tangible deliverables and the dashed lines represent intangible deliverables.

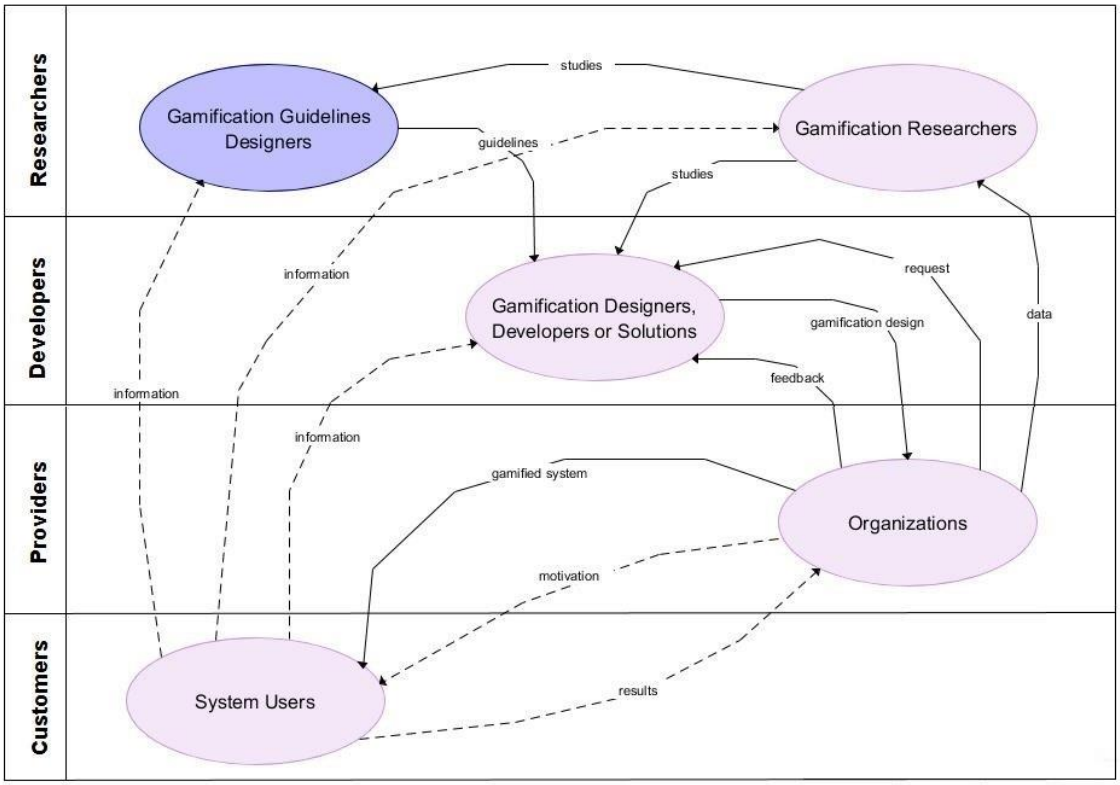

FIGURE 2 - VALUE NETWORK MODEL FOR GAMIFICATION DESIGN

The model from Figure 2 shows that gamification guideline designers get much information from the studies of gamification researchers. Then, the guidelines they produce can be used by gamification designers or developers that offer their services to organizations. The organizations provide the gamified systems to their users, which are the final customers of this scenario. The system users either approve the system or not, and that affects their results in the organization. Organizations can then provide feedback to the entities that gamified their systems, and sometimes even data containing their results to researchers. Finally, system users can also provide information about gamification fallouts to every entity in the gamification business, either by direct conversation or by word spreading.

If the organization is an educational institution, and the system users are students, their results can come in the form of better grades. Which besides helping students achieve a better future for themselves, might also improve the reputation of the institution.

2.4. Business Model Canvas

The business model canvas is a tool proposed by Alexander Osterwalder that outlines nine building blocks for the business model in one page. It lets innovators reflect individually in each block to help them define their business idea and everything that comes with it [22].

Next, the full canvas for business proposal of this document is presented (Table 2) and then, each of its segments are described. Since the solution is not planned to be commercialized, some of the segments are from the perspective of organizations that decide to use a decent gamification design in their systems.

<table>
<tr>
<td rowspan="2">Key Partners

-Gamification designers/developers

-Organizations that want to gamify their systems

-Gamification enabling solutions</td>
<td>Key Activities

-Development and design of the guidelines

-Testing the guidelines

-Publication of the guidelines</td>
<td rowspan="2">Value Propositions

-Provide gamification designers with reliable guidelines that are easy to understand, and are mainly focused in educational contexts

-Deliver where other guidelines fail

-Make possible the creation of gamified systems capable of motivating their users, making them more happy, productive, loyal, and active

-Attracting many interested users or customers because of the positive publicity made

-Prevent designers from falling into the trap of poor gamification design</td>
<td>Customer Relationships

-Quality of the product</td>
<td rowspan="2">Customer Segments

-Designers/Organizations:
Will have reliable guidelines to gamify their systems

-System users:
Will take advantage of good gamification designs capable of motivating them</td>
</tr>
<tr>
<td>Key Resources

-Hardware

-Software

-Test subjects

-For organizations: designers and developers</td>
<td>Channels

-Digital marketing

-Conferences

-Workshops</td>
</tr>
<tr>
<td colspan="3">Cost Structure

-Distribution of the guidelines

-For organizations: hardware, software licenses and human resources</td>
<td colspan="2">Revenue Streams

-Ads on the distribution channels

-For organizations: better productivity of their system users and good publicity</td>
</tr>
</table>

TABLE 2 - BUSINESS MODEL CANVAS FOR THE GAMIFICATION DESIGN GUIDELINES

Key partners: This segment should contain the most important partners and suppliers of the business and their motivations.

For this project, the partners are any organization or designer that decides to use the proposed guidelines with the purpose of gamifying their systems. From the perspective of organizations that try using gamified systems, the partners would be companies that produce software to help in the process of gamification, and gamification designers selling their services.

Key activities: This segment should contain the most important activities required by the business. They can be activities related to distribution, customer relationships, revenue, etc.

For this project, the key activities are the design and development of the gamification guidelines, which includes testing a prototype that uses them. In a later stage, one key activity would be the publication of the guidelines.

Value proposition: This segment should specify the core values that will be delivered to the customer, and the needs that will be satisfied.

The purpose of this project is to provide gamification designers with reliable guidelines that are easy to understand and are mainly focused in educational contexts.

Thanks to an extensive research of the literature and various evaluations, these guidelines deliver where others fail and make possible the creation of gamified systems capable of motivating their users, making them more happy, productive, loyal, and active while attracting many interested users or customers because of the positive publicity made by default. All of this, without falling into the trap of poor gamification design.

Customer relationship: This segment should specify the relationships that will be established with the targeted customers, their cost, and their format.

Any organization or designer is free to use the guidelines proposed in this document. From both the viewpoints of this project, and organizations with gamified systems, the relationship with their customers comes from providing a reliable and motivating product or system.

Customer segment: This segment should contain the classes of customers that the business is creating value for, while stipulating the most important customers.

For this project, the direct customers are the designers and organizations that will follow the proposed guidelines to gamify their systems. There is also an indirect group of customers which is everyone using systems that were gamified following the guidelines proposed in this document.

Key resources: This segment should specify the resources needed for the activity of the business to be possible, stipulating the most important ones.

To complete this project, it was necessary to have software to develop the gamified prototype, hardware to run the software, and volunteers to test the prototype. Organizations that want to gamify their systems also need designers and developers to create the new system.

Distribution channels: This segment should specify the way the customers will be reached, and what channels are best fitted to the routines of the business and customers.

Part of this project is being considered to be added as a chapter of a book about education and game elements. Other possible distribution channels include digital marketing, conferences, and workshops.

Cost structure: This segment should contain the resources and activities that cause the most relevant expenses for the business.

For this project, the costs would be only related to the distribution of the guidelines. For organizations that want to gamify their systems, the costs come from hardware and software purchasing, and paying human resources to develop their new systems.

Revenue stream: This segment should contain the sources of revenue of the business, what and how do customers pay, and how much does every revenue stream contribute to the overall profit.

Since this project is not meant to be commercialized, the only possible way of having revenues is if it is decided to have ads in the digital distribution channels. For organizations with gamified systems, the revenue comes from better productivity of users of the systems, their loyalty to the organization, and good publicity that may attract new users or clients.

3. State of the Art

In this chapter the results of an extended research on the world of game design and gamification design are presented, with a section dedicated to game design elements, since gamification is based on their usage.

Then, other gamification design frameworks are introduced, and after that, existing products that were made to enable gamification in desired systems.

Finally, and since a Moodle plugin was planned to be developed in order to apply and test the created gamification framework, there is a section dedicated to gamification in education.

It is important to note that this chapter only presents the elements, frameworks, and solutions, and does not analyze them to detail or evaluates them. However, it introduces common gamification design concepts that are recurrently used in this document.

3.1. Game Design Elements

Gamification is considered by some authors as being the usage of the same game affordances (easily recognizable game elements) in non-game environments, and by others as producing in the gamified system users the same psychological feelings often generated by games [3].

Both the affordances and the triggered feelings are game elements. This section starts by presenting a common game design framework, the Mechanics-Dynamics-Aesthetics (MDA) Framework, and then, explains what affordances are common in games and in gamification design, and what emotional states are often prompted in players by games. The section ends by introducing the concept of “flow”.

3.1.1. MDA Framework

The Mechanics-Dynamics-Aesthetics framework was developed for the “Game Design and Tuning Workshop” at the Game Developers Conference, San Jose 2001-2004. Its purpose is to clarify the connections between game design, criticism, and technical research.

Games consumption, unlike other entertainment mediums, is unpredictable, as the sequence of events that occur depend upon the actions taken by the player. The MDA framework divides the consumption of games into three different sequential categories (Rules, System, and “Fun”), and establishes their design counterparts as Mechanics, Dynamics, and Aesthetics, respectively:

- **Mechanics** are the hidden game components, like the algorithms, data structures, and the interactions between them. They are also the game elements that have a purpose for the gameplay and its rules (for example, a die in a board game).
- **Dynamics** are the behaviors mechanics take based on players input. Basically, the way a player interacts with a game and how it responds (for example, rolling a die).
- **Aesthetics** are all the emotional responses evoked in the player by the game (for example, the hope of dicing a high number).

Both developers and players interact with these categories but with different perspectives. Developers firstly produce the game mechanics and then create the dynamics that will let players interact with those mechanics. Dynamics are what leads to aesthetic experiences, but developers do not feel them as they can only be experienced during gameplay. Players, on the other hand, firstly

contact the aesthetics. Then they interact directly with the dynamics, which operate on mechanics. However, players cannot operate with mechanics directly (Figure 3).

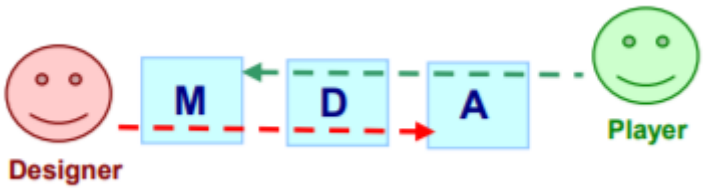

FIGURE 3 - DESIGNERS AND PLAYERS PERSPECTIVES OVER MDA [23]

When developing a game, the focus can be in either the perspective of the developer, the perspective of the player, or a mix of both. Focusing in the perspective of the developer gives rise to a **feature-driven** system, while focusing on the perspective of the player creates an **experience-driven** system [23].

3.1.2. Common game mechanics

Some game mechanics are popular among games and gamified systems alike. The seven most commonly studied ones are [24]:

- **Badges**, which are symbolic prizes that have the purpose of showing that whoever received them was able to do some task or complete some goal. They are usually presented as icons that appear to users when received and sometimes can even be displayed in their profiles to be exposed to other people. Badges normally do not unlock or offer any other rewards and are just a way of bragging rights. Because of that, they should be given wisely and always carry meaning, distinguishing them from other types of collectibles.

- **Leaderboards** or rankings, which show users how they compare among their colleagues or adversaries. They try to motivate by promoting competition and the desire to be the best, and by giving a sense of belonging to a community. However, competition sometimes can create pressure and demoralize lower ranking users.

- **Points**, which are imaginary units received when completing some tasks. Usually, the better the task was completed, the more points are earned. They can be used to decide positions in leaderboards, unlock new things, or advance user levels. Which are just a way of showing the overall user performance.

- **Immediate feedback**, which is basically just letting users know how well they performed in some task and can be shown in the form of other game mechanics such as badges or points. Immediate feedback is a good way of teaching and showing users how can they become better at what they do.

- **Goals** or challenges, which can be either completing a simple activity, or completing a set of various assignments. They are typically used alongside other game mechanics and can assist users by guiding them through the tasks that should be accomplished.

- **Progress bars**, which are used to show users how much of a task they completed, and how much is still missing, giving them feedback about their efficiency and prompting their desire for accomplishment. Sometimes they can even give prizes when filled.

- **Rewards**, which can come in the form of other mechanics like points or badges but can also be unlockables or gifts. While rewards are always extrinsic motivators, they can also carry intrinsic values like the sense of accomplishment [25]. A certificate, being a symbol of achievement, is an example of a reward that has a lot of intrinsic value. Money, on the other hand, has mostly extrinsic value. Rewards can be random to create unpredictability and positive surprises, or methodical to recognize users for their consistency in performing certain actions.

- **Storylines**, which give a narrative to the activities of the system in order to contextualize them and give a more meaningful experience to users. They are a good way to keep people involved.

All the mentioned mechanics are used in gamification design. When the focus of the designer is in applying them, they are creating feature-driven system, however, it is important to note that a feature-driven approach that does not evoke any kind of emotions in users is essentially useless.

3.1.3. Emotion in games

According to the MDA Framework, the emotions caused by games are the aesthetics, and a game or gamified system focused on aesthetics is an experience-driven system. Robin Hunicke, Marc LeBlanc and Robert Zubek in their article "MDA: A Formal Approach to Game Design and Game Research", characterized aesthetics using the following taxonomy [23]:

1. **Sensation** (game as sense-pleasure)
2. **Fantasy** (game as make-believe)
3. **Narrative** (game as drama)
4. **Challenge** (game as obstacle course)
5. **Fellowship** (game as social framework)
6. **Discovery** (game as uncharted territory)
7. **Expression** (game as self-discovery)
8. **Submission** (game as pastime)

For Robin Hunicke et al., games are engaging because they contain some of these eight aesthetics.

Likewise, to the speaker on education Marc Prensky [26], games are a unique entertainment medium that provides elements that are not found massively in any other form of entertainment. He defined the elements delivered by games the following way:

1. Games are a form of **fun**. That gives us enjoyment and pleasure.
2. Games are form of **play**. That gives us intense and passionate involvement.
3. Games have **rules**. That gives us structure.
4. Games have **goals**. That gives us motivation.
5. Games are **interactive**. That gives us doing.
6. Games are **adaptive**. That gives us flow.

7. Games have **outcomes and feedback**. That gives us learning.
8. Games have **win states**. That gives us ego gratification.
9. Games have **conflict/competition/challenge/opposition**. That gives us adrenaline.
10. Games have **problem solving**. That sparks our creativity.
11. Games have **interaction**. That gives us social groups.
12. Games have **representation and story**. That gives us emotion.

It can be concluded that despite some wording differences, both authors agree in many points, with pleasure, involvement, drama, challenge, and socialization being common well-regarded game aesthetics. So, when designing a gamified system, they should be taken in account.

3.1.4. Cognitive Flow

Cognitive flow is the name given to the state a person is when they are so focused in a task that they ignore what is happening in their surroundings. To make this occur in a game or gamified system, its design must be very well done. It must have concrete goals with manageable rules that fit the capabilities of the player, clear and timely feedback, and eliminate distractions [27].

Psychologist Mihaly Csikszentmihalyi evaluated flow and concluded that when the difficulty of a task is too high for the skill of whoever is doing it, that person becomes anxious. On the other hand, when the difficulty of a task is too low in comparison to the skill, people become bored. The flow state is reached when difficulty and skill are proportional (Figure 4).

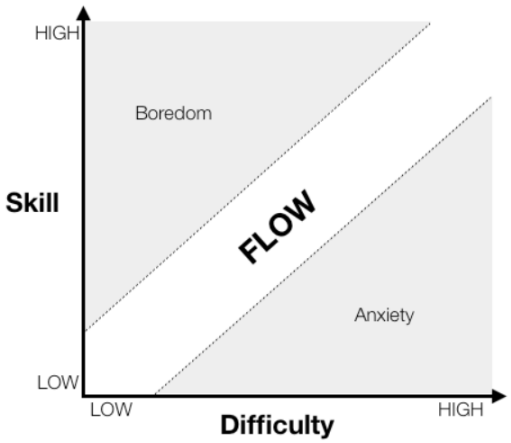

FIGURE 4 - FLOW IN RELATION TO SKILL AND DIFFICULTY [27]

When in flow, people feel completely in control of the activity they are doing and do not need any other reason to do that activity other than the joy of doing it.

3.2. Gamification Design Frameworks

There are several well-known gamification design frameworks. Generally, those frameworks not only provide guidelines to correctly apply gamification, but also describe users and their main motivational factors, agreeing that user characteristics are very important to gamification design. In this section, some of the most eminent gamification design frameworks are exposed. Six Steps to Gamification, Octalysis, and Marczewski's Frameworks were selected due to recognition and available public extensive documentation, while "How to Gamify?" was selected for being a

comparatively lesser known study on multiple gamification frameworks that tries to connect every step recommended, which is a goal akin to the purpose of this document.

3.2.1. Six Steps to Gamification

Kevin Werbach and Dan Hunter defined a gamification design framework called "Six Steps to Gamification" with 6 steps designers should take to create a good gamified system, all starting with the letter "D" [28]. The authors emphasized, however, that the steps they defined are not meant to be done linearly every time, but iteratively and be under constant revision, receiving feedback from users of the gamified system.

The 6 steps are the following:

1. **Define your business objectives**: The goal must not be about creating a system that makes users happy, but one that improves the business in some way, for example, by improving the efficiency and performance of the users. A poor definition of the objectives can lead to a fun system but that does not improve anything, or even a system that hinders the goals of the business.
2. **Delineate your target behavior**: The specific steps the targeted group must take to achieve the business goal must be described. With emphasis on the important tasks.
3. **Describe your players**: Assume that users are players that want enjoyment from using the system. Categorize them in groups (people who like to explore and discover new things, people who like to compete and be the best, people who like to socialize, etc.), and reflect about aspects of the system that can make it more enjoyable to those groups.
4. **Device your activity loops**: Create the structure of the gamified system focusing on 2 levels:
    a. The micro level or engagement cycle is made of the activities and respective feedbacks. Feedback is crucial, so it is important to know how people will see and learn from it, so they can be led into the right path.
    b. The macro level is focused on the "Player Journey", that is how the users go from newbies to experts, and how the system responds to them at those different stages.
5. **Don't forget the fun**: It is important to not only focus on structures and mechanics, but also in building a system that makes people want to use it, or else users will not care for it. There are different ways of having fun (surpassing challenges, discovering things, socializing, etc.). Focus on what type of fun can be more useful for the business goals, for example, unlocking achievements when the business goals are all about the results, or allowing collaboration between users when the goals are to develop new ideas.
6. **Deploy**: Find the appropriate tools, pick the specific game elements that were previously decided, and build the system.

3.2.2. Octalysis

Octalysis [29] is a human-centric gamification design framework developed by Yu-Kai Chou.

Being human-centric, Octalysis presents a structure to analyze the main forces behind human motivation, denominating them "**core drives**", and states how to apply those drives. Octalysis goals are to produce improvements in user engagement and ROI and can be used in multiple business areas.

The core drives suggested by Octalysis are 8:

- **Meaning**: Believing in a greater purpose or "prophecy" for doing some task.
- **Accomplishment**: Developing skills and overcoming challenges.

- **Empowerment**: Engaging in a creative process of finding different solutions.
- **Ownership**: Feeling responsibility over something and wanting to make it better.
- **Social Influence**: Every social element that drives people (acceptance, competition, etc.).
- **Scarcity**: Wanting something that cannot be owned at the moment and thinking about it.
- **Unpredictability**: Wanting to find what happens next.
- **Avoidance**: Avoiding something negative.

There is also a ninth hidden drive called "Sensation", though no details are provided for it.

These core drives are divided in 2 groups, the "**Left Brain Drives**" and the "**Right Brain Drives**" (based on the idea that the left part of the brain deals with logic, and the right part of the brain deals with creativity). Left brain drives (Accomplishment, Ownership, and Scarcity) are based on logic and extrinsic rewards, and usually stop having the desired motivational effects once people get used to the rewarding system. Right brain drives (Empowerment, Social Influence, and Unpredictability) are based around intrinsic motivation, and concepts like creativity and self-expression. Intrinsic motivators are generally preferred.

Besides that, techniques that use determined core drives are also divided in "**White Hat Gamification**" and "**Black Hat Gamification**". The white hat drives (Meaning, Accomplishment, and Empowerment) are the ones that make people feel powerful and fulfilled, but do not have urgency. Black hat drives (Scarcity, Unpredictability, and Avoidance) are the ones that make people feel addicted and anxious in fear of losing something or not fulfilling a wish. They are a good way to motivate people, but do not make them happy.

Every system uses Octalysis core drives in different levels, see for example Facebook (Figure 5).

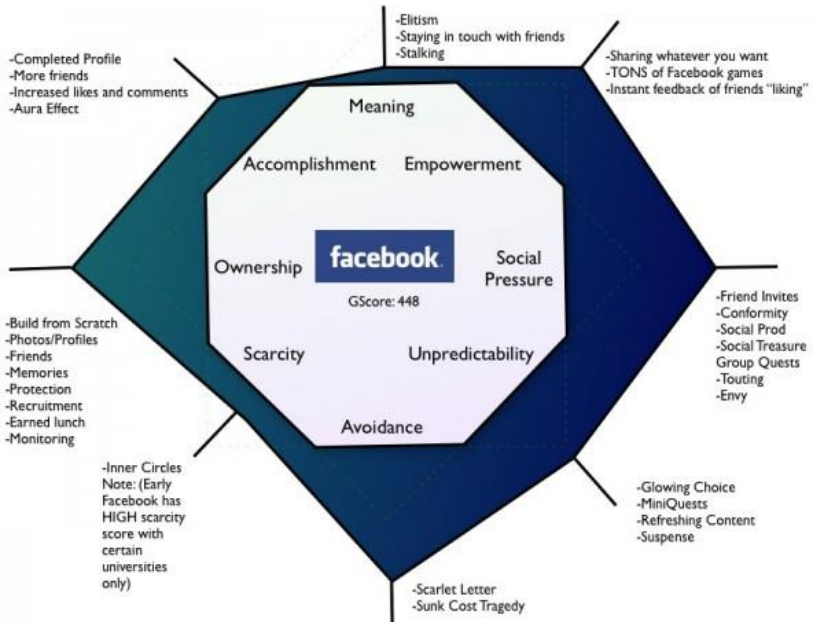

FIGURE 5 - OCTALYSIS ANALYSIS OF FACEBOOK [29]

Based on the image, it can be concluded that Facebook addiction comes mainly from right brain drives, specifically the Social drive. The exceptions are the drives of Ownership and Avoidance.

An Octalysis Score can be calculated by attributing a value between 0 and 10 to each drive and then sum the square of all values, resulting in a score between 0 and 800.

Complete information of how to correctly apply the Octalysis framework is not free and only the first 2 of 5 levels of implementation are available publicly:

- **1st level**: Analyze the levels of the 8 core drives in the existing system and in the planned design ideas to get which drives are more relevant than others.
- **2nd level**: Follow users of the system through their journey in 4 steps (discovery, on-boarding, scaffolding, and end-game), and for each step focus on different core drives.
    - **Discovery**: The user learns about the system.
    - **On-boarding**: The user gets familiar with the system and its rules.
    - **Scaffolding**: The user uses what they know to get the best out of the system.
    - **End-game**: The user feels that everything about the system was already explored.

The third level is only briefly addressed and consists in separating users in the four different character types created by Richard Bartle (achievers, explorers, socializers, and killers), focusing once again in different drives for each type.

- **Achievers**: Strive to obtain personal success.
- **Explorers**: Seek the discovery of new things.
- **Socializers**: Pursue the construction of social relationships.
- **Killers**: Like to compete and defeat others.

3.2.3. Marczewski's Frameworks

Marczewski created multiple gamification related frameworks that deal with topics like gamification design, intrinsic motivation, and usage of a system over time [30].

The most well-known of his frameworks is "**GAME**", which divides the gamification design process in 4 steps:

1. **Gather**: Ask what is being gamified, why, and for whom. Decide how success is going to be measured.
2. **Act**: Design the best solution for the business goals and user experience. Test with system users.
3. **Measure**: Evaluate user activities and outcomes, and check if they met the defined goals. Make improvements based on the observations.
4. **Enrich**: Based on the gathered data, iterate the gamified system, and keep content fresh and up with the needs of the users.

In gamification design, motivation is always a very important subject, so Marczewski also developed a framework for intrinsic motivation called "**RAMP**":

- **Relatedness**: Wanting to have social status and felling of belonging.
- **Autonomy**: Wanting to express creativity and choice.
- **Mastery**: Wanting to learn and improve skills.
- **Purpose**: Wanting to help others and have a meaning in life.

Marczewski also considers that different stages of usage of a system require different kinds of attention, so he developed the **EEEE** framework of stages of use over time:

1. **Enroll**: The first moments of the users in the system.
2. **Enthuse**: When users augment their activity rate.

3. **Engage**: When users either find the true usefulness of the system and their activity rate stays still, or do not and their activity rate decreases drastically (Figure 6). This can be caused by poor design.
4. **Endear**: If the engagement was done correctly, users shall find their intrinsic reason to use the gamified system. There may be a small decrease in activity at this stage if the reason found is not strong enough (Figure 6).

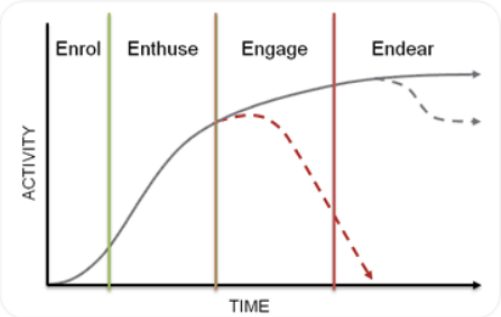

FIGURE 6 - USER ACTIVITY OVER TIME [30]

Marczewski also advises designers to remember to make usage of the system voluntary, make it fun, and having attention to the possibility of cheating the system, because it can drastically decrease motivation in fair users. For Marczewski, intrinsic motivation is better than extrinsic motivation.

3.2.4. How to gamify? A method for designing gamification

Morschheuser, Werder, Hamari, and Abe, based on data gathered from the literature, interviews, and other gamification models, divided the gamification process into 7 phases in their article "How to gamify? A method for designing gamification" [31]. They concluded that most gamification methods follow similar guidelines with differences in the details.

The 7 phases are:

1. **Project preparation**: Define what are the problems that should be addressed and how can the results be measured. Have clear understanding of the objectives and decide if gamification is applicable. If yes, identify the requirements (Figure 7).

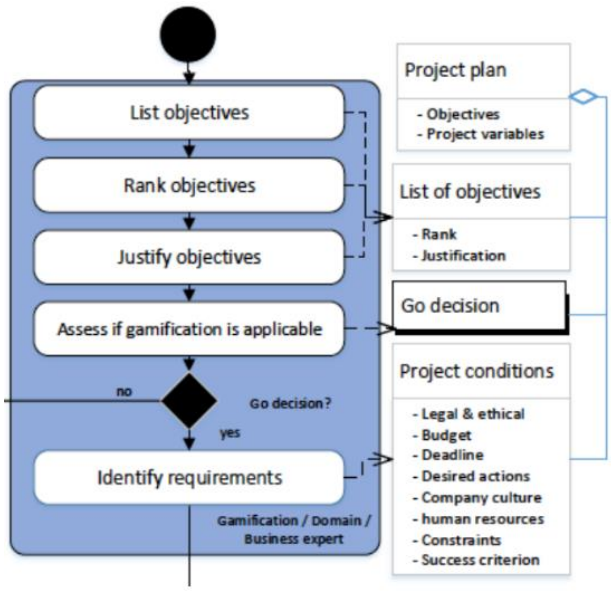

FIGURE 7 - ACTIVITIES OF THE PREPARATION PHASE [31]

2. **Analysis (of context and users)**: Many frameworks agree that system users should be analyzed, but Morschheuser et al. believe that the context analysis should not be underestimated. Depending of the context, designers decide if users should be segmented in larger, more generic groups or in smaller, more detailed ones. When segmenting, designers ought to create personas (particular types of character that a person seems to have) [32] (Figure 8).

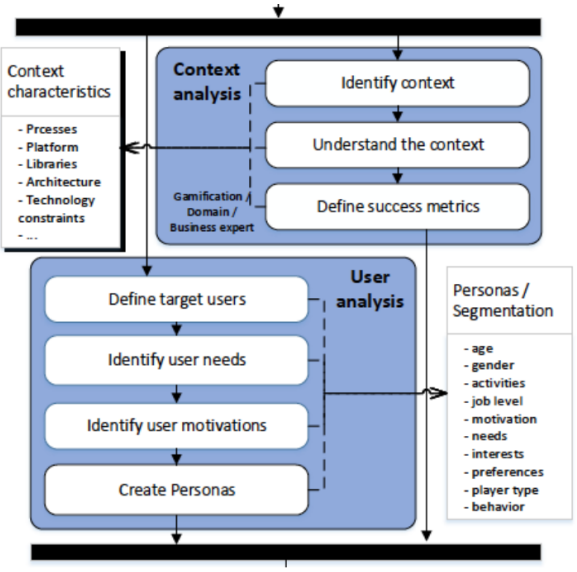

FIGURE 8 - ACTIVITIES OF THE ANALYSIS PHASE [31]

3. **Ideation**: The decision of how gamification should be applied. It is debated if the focus should be in applying game elements, or in trying to produce specific feelings in the system users, but the first step must be always brainstorming ideas. When a list of ideas is produced, they should be consolidated. To help the brainstorm, some tools can be used. Those tools range from physical objects such as videogames to help stimulate ideas and establish patterns, to theorical guides such as the design lenses created by Jesse Schell (perspectives observing a game) to lead design in a specific direction. Documents such as canvas and decision trees may be used to communicate ideas and support guidance.
4. **Design of prototypes**: Sketch quick prototypes. Test and improve the ideas until they seem enough to reach the predefined goals. In the end, create a development concept with information about the implementation (Figure 9).

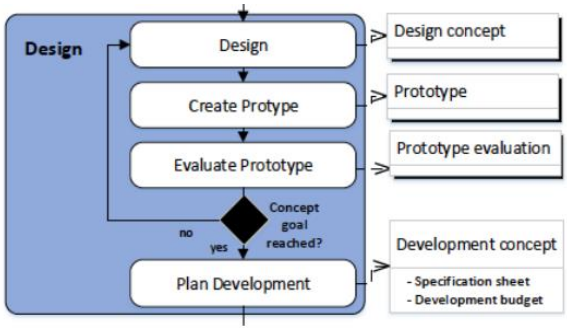

FIGURE 9 - ACTIVITIES OF THE DESIGN PHASE [31]

5. **Implementation of a design**: Decide who is going to implement gamification, or if a platform will be used. Have an expert manage implementation and continuously test and evaluate

the implemented designs until a good pilot can be created to be used for field evaluation of the design (Figure 10).

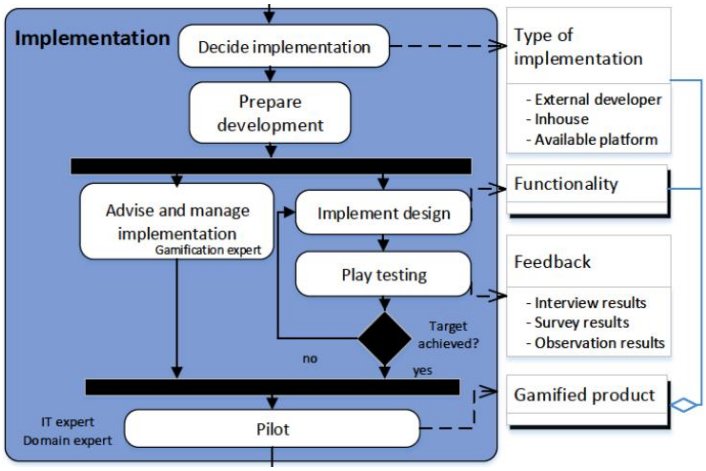

FIGURE 10 - ACTIVITIES OF THE IMPLEMENTATION PHASE [31]

6. **Evaluation**: Investigate if the solution meets the objectives. This can be done by conducting surveys and interviews, but more importantly, by playtesting. In a playtest, system users and their actions using the gamified platform are observed and many conclusions can be taken from that observation.
7. **Monitoring**: Finally, the system usage should be investigated at regular intervals to continuously produce improvements. A good process that can be used is A/B-testing, where two design alternatives are presented randomly to users, and the success rate of each one is registered.

3.3. Gamification Enabling Solutions

To apply gamification design in specific systems, there are multiple online SaaS that automatize that process by offering various usable game mechanics, and by managing analytics of the gamified system.

The two renowned gamification enabling solutions with the most accessible and straightforward informative data found were CallidusCloud SalesMotivate and IActionable.

3.3.1. SalesMotivate

SalesMotivate [33], known as Badgeville before its acquisition by CallidusCloud, is a SaaS targeted at sales organizations that can be integrated in the software they use. It provides several features based on game elements that can be exploited through various kinds of devices and platforms.

Leaderboards and contests are some of the features used by SalesMotivate to promote competition between employees, hopping to create a culture of success by motivating them to be at the top of the leaderboard and by letting them know where they stand against their colleagues.

The other important feature used is activity track, where employee progress is tracked and streamed in real-time to once again motivate by competition and by pride since every system user will have access to the stream. It is also possible to reward workers who reach key milestones with point and badges.

All these features are applied in a community context, as points and badges have a lot less meaning when used in an individual context.

CallidusCloud claims that SalesMotivate increases business success significantly.

3.3.2. IActionable

IActionable declares itself as an "employee management platform that leverages gamification to increase employee performance, recognition, and engagement" [34].

To close the gap between manager expectations and employee performance, IActionable offers features to clarify to employees what is expected from them, and how well are they meeting those expectations, while keeping the feedback in real-time. The gamification elements used by IActionable are onboarding, goals, score, achievements, leaderboards, and contests. All these elements try to motivate employees through competition, bragging rights, and exposition of individual progress.

IActionable works in 4 stages. The first one is to create a system that makes sense to the business environment. Next, the system is connected to the business data and automated. There are already multiple platforms that can be easily integrated with IActionable, but custom integrations are also offered. The third stage is giving employees real-time feedback, so they can adapt more easily to the working environment and be more motivated. Finally, adjustments to the system can be constantly done to keep it fresh.

IActionable claims to greatly improve employee engagement.

3.4. Gamification in Education

Gamification design has also been used in education for a long time, even before the concept of "gamification" ever existed. Grades, for example, are a longstanding form of gamification. More recently, Moodle was released to aid electronic learning, and while in its core it already presents some gamification design elements, plugins were developed to make it even more gamified.

3.4.1. Grade point average

Grade point average (GPA) is the average of all the grades a student obtained in school [35]. It is used all over the world and accompanies students from elementary school to college.

GPA is usually the measurement that universities and some private schools use to evaluate their candidates, but it can also have other less evident uses, such as giving motivation to students. Grades are very analogous with points in a game that can be increased with hard work. In many schools, students with the best grades can reach top students boards which are like leaderboards in a game, and even receive scholarships, which are basically prizes and rewards.

Grades, boards for students that achieved the top grades, and scholarships can all be considered gameful elements, meaning that gamification design is already being applied in education. However, there are still many students with poor grades, which means that the system is not good enough. The cause of it is probably due to poor gamification design, mainly not having in consideration the different types of "users", a step recommended in most gamification design frameworks. In the context of education, users are students and they all have different backgrounds, likes, dislikes, talents, and inabilities and as such, the system should behave accordingly to those differences.

Besides that, GPA can become heavily demotivating to students with lesser grades by punishing and exposing them. The highest grade is seen many times as the starting point and anything below that as a failure, which causes unnecessary pressure. Instead, an alternative approach to the grading system could be to have grades grow from zero to their maximum value. A system like that becomes even more comparable to points and makes every grade look like an achievement to be proud [36].

3.4.2. Moodle plugins

The modular setup of Moodle allows developers to easily create plugins and add-ons for the platform.

There are six plugins in the official Moodle plugin list that are part of the gamification set [37]. Table 3 describes them and some of their main characteristics. It is sorted by number of "Fans", which are people who publicly liked the plugin.

	Functionalities	Downloads	Fans	Price
Level Up!	Lets users gain experience points with their actions in the course to reach new levels. Personal congratulations messages can be configured	4000	296	Free
H5P	Allows the creation of various types of interactive content in a Moodle course. Some of the possible types of content are memory games, personality quizzes, and arithmetic quizzes	12000	245	Free
Game	Allows the creation of interactive games using questions, glossaries, and quizzes. It includes games such as hangman, crossword, and sudoku	6000	145	Free
Quizventure	Contains a game in which possible answers of questions from the course come down in the form of spaceships and students must shoot the correct ones	356	70	Free
Stash	Lets course administrators hide items from an inventory in different activities and resources from the course. Then, users can find them to unlock new content	329	50	Free
Mootivated	Allows users to be rewarded with virtual coins that can be used to customize a personal avatar with multiple items	438	20	Needs a paid third-party service

TABLE 3 - MOODLE PLUGINS THAT ARE PART OF THE GAMIFICATION SET [37]

4. Guidelines Proposal

In this chapter, the frameworks introduced in chapter 3 are put through a general analysis and compared with each other. The analysis is mostly conducted using results found across the literature and comparisons are made using the number of properties accessed by the mentioned gamification frameworks.

Then, the proposed set of iterative gamification design guidelines is presented. This includes the strategies used and a step-by-step reasoning of each stage considered.

Finally, it is explained how the proposed guidelines were used to create the planned Moodle plugin and surrounding gamified environment.

With the research that was done, it is expected that the projected guidelines can exceed or at least match the currently obtainable frameworks in terms of relevant points approached and user breakdown.

4.1. Gamification Frameworks Analysis

The gamification design frameworks mentioned in section 3.2 and several others present across the literature share many aspects in common. Alberto Mora et al. in the article “A literature review of gamification design frameworks” studied numerous frameworks found by searching academic articles about gamification, and examined their usage of game design principles and the design considerations being applied [38].

They found that most frameworks are based on **Human-Focused Design** principles, meaning that the main goal of the design is to work on the feelings of the users. This means that the Self-Determination Theory (SDT), which is a theory of motivation concerned with supporting the intrinsic tendencies of people to make them behave in effective and healthy ways [39], is a predominant approach used to design gamification guidelines.

After researching the available frameworks, Mora et al. took multiple common gamification design items (properties that are accessed by the frameworks) from the literature and organized them into five categories:

- **Economic** (objectives, viability, risk, ROI, and stakeholders)
- **Logic** (loop, end game/epic win, on-boarding, and rules)
- **Measurement** (metrics and analytic)
- **Psychology** (fun, motivation, social, desired behaviors, and ethics)
- **Interaction** (narrative, UI/UX, and technology)

Most of these items are inherited from game design, meaning that game design items can also be used in gamification, although in a different way.

From the mentioned items, the ten more meaningful (in terms of results and heterogeneity) were viability, stakeholders, loop, endgame, on-boarding, rules, metrics, ethics, UI/UX, and technology. The other items were either commonly referenced in every framework and thus, should always be taken in consideration (e.g. objectives and most of the psychological items) or scarcely referenced and thus making it reasonable to ignore them (e.g. risk, ROI, and analytics).

Table 4 is adapted from the table arranged by Mora et al. and shows the meaningful items that are referenced in the frameworks mentioned in section 3.2. **E** (explicit) means the item is openly

stated in the framework, **I** (implicit) means the item is either inferred in the framework or referred inside another academic work of the authors, and **U** (unavailable) means the item is not referred at all.

Morschheuser et al.'s framework [31] was not present in the original table and was specifically examined according to the specified parameters and added for this document.

Categories	Economic		Logic				Measurement	Psychology	Interaction	
Features	Viability	Stakeholders	Loop	Endgame	On-boarding	Rules	Metrics	Ethics	UI/UX	Technology
Six Steps to Gamification, Werbach and Hunter	I	I	E	E	E	E	E	I	E	E
Gamification Framework, Marczewski	E	E	E	U	E	U	E	U	U	E
Octalysis, Chou	U	U	U	E	E	U	E	U	U	U
How to gamify?, Morschheuser et al.	E	E	I	U	U	I	E	E	U	E

TABLE 4 - FEATURE SUMMARY OF DIFFERENT FRAMEWORKS. ADAPTED FROM [38]

It can be concluded from Table 4 that Werbach and Hunter's **Six Steps to Gamification** is the most complete framework of the four analyzed. In the original table it was also considered the most complete tied with Julius and Salo's framework for gamification. The latter was ignored for being specifically targeted at marketing environments [38].

Six Steps to Gamification is also the most referenced by other authors and, of the four analyzed frameworks, it is only less complete than Marczewsky and Morschheuser et al.'s frameworks when it comes to viability, stakeholders, and ethics. On the other hand, Octalysis, while ignoring many items, still holds value for the fact that its analysis to the motivation of users is very deep, making it a relevant framework.

4.2. Integrative Gamification Design Guidelines

A review of the literature indicates that gamification design frameworks share many features in the sets of steps they provide. Six Steps to Gamification, from Werbach and Hunter, appears to be the most complete gamification design framework from the ones that were found in this research. And with that in consideration, it was used as a basis for the development of the gamification design guidelines proposed by this document, with the weak points of the framework, such as its middling economic assessment and slight disregard for ethics being addressed.

However, other gamification frameworks were not completely disregarded. The extensive evaluation of user needs from Octalysis was also tackled and adapted to this work.

Based on all the data gathered it was possible to start designing the list of steps needed for a good gamification design. These steps are not supposed to establish a completely new gamification design framework, but rather an arrangement of ideas from other frameworks that can be used together to form a strong set of guidelines. Nevertheless, just like most gamification frameworks, the proposed guidelines are arranged in a pattern that makes them more memorable and easier to remember.

All steps from the guidelines must receive the output of the previous ones as input.

1st step: Study the environment

This should be the first step when designing a gamified system. Here, designers should debate the viability of the project and if gamification will be useful. Basically, why is gamification being applied.

Other criteria that must be analyzed are the available technologies, the costs and ROI, the interests of the stakeholders (if present), and the objectives of the system.

Based on everything from this stage, the metrics that will be used to test the gamification results should be delineated. They can be related to user engagement, time spent, ROI, or system quality.

To keep the environmental information organized, designers could create a canvas. The standard Business Model Canvas is recommended, but there is also a framework proposed by Sergio Jiménez called "Gamification Model Canvas" that was made explicitly for gamification design [38].

2nd step: Analyze the players

In this step, designers should analyze the targeted users of the system. This analysis should not be only about age and gender, but also about personalities.

To examine the personalities, designers can use any approach they want. One possibility is dividing users according to the Big Five personality traits model (which is a taxonomy for common personality traits) or any other similar system, but the advice is to use the Hexad User Types Scale (which groups users according to their main motivations), since it is a system made specifically to the game world.

Because personalities can vary much between user groups, it is important to either focus on the most common personalities, or even better, to plan features targeted at every type of user.

It is also important to never forget about ethics, as it is a theme that should always be addressed or else the system may fail prematurely [31].

After this analysis, designers can create diagrams or tables showing the incidence of user characteristics and personalities and write down any missing information.

3rd step: Select the elements

This is a more concrete step where many frameworks fail to provide solid information, opting instead for giving ambiguous advices.

Here, designers should think of all the reasonable mechanics and dynamics and what kind of motivators are they. Designers do not need to be glued to the most common game elements and can come up with ideas of their own. To do that, they can partake brainstorms, get inspiration from other sources or ask opinions from other people and future users of the system.

Designers should also remember that it is important to keep the system interface attractive and the user experience simple.

A multi criteria decision making method is an example of a way to decide which game elements should be used.

Tondello et al., in the article "Elements of Gameful Design Emerging from User Preferences", concluded that socialization elements are preferred by men, socializers, and extroverts; assistance elements by women and extroverts; immersion elements by women, achievers, and free spirits; risk/reward elements by younger achievers and players; customization elements by younger women who are more open to experiences; progression elements slightly by achievers and philanthropists; altruism elements by younger men, philanthropists, and socializers; and incentive elements by

younger players who score high on neuroticism [5]. However, designers can partake their own studies and reach personal conclusions.

4th step: Prepare the loops

Here, the goal is to project the journey of the user in the system from the on-boarding to the end-game. Designers must delineate the system rules and the intended emotions for each stage of the journey (intrinsic motivators are generally preferable).

Besides that, like Werbach and Hunter agree, there should also exist a micro level/engagement cycle providing continuous feedback to the user [28]. The main objective is to design a system that is motivating and fun and that keeps the user in cognitive flow, with its difficulty adjusting to the user and constantly offering new features.

Designers need to consult the list of game elements that resulted from the previous step and apply them in the moments they make more sense. There should not be applied any elements without research.

After writing down the ideas for each stage of the journey, designers could analyze the caused motivators by conducting some Octalysis-like analysis.

Final step: Continuously deploy

After the development of the gamified system and its first deployment, it is imperative to analyze its results recurring to the previously delineated metrics.

It should be perceived what is working and what is not from the previous steps. They all have the possibility of being retaken for better results.

This is a continuous process as the needs, preferences, and technologies are constantly changing.

Figure 11 summarizes the designed set of guidelines in the form of a diagram.

FIGURE 11 - INTEGRATIVE GAMIFICATION DESIGN GUIDELINES SUMMARY

4.3. Guidelines Application

The proposed guidelines were used in the design and development of a gamified Moodle environment, which was made using options provided by Moodle itself and complemented with key features provided by a developed plugin. It was anticipated that since the proposed guidelines are comprehensive, they could be easily consulted for the formation of a gamified educational system, the category the created module belongs.

In this document, every action taken until a final solution was reached is registered. Here, it is explained how those actions fit with each step of the proposed integrative gamification guidelines, and where they can be found:

Study the environment:

This step is essentially dealt in sections 1.2 and 1.3 (Problem and Objectives respectively), where the reasons to apply gamification are introduced. Then, in chapter 2 (Value Analysis), the study of the environment is complemented with an analysis to the value the gamified system can produce and its costs, with the results being organized in a Business Model Canvas.

As for the metrics that were planned to evaluate the system, they can be found in section 7.1 (Test Plan).

Analyze the players:

The analysis to the users of the gamified system, which are considered the players, can be found in section 5.1 (Game Mechanics Selection). There, the characteristics of the targeted user group are

studied in order to select the game mechanics that are most appropriate for that group. The analysis done is based on the Big Five personality traits model and on the Hexad User Types Scale.

Stipulations regarding the concept of ethics are mentioned in subsection 5.4.1 (Requirements).

Select the elements:

This step is also dealt in section 5.1. Multicriteria analysis methods such as the "Analytic Hierarchy Process" (AHP) and the "Technique of Order Preference by Similarity to Ideal Solution" (TOPSIS) are used to decide which are the best game mechanics to apply on the planned gamified system based on how much they fit in the dynamics desired by the targeted users. Only the common game mechanics from subsection 3.1.2 are compared against each other, but after the breakdown is completed, other mechanics that meet the results assembled are presented.

With the goal of keeping the user interface (UI) and user experience (UX) desirable, some requisites are defined in subsection 5.4.1 (Requirements), the UI being explained in section 6.4 (User Interface).

Prepare the loops:

The macro and micro level activity loops along with the targeted user behaviors are all designed in section 5.2 (Activity Loops). In that section, the game elements selected in the previous step are used to plan the journey of the users of the developed gamified system and in the end, an Octalysis analysis is conducted to verify how strong that system is in certain points.

Continuously deploy:

Chapter 7 (Evaluation) and more specifically section 7.2 (Test Results) analyze how well the developed gamified system worked based on the previously defined metrics and user feedback. The results of the evaluation are taken and discussed in chapter 8 (Conclusion), formulating the prospect of any future work to improve what was done.

5. Moodle Plugin Design

This chapter contains the design of the system that was created to test the gamification guidelines projected. This includes the selected game mechanics, defined activity loops, and the architecture of the developed Moodle plugin, which is the main component of the created gamified system.

The first section of this chapter consists in the selection of the game mechanics that are better suited for the target audience of the system, using dynamics. To do that, the targeted users are analyzed and afterwards comparisons are made using multi criteria decision making methods.

The second section is about the micro and macro level loops, and targeted behaviors for users of the gamified Moodle environment.

The third section is about commonly used Moodle concepts and terminologies. It also contains some rules for developing Moodle plugins.

The fourth and last section is about the architecture of the plugin. Functional and non-functional requirements, use cases, and domain model, as well as alternatives, are presented.

5.1. Game Mechanics Selection

Game mechanics should not be inserted into a gamified system without first studying if they are appropriate. One criterion that should be taken in consideration is the type of people that will be using the system, as it was mentioned in most of the frameworks presented in section 3.2.

With that problem in mind, to verify what the preferences of different groups of people in relation to game mechanics in gamified systems are, and to group the similar mechanics in order to more easily studying them, Gustavo F. Tondello et al. inquired multiple people around the world asking questions about their personalities and preferred gameful design elements, among other themes. Later, they wrote an article called “Elements of Gameful Design Emerging from User Preferences” analyzing the results, and concluded that different game mechanics work better with different kinds of people [5].

In this section, a step further to that analysis is taken by using the multicriteria analysis methods AHP and TOPSIS to determine from the common game mechanics mentioned in subsection 3.1.2 (**badges**, **leaderboards**, **points**, **immediate feedback**, **goals**, **progress bars**, **rewards**, and **storylines**) which are the best suited to use when the targeted users are southern European college students. It was decided to analyze the preferences of that specific group of people because the smaller the targeted group, the more reliable the results will be, and because most people that would end up testing the gamified system to be produced alongside this document were southern European college students or at least southern European.

AHP is used to determine the weights of each criteria and TOPSIS to determine the best and worst mechanics on a specific scenario. AHP divides the decision problem into hierarchy levels to facilitate the problem comprehension [40]. The first step when applying AHP is to develop a decision tree (Figure 12).

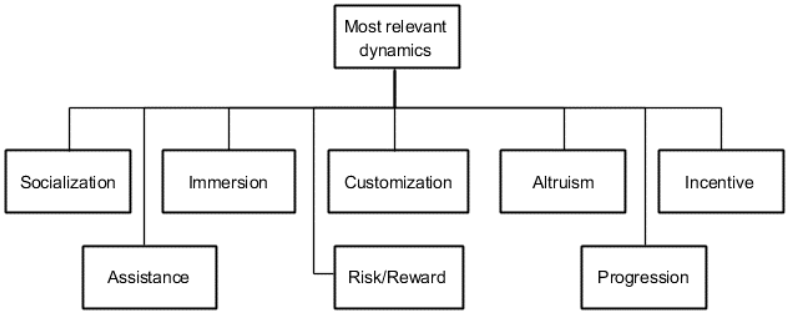

FIGURE 12 - DECISION TREE FOR GAMIFICATION DYNAMICS RELEVANCY

Tondello et al. [5], adopting a principal component analysis, grouped multiple gameful design elements into 8 groups (**socialization**, **assistance**, **immersion**, **risk/reward**, **customization**, **progression**, **altruism**, and **incentive**) and then, using a hierarchical cluster analysis, joined the 8 groups into 3 high-level categories (**internal motivators (IM)**, **external motivators (EM)**, and **social motivators (SM)**). Initially, it was decided to use the mentioned high-level categories as criteria for the decision tree, as they represent user interests when using gamified applications, however, the results were a bit biased and mechanics which were not so popular among the targeted users were overrated while others were undervalued due to their group, so the final decision was to use the 8 groups as criteria. That reduces (but does not eliminate) the risk of having overrated and underrated mechanics and since those groups represent game dynamics to a certain degree, the results will present preferred mechanics in relation with preferred dynamics. Thus, focusing on a concept that is closer to the end user.

The second step is to compare the criteria. To prevent precipitated assumptions and to make sure the comparisons as reliable as possible, the results from the study made by Tondello et al. will be taken in consideration, namely the preferences for members of different groups of the Gamification User Types Hexad Scale and the Big Five personality traits model.

David P. Schmitt et al. in the article "The Geographic Distribution of Big Five Personality Traits" studied and evaluated the prevalence of the Big Five personalities across the world using more than 1000 test subjects, most of them college students [41]. As it was mentioned, the focus is in southern Europeans because of the reasons previously declared and because the Big Five personality traits model was made by westerns and is debatable if it is applicable to other cultures.

According to the study made by Schmitt et al., southern Europeans present higher values in **Openness** (whether one is creative, imaginative, and introspective) and **Agreeableness** (whether one is generous, gentle, and kind) compared to other traits. People who show higher values in Openness tend to have characteristics from **Philanthropists** (altruistic people that like to enrich the lives of others) and **Free Spirts** (people that like to create and explore) of the Hexad User Types Scale, while people who show higher values in Agreeableness tend to have characteristics from Philanthropists and **Socializers** (people that like to create social connections) [42].

	Slight preference	**Moderate preference**
Openness	-	Customization
Agreeableness	-	-
Philanthropists	Immersion, Progression	Altruism
Free Spirits	-	Immersion
Socializers	Assistance	Socialization, Altruism

TABLE 5 - GAMIFICATION ELEMENTS PREFERENCES FOR EACH TYPE OF PEOPLE [5]

From Table 5, it can be perceived that in southern Europeans preferences for gameful design elements there are present two social motivators with moderate preference (altruism and socialization) and one with slight preference (assistance), one individual motivator with moderate preference (immersion) and one with slight preference (progression), and one external motivator with moderate preference (customization). This serves as the basis for the comparison values which use Saaty's fundamental scale. Motivators with moderate preference have strong importance over motivators without any preference (5) and weak importance over motivators with slight preference (3), and motivators with slight preference have weak importance over motivators without any preference (3) (see Table 6).

	Socialization	Assistance	Immersion	Risk/Reward	Customization	Progression	Altruism	Incentive
Socialization	1	3	1	5	1	3	1	5
Assistance	1/3	1	1/3	3	1/3	1	1/3	3
Immersion	1	3	1	5	1	3	1	5
Risk/Reward	1/5	1/3	1/5	1	1/5	1/3	1/5	1
Customization	1	3	1	5	1	3	1	5
Progression	1/3	1	1/3	3	1/3	1	1/3	3
Altruism	1	3	1	5	1	3	1	5
Incentive	1/5	1/3	1/5	1	1/5	1/3	1/5	1
Sum	5,07	14,67	5,07	28,00	5,07	14,67	5,07	28,00

TABLE 6 - CRITERIA COMPARISON MATRIX (A) FOR THE PREFERENCES OF SOUTHERN EUROPEAN STUDENTS [41]

The third step is to normalize the table and calculate the priorities vector, which is the mean of each row. Motivators with moderate preference ended up with a weight of 0.19, motivators with slight preference with 0.08, and motivators with no preference with 0.03 (see Table 7).

	Socialization	Assistance	Immersion	Risk/Reward	Customization	Progression	Altruism	Incentive	**Mean (x)**
Socialization	0,20	0,20	0,20	0,18	0,20	0,20	0,20	0,18	0,19
Assistance	0,07	0,07	0,07	0,11	0,07	0,07	0,07	0,11	0,08
Immersion	0,20	0,20	0,20	0,18	0,20	0,20	0,20	0,18	0,19
Risk/Reward	0,04	0,02	0,04	0,04	0,04	0,02	0,04	0,04	0,03
Customization	0,20	0,20	0,20	0,18	0,20	0,20	0,20	0,18	0,19
Progression	0,07	0,07	0,07	0,11	0,07	0,07	0,07	0,11	0,08
Altruism	0,20	0,20	0,20	0,18	0,20	0,20	0,20	0,18	0,19
Incentive	0,04	0,02	0,04	0,04	0,04	0,02	0,04	0,04	0,03

TABLE 7 - NORMALIZED CRITERIA COMPARISON MATRIX

Finally, it should be calculated the consistency value (RC) of the priorities vector. The value ended up being 0.02 which is less than 0.1 meaning that the weights are consistent:

$$Ax = \lambda_{max}x = \begin{bmatrix} 1.58 \\ 0.62 \\ 1.58 \\ 0.28 \\ 1.58 \\ 0.62 \\ 1.58 \\ 0.28 \end{bmatrix}$$

$$\lambda_{max} = average\left\{\frac{1.58}{0.19}, \frac{0.62}{0.08}, \frac{1.58}{0.19}, \frac{0.28}{0.03}, \frac{1.58}{0.19}, \frac{0.62}{0.08}, \frac{1.58}{0.19}, \frac{0.28}{0.03}\right\} = 8.09$$

$$IC = \frac{\lambda_{max} - n}{n-1} = \frac{8.09-8}{8-1} = 0.01$$

$$RC = \frac{IC}{IR} = \frac{0.01}{0.58} = 0.02$$

TOPSIS analyses the best- and worst-case scenarios using weighted decisions. The best alternative is the one closest to the ideal solution and farthest from the negative ideal solution [43]. The first step is to construct the normalized decision matrix. The values used are based on the correlation of each mechanic to groups belonging to the high-level categories calculated in the exploratory factor analysis from the article written by Tondello et al. (see Table 8) [5].

	Socialization	Assistance	Immersion	Risk/Reward	Customization	Progression	Altruism	Incentive
Badges	1	1	1	1	1	1	1	8
Leaderboards	8	1	1	1	1	1	1	1
Points	1	1	1	4	6	1	1	4
Immediate Feedback	1	1	1	1	1	5	1	4
Goals	1	1	4	5	1	1	1	1
Progress Bars	1	1	1	1	1	6	1	1
Rewards	1	1	1	4	4	1	1	5
Storylines	1	1	5	1	1	1	1	4
$\sum {x_{ij}}^2$	71	8	47	62	58	67	8	140
$\sqrt{\sum {x_{ij}}^2}$	8,43	2,83	6,86	7,87	7,62	8,19	2,83	11,83

TABLE 8 - DECISION MATRIX BASED ON THE EXPLORATORY FACTOR ANALYSIS MADE BY TONDELLO ET AL. [5]

After dividing each column by $\sqrt{\sum {x_{ij}}^2}$, the second step is to calculate the weighted normalized decision matrix. The weights used are the ones calculated using AHP (see Table 9).

	Socialization	Assistance	Immersion	Risk/Reward	Customization	Progression	Altruism	Incentive
Weights	**0,19**	**0,08**	**0,19**	**0,03**	**0,19**	**0,08**	**0,19**	**0,03**
Badges	0,023	0,028	0,028	0,004	0,025	0,010	0,067	0,020
Leaderboards	0,180	0,028	0,028	0,004	0,025	0,010	0,067	0,003
Points	0,023	0,028	0,028	0,015	0,150	0,010	0,067	0,010
Immediate Feedback	0,023	0,028	0,028	0,004	0,025	0,049	0,067	0,010
Goals	0,023	0,028	0,111	0,019	0,025	0,010	0,067	0,003
Progress Bars	0,023	0,028	0,028	0,004	0,025	0,059	0,067	0,003
Rewards	0,023	0,028	0,028	0,015	0,100	0,010	0,067	0,013
Storylines	0,023	0,028	0,139	0,004	0,025	0,010	0,067	0,010

TABLE 9 - WEIGHTED NORMALIZED DECISION MATRIX

The next step is to calculate the ideal and negative ideal solution:

$$A^* = \{0.180, 0.028, 0.139, 0.019, 0.150, 0.059, 0.067, 0.020\}$$

$$A' = \{0.023, 0.028, 0.028, 0.004, 0.025, 0.010, 0.067, 0.003\}$$

Then, the separation from the ideal and negative ideal solutions:

$$S_i^* = \sqrt{\sum(v_j^* - v_{ij})^2} = [0.235 \quad 0.175 \quad 0.199 \quad 0.231 \quad 0.210 \quad 0.231 \quad 0.205 \quad 0.208]$$

$$S_i' = \sqrt{\sum(v_j' - v_{ij})^2} = [0.018 \quad 0.158 \quad 0.125 \quad 0.040 \quad 0.085 \quad 0.049 \quad 0.076 \quad 0.111]$$

And finally, calculate the relative closeness to the ideal solution:

$$C_i^* = \frac{S'_i}{S_i^* + S'_i} = [0.07 \quad 0.47 \quad 0.39 \quad 0.15 \quad 0.29 \quad 0.17 \quad 0.27 \quad 0.35]$$

In conclusion, the best gamification design element for southern European college students according to the analysis done is **leaderboards**, with a relative closeness to the ideal solution of 0.47. **Points**, **storylines**, **goals**, and **rewards** also appear to be comparatively good, while badges seem to be less recommended.

It is important to note that "leaderboards" is the only representant of social motivators that was analyzed, others could be thought when designing a gamified system, as social motivators seem to be advised by the results obtained. Also, people with high levels of Openness (the case of the group investigated) prefer customization mechanics, which were not represented enough in this analysis. These two factors were taken in consideration when designing the gamified system.

Finally, since the targeted group for the prototype developed alongside this document appears to have more characteristics from **philanthropists**, **free spirits**, and **socializers**, logic seems to dictate that the most relevant aesthetics are **fellowship** and **discovery**, being important to develop a system that provides **interaction** between users and **problem solving**.

With that held, a list of usable game elements to be applied in the planned gamified system can be delineated. Those are:

- **Individual leaderboards** (adds socialization);
- **Class leaderboards** (adds socialization and fellowship);
- **Points** (adds customization);
- **Weekly updates** (adds socialization and discovery);
- **Completed tasks** (adds goals and problem solving);
- **Unlockable content** (adds goals);
- **Quizzes with immediate feedback** (adds problem solving);
- **Reputation points** (adds socialization, fellowship, and interaction);
- **Profile edition** (adds customization).

Other relevant elements such as storylines and rewards were discarded for being too hard to implement in the planned prototype.

5.2. Activity Loops

Defining activity loops for the system is an important step to develop a decent gamified application, as "loops" is a concept that is mentioned frequently by gamification frameworks [38].

The prime objective is to create an environment capable of keeping users in a state of **flow**, being able to adjust its difficulty to their level of mastery. To do that, it is imperative to have the actions users should take well planned, along with the goals of taking such actions.

Since the projected gamified system should be used in an educational setting, pedagogical subjects must be tackled, as to create a good gamified Moodle environment for students, just adding a single plugin is not enough, the surrounding system must also be adapted.

Here, the micro and macro level loops for the developed Moodle plugin and surrounding system are described, along with the targeted user behavior, more specifically, the targeted student behavior.

5.2.1. Micro level

Students should start each week by reading the documents submitted by the teacher, which can be PDFs, URLs, or both. Then, students should answer a quiz to see if understood what they read. Students can then use the results of the quiz to prepare questions for the next class.

The type and order of classes for a specific course in a week is a decision of the schooling institution, but a good approach would be to have theorical classes first and then practical classes. After them, another more difficult quiz could be provided to see what students have failed to learn or understand properly.

Both quizzes should be short (e.g. 5-10 questions) in order to not bore students, and the second quiz should give a bit more points than the first.

Also, once a week, preferably at the end, students can recommend a colleague to receive some extra points. The purpose of this feature is to have an extra social game element, and to help students that are good but are not evidenced enough become more motivated. There is a risk of this feature becoming a popularity contest, so it needs to be analyzed the most.

Figure 13 symbolizes the micro level loops.

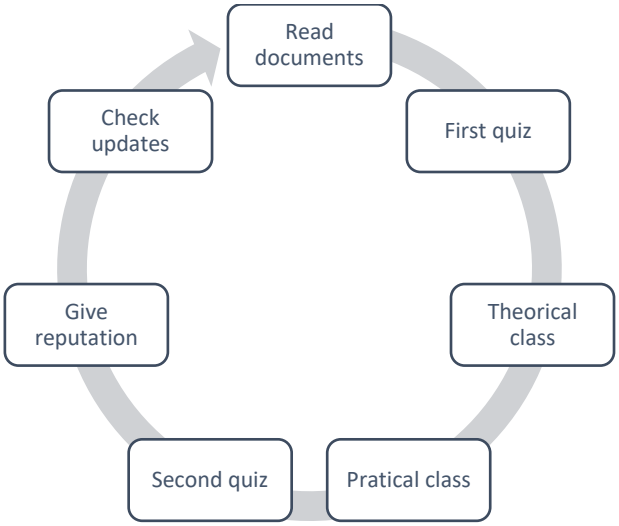

FIGURE 13 - MICRO LEVEL LOOPS

5.2.2. Macro level

The macro level is basically just repeating the micro level each week with some practical projects and exams thrown in between.

The number of projects and exams per semester is on the criteria of the schooling institution, but it would be suggested to have 2 or 3 mid-term projects or exams, and one final project or exam.

After each mid-term project/exam, there should be an announcement in the main Moodle page of the course with the current standings of the leaderboards (without the last places to not discourage students) and the recap of the previous weeks showing information like most improved

students and classes. The purpose of this announcement is to incite competition and to show students that the gamification elements from the course have some meaning.

At the end of the semester, the best students and members of the best classes can be rewarded with titles that can be presented on their Moodle profiles for bragging rights.

Because many students miss the first weeks, scores should only start counting when the registrations are concluded.

Figure 14 symbolizes the macro level loops.

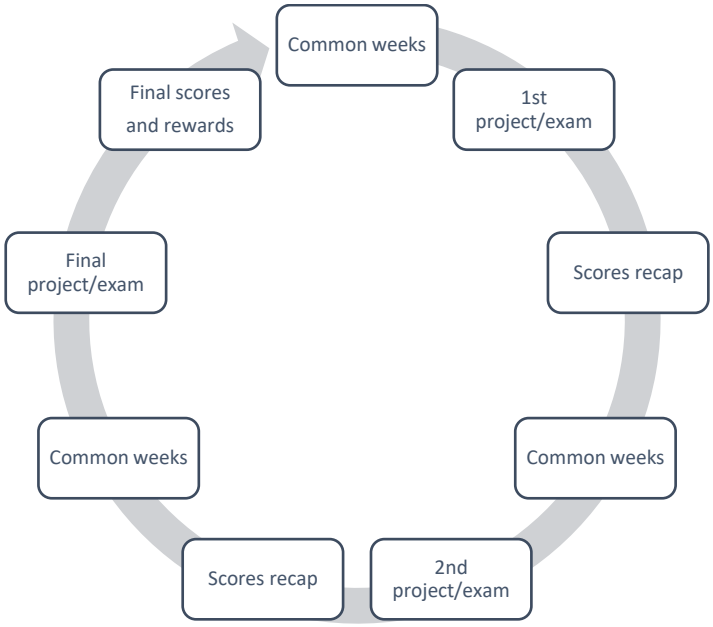

FIGURE 14 - MACRO LEVEL LOOPS

5.2.3. Targeted behavior

The targeted behavior for students using the gamified Moodle page is to always study the provided documents before classes to be better prepared to comprehend the matter and to generate more doubts that can later be asked to teachers. And after the classes, study a bit more and assimilate the matter.

It is also expected that students communicate more between each other, even using Moodle tools such as the chat for that, and to further explore the Moodle page of the course in order to discover more gamified elements and improve their personal profiles.

It is anticipated that the gamification elements present on the Moodle page of the course can encourage these behaviors.

It should be made clear that the gamification elements do not influence the final grade, unless decided otherwise, but even though, these elements should be portrayed seriously so that students do not take them as a joke.

5.2.4. Octalysis analysis

Next, is the Octalysis analysis for the gamified system (Figure 15).

The different stages do not have a great impact on this analysis because almost every feature of the system remains the same from the discovery stage to the end-game. This is acceptable because each course usually takes six months at most and as such, there is no need to keep users motivated for longer periods of time.

FIGURE 15 - OCTALYSIS ANALYSIS FOR THE PROJECTED MOODLE PLUGIN

The octagon is mostly balanced with slight tendency for the right brain core drives, mainly because of the strong social influence. It also as a small bias towards black hat core drives because the empowerment is low. This is a facet that could be improved in future iterations.

Each drive of the octagon is represented in the following ways:

- The feature to give reputation points to other students, and the class leaderboards give **meaning** to the system, as students may feel they are also helping their colleagues;
- Tasks and quizzes give a sense of **accomplishment** to students, especially if they visually show the progress made;
- **Empowerment** of creativity is only represented by the user profile with its features being few and poor. Users can only customize and express their creativity in this section;
- **Ownership** is only represented by points, making it little advanced;
- **Social influence** is the strongest drive, being represented by the leaderboards and the feature to give reputation points. These features give both companionship and competition;
- Unlockable content such as quizzes give students a feeling of impatience (**scarcity**) to access those options;
- Curiosity may be caused by the students desire to check the quizzes and see what result they can get, and **unpredictability** can be caused by the weekly updates feature, as students will not know who is going to be referenced;
- And finally, the fear of getting poor results in the leaderboards and quizzes can trigger the **avoidance** drive in students.

5.3. Moodle Concepts

Moodle is a Learning Management System (LMS) aiming to provide virtual educational tools to teachers and students. It is also an open source web application written in PHP that encourages software developers to contribute to the system by patching core functionalities or creating add-ons.

Moodle, being a modular system, is structured as an application core surrounded by various plugins, making it highly extensible and customizable. To allow the communication of the plugins with the core application, numerous APIs are provided [44].

The Moodle core provides a set of key concepts that plugins need to work with, such as:

- **Courses**: Sequences of activities and resources grouped into sections;
- **Users**: Anyone using the Moodle system. They can have roles with different functionalities, such as “student” or “teacher”;
- **Course enrolment**: Functionality that gives users with a given role the possibility to participate in courses;
- **Groups**: Collections of users that can be associated to courses or activities. They can function as classes.

On the other hand, plugins can be of multiple types. The most common ones according to Moodle are the following:

- **Activities and resources**: The most basic individual components that make up a course. Include forums, wikis, quizzes, and assignments. Resources can be, for example, pages or links;
- **Blocks**: Small bits of functionalities that can be added to pages to provide different ways of viewing stored data;
- **Themes**: Change the visual style of the Moodle site;
- **Language packs**: Localize Moodle components to other languages;
- **Course formats**: Control how the course structure is presented to users;
- **Authentication plugins**: Control how users log in to the system;
- **Enrolment plugins**: Control which users are enrolled in which courses;
- **Repository plugins**: Give ways for users to upload their content into Moodle.

In short, the components of Moodle are organized like in Figure 16.

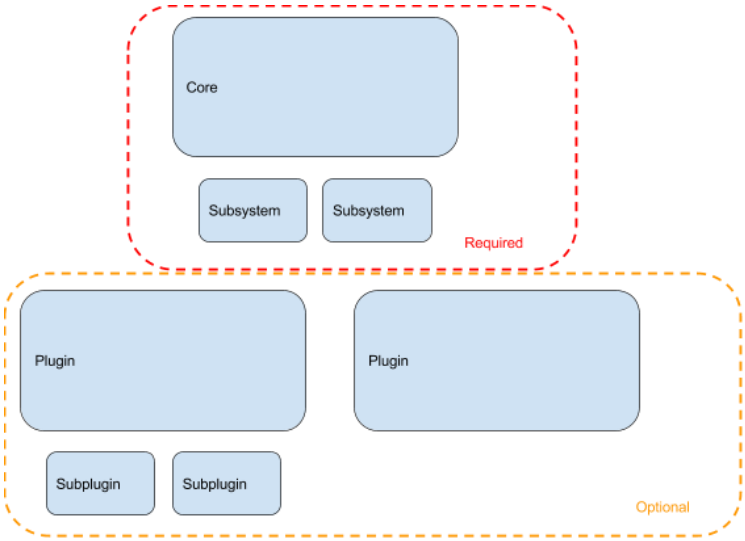

FIGURE 16 - MOODLE COMPONENTS ORGANIZATION [45]

The core contains the base functionalities trusted by all the other components, and subsystems are just parts of the core that are logically grouped according to their relations. Plugins are optional components that extend the functionalities of Moodle, while sub-plugins extend the functionalities of plugins.

Moodle plugins are basically folders of PHP, CSS, and JavaScript scripts. The core communicates with the plugins using specific entry points defined in their files.

The plugin design recommended by Moodle is composed of the following elements (see Figure 17):

- The **Low Level API** accesses the database tables without needing to check permissions.
- The **Component API** defines the functionalities of the plugin. It needs to preform permission checks and can be called by other components.
- The **External API** is a single class that wraps the functions of the Component API, exposing them and allowing their usage by other applications and plugins.
- The **Webservice API** is a file listing the functions of the External API, allowing them to be called from AJAX or webservice clients [45].

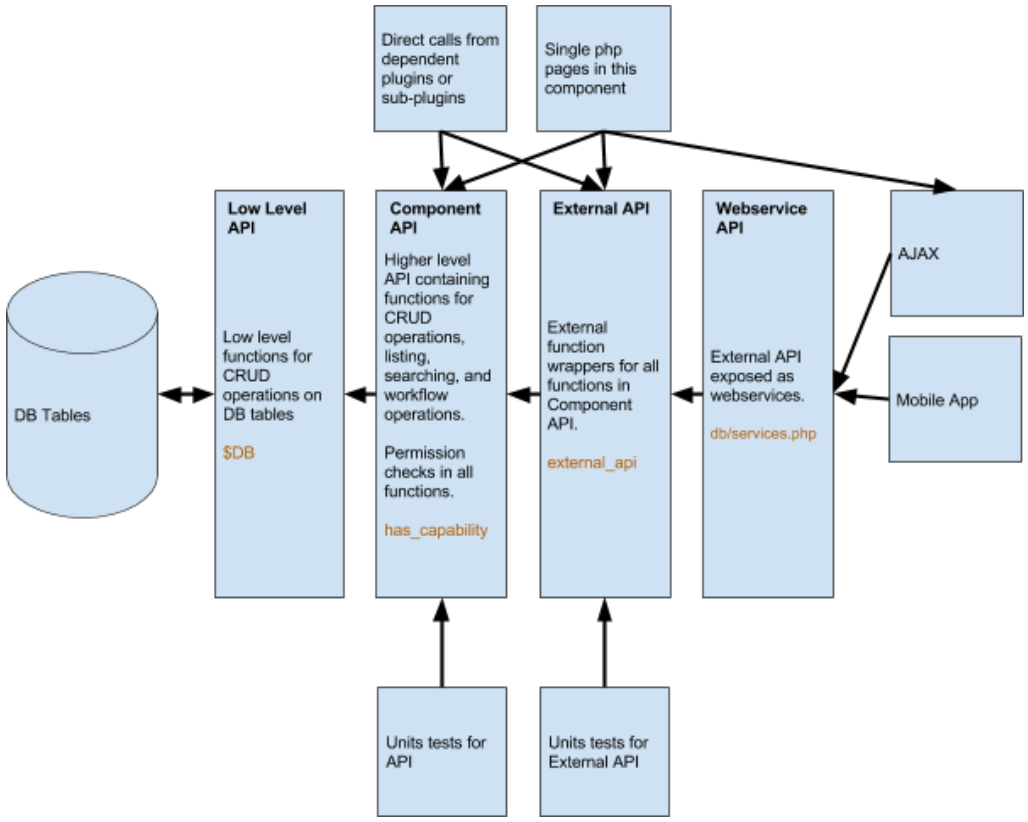

FIGURE 17 - IDEAL MOODLE PLUGIN DESIGN [45]

It was decided that the plugin developed would be of type **block** as it would be mainly composed by a set of game elements that can be positioned into various places, and that are basically just information being presented in a more attractive way.

5.4. Moodle Plugin Architecture

With the comparisons that were made in previous chapters, one can assume which mechanics are best suited for the target group, and which emotions should the plugin aim to provoke. For now, the design was done based on the conclusions from section 5.1 and the loops defined in section 5.2. However, to make sure gamification is well applied, it is not enough to simply apply these elements even if they are based on an analysis. The full set of guidelines must be followed in order to reduce the risk of gamification failing. This includes testing and redesigning elements, which should be done at a later stage.

The projected gamified system must offer multiple gamification elements. It should be composed of features provided by the base application of Moodle, along with functionalities added via the developed plugin.

That plugin delivers various gamification elements that were considered best fitted for the environment in study, being leaderboards the most important. The fact that it contains many specific gamification features gives it an advantage over other plugins that do not provide the required functionalities.

The developed plugin was planned to be of the type "**block**" because a plugin of this type should provide all the projected features. If it was shown that a block was too limited to cover the requirements, the plugin developed could be redesigned to be of the type "**activity**" instead. Also, if after a more careful analysis, an existing plugin would be considered worthy of being used to test

the gamification guidelines designed, it could be easily added to the system with the goal of covering missing or mediocre functionalities. Assuming it would not cause incompatibilities.

However, none of those scenarios were verified, and the plugin developed was enough to test the designed gamified system as it was initially projected.

5.4.1. Requirements

Several functional and non-functional requirements for the developed plugin were projected. They can be grouped using the FURPS+ framework [46] for classification of requirements in the following categories:

- **Functionality**: The plugin must cover the use cases to be described on subsection 5.4.2. Besides that, it must not hold any kind of security risks, as it will deal with personal user data;
- **Usability**: The plugin must offer a good UX. Some of the basics are not showing to much or irrelevant information on the screen, and using common affordances;
- **Reliability**: The plugin must return accurate results (e.g. scores and positions) and never freeze or crash, as those situations can demotivate users. If it does crash, it must show informative messages to the user;
- **Performance**: The plugin must have a good performance and a quick flux to prevent user boredom. This means it should not take much more than one second to respond to any user interaction;
- **Support**: The plugin must be modular, testable, and well documented.

Plus, the plugin must be written in PHP and have its data persisted in a MariaDB database to fit the requirements specified by Moodle. Moodle also has a set of coding rules that must be followed in order to add the plugin to their official directory.

It is also important that the gamified environment is kept ethical. That can be achieved by not dealing with any controversial or sensible theme, and by having special caution to respect every user and never expose them.

5.4.2. Use cases

Figure 18 is a diagram with the main use cases of the projected gamified system. Some of them were already provided by Moodle and only needed to suffer minor changes, while others needed to be created from scratch and added to the system via the developed plugin (signaled with an “*”). Users can either be teachers or students, but the gamification elements implemented were only targeted at students.

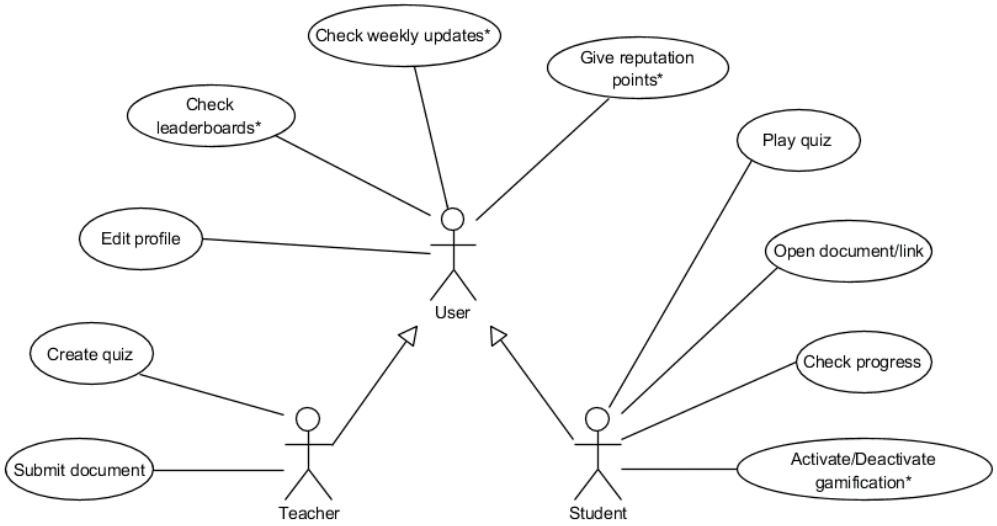

FIGURE 18 - USE CASE DIAGRAM FOR THE DEVELOPED MOODLE PLUGIN

Table 10 synthetizes the use cases.

Use case	Description
Edit profile	Users can edit personal info on their profiles (i.e. photo, description, social networks, etc.). Moodle already offers this feature by default, but some other options like adding unlockable titles to the profile or changing the background could be implemented.
Check leaderboards*	Users can check the top students, top classes, and top students of the week, for each course. Students can also see their rank and the users who are closer to them, but not the ones who are at the bottom in order to prevent discouragement of bottom tier students. Scores are calculated according to performance on quizzes, documents read, reputation points, and grades.
Check weekly updates*	Users can view weekly updated information about the top students, classes, and most improved students.
Give reputation points*	Users can give a few reputation points per week to other students in order to improve their scores.
Create quiz	Teachers can create small quizzes for the students. They should always show the correct answers after they are played, since immediate feedback is an important gamification element in this context. Moodle already provides quizzes by default, but the plugin should offer a way to assign a value to each played quiz.
Play quiz	Students can play the quizzes created by the teachers to learn and improve their scores.
Submit document	Teachers can submit documents to the platform. Moodle already offers this option by default, but for this plugin each document should have a predefined value that is used to improve the scores of the students.

Use case	Description
Open document/link	Students can open documents and links in the platform, improving their personal scores.
Check progress	Students can check their progress for each course. The progress can be based on quizzes played and documents consulted. This also adds goals to the plugin.
Activate/Deactivate gamification*	Students can activate/deactivate the gamification options at will. Students who have gamification disabled do not appear on leaderboards or weekly updates, do not have their results considered for the scores of their classes, and cannot give or receive reputation points, but can still play the quizzes and check their progress. Not everybody will like the gamification features offered, so they will not be imposed.

TABLE 10 - USE CASES DESCRIPTION

5.4.3. Domain model

Figure 19 presents the domain model of the developed plugin.

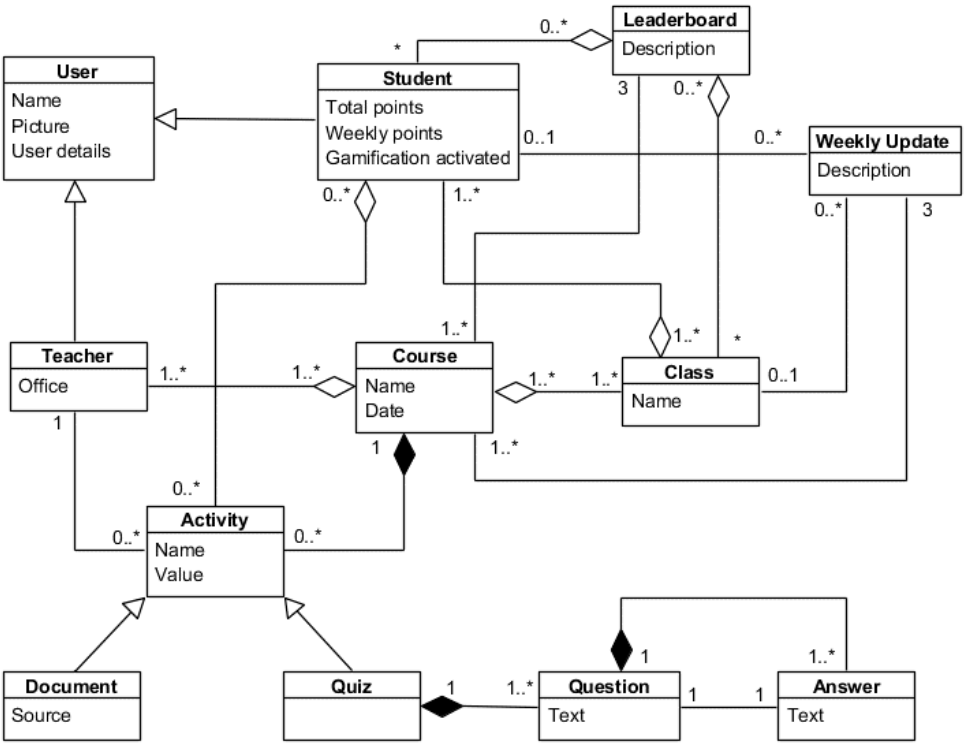

FIGURE 19 - DOMAIN MODEL OF THE DEVELOPED PLUGIN

A **User** can be either a **Student** or a **Teacher** and they are represented by a name, a picture, and other more specific details. Teachers, which also have an office, need to be enrolled in at least one **Course** where they can submit **Activities**. An Activity can be a **Document** or a **Quiz**, and they have specific values that are added to the points of Students who complete them. A Quiz is composed of at least one **Question**, and Questions always have a right **Answer** and one or various wrong Answers.

Courses have a minimum of one Teacher and a collection of **Classes**, which are groups of Students. Although Moodle needs Students to be directly enrolled in Courses, in the gamified environment designed, Students will always be part of at least one Class.

Courses have three **Leaderboards** ("General Leaderboard", "Weekly Leaderboard", and "Class Leaderboard") and three **Weekly Updates** ("Best of the week", "Most improved", and "Class of the week"). Each Weekly Update is associated to either a Student or a Class, and each Leaderboard contains either a collection of Students or a collection of Classes.

The positions of the Students in the Leaderboards, and their presence in the Weekly Updates are defined using their total points and weekly points, while the scores for the Classes are calculated by adding the points of its Students that have gamification activated. If Students deactivate gamification, they will also not be part of any Leaderboard nor Weekly Update, but they will still be able to complete every Activity, and as such, Students have a list of completed Activities.

6. Moodle Plugin Solution

This chapter is focused on the development of the purposed Moodle plugin and its surrounding environment, which was used to test the gamification elements resulting from the analyses done on previous chapters.

It contains sections that cover the setup of the Moodle environment (including the creation of courses, users, and groups), the most important architectural components of the plugin (such as its classes, APIs used, and database), the sequence of events that regularly occur when the plugin is used, the analysis of the designed user interface, and an overview of the non-functional requirements tackled.

While the goal was to follow what was stated in chapter 5, the ideal Moodle plugin design was mainly cast off, as it would consume to much development time and it was not necessary for the plugin prototype. However, it should be applied in future versions.

6.1. Setup

To function, Moodle requires a PHP-capable web server, a database, and a file store for uploaded and generated files. Moodle can install itself once its code has been copied to the web server and a blank database is created.

To develop the Moodle plugin locally, without needing access to the internet or a live server, the web server solution stack **XAMPP** was used. XAMPP provides easy local access to an Apache web server to host the website, a MariaDB database (one of the databases supported by Moodle), and a PHP interpreter [47].

The first step to have a functional Moodle webpage was to download and install the software from their official site. The web server and database required were both provided by XAMPP (v3.2.2). During the installation, an administrator was created to control the whole Moodle instance, for example, personalizing the web page, installing plugins, and creating users and courses. The Moodle version installed was 3.6.2+ (Build: 20190208).

In order to have Moodle work on the computer, the file "**config.php**" in the root folder of the installation needed to be configured. $CFG->dbtype was set as 'mariadb', and for testing purposes $CFG->dbhost was set as 'localhost' and $CFG->wwwroot as 'http://localhost/moodle'. A folder was also specified for $CFG->dataroot. This folder contains cache and uploaded files and should be placed outside of the main Moodle package.

After everything was properly set up, 4 courses, 20 students, and 5 groups (to function as classes) were created. The students were assigned in groups of 4 to each class and enrolled in 2 of the 4 courses. The goal was to have 10 students in each course.

The students created have usernames made of a color and an animal. The purpose was to keep anonymity but at the same time create a feel of account ownership. Something mere numbers or letters could possibly not achieve. This was all done on the "Site administration" menu.

After that, while in "edit mode", the contents of the courses were defined. Two of the courses ended up with no gamification elements, just a link to a learning resource and another to a document with questions about that resource. The other two courses also ended up with a link for a learning resource, but instead of another one to a document with questions, they got a quiz providing immediate feedback, which can only be accessed once the students open the corresponding

resource. These latter two courses also had enabled the block “Course completion status”, which is a plugin that displays the completed activities of the student showing their progress, and the block with gamification elements created specifically for this experiment (named “**Gamification Banner**”).

Both courses were divided by weeks and users can edit their profiles with parameters like name, e-mail, website, and picture. Customizing with backgrounds and unlockable titles ended up not being available for the system developed.

Figure 20 shows the home page of a non-gamified course created and Figure 21 of a gamified course.

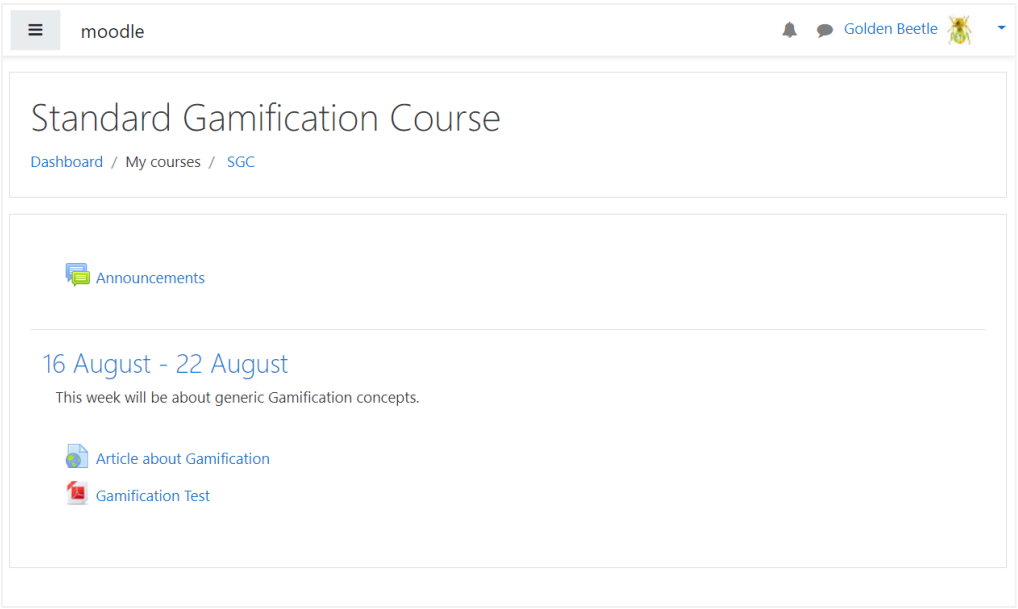

FIGURE 20 - NON-GAMIFIED COURSE HOME PAGE

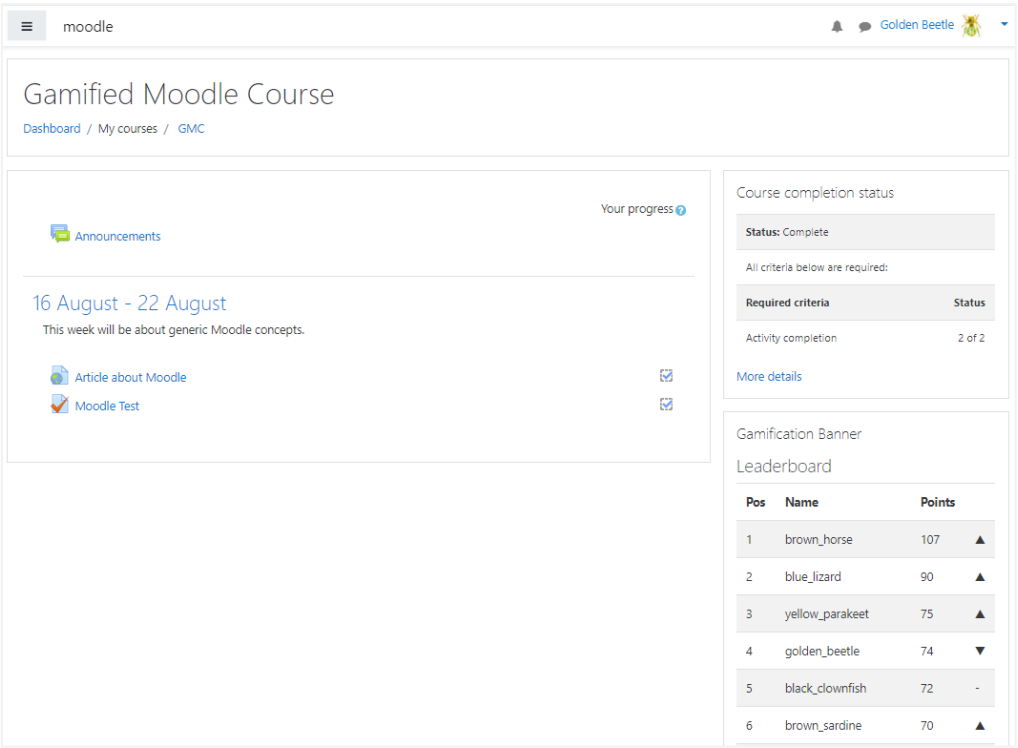

FIGURE 21 - GAMIFIED COURSE HOME PAGE

The rules for scoring points for the Gamification Banner block were defined as the following:

Grades obtained in quizzes give the same amount of points multiplied by **2** (for example, a student that scores 20 on a quiz receives 40 points) and completing an activity, such as opening a resource, gives **10** points. If a user gives reputation to a student, the receiving student also gets **10** points.

It was decided that these rules were to be explained in the "Announcements" link, located at the top of the page. Rules is one of the most meaningful game design items [38], so they should be well defined and explained to users.

The themes decided for the courses were "Gamification" and "Moodle", so the final result, was the creation of a "Gamified Gamification Course" (GMC), a "Standard Gamification Course" (SGC), a "Gamified Moodle Course" (GMC), and a "Standard Moodle Course" (SMC).

Students assigned to one gamified course will be competing not only with students of the same course, but also with students of the other gamified course. If this plugin was to be applied in a real context, this should not happen, as some courses may be easier than others. This behavior should be reviewed in future versions.

6.2. Architectural Components

The developed plugin was made of various components, such as classes, methods, APIs, and database entities. In this section, they are described.

6.2.1. Classes and methods

The plugin created is a block named "Gamification Banner", so its source code is located in the package "moodle/blocks/gamificationbanner". Its most relevant files are:

- **block_gamificationbanner.php**, which holds the class definition and manages and renders the plugin. It extends the Moodle class "block_list", meaning that this block will display different kinds of content to the user as a list [48]. This class has some essential methods such as:
    - **init**: The first method that is called. Used to set the title of the block and other actions that should be done as early as possible;
    - **specialization**: Called immediately after the framework loads the instance data. Used for example to set data that the user configured by editing the block;
    - **get_content**: Gets the content that should be rendered. In this method everything that will appear to the user has to be defined and set to the variable "content";
    - **instance_config_save**: Called immediately after the user edits the block. Used to update its content;
    - **applicable_formats**: Decides where the block should appear. Examples of places include site index and course view;
    - **instance_delete**: Called after the block is deleted. Can be used to clean the database records of the block instance.
    - **instance_allow_multiple:** Returns a Boolean deciding if it is possible to have multiple instances of the block on the same page;
    - **has_config:** Returns a Boolean deciding if the block has configuration options that change all the instances of the block;

    - **hide_header:** Returns a Boolean deciding if the block should be presented with a header.
- **db/access.php**, which holds new capabilities created by the block. Capabilities are defined by arrays and decide what features different types of users can do in the block (i.e.: adding instances, viewing pages, or managing pages).
- **version.php**, which holds information about the plugin version, its minimum accepted Moodle version, and other advanced parameters. Changing the plugin version forces Moodle to ask to update it.
- **settings.php**, which holds the global settings of the block. Global settings are applicable to all instances of the block. They can be accessed in the administration options.
- **edit_form.php**, which contains a class extending "block_edit_form". This class contains the method "specific_definition" where options to edit each instance of the block are added to the variable "mform". These options are accessible when the user is in "edit mode".
- **view.php**, which has the job of opening a page displaying extra information about the gamification banner along with some settings accessible to students, as they do not have access to "edit mode". It contains the logic to assimilate the data sent to the displayed page and to deal with possible responses.
- **gamificationbanner_seemore.php**, which is a class containing the definition of the page displayed by view.php. It presents all the different leaderboards while the banner on the main page of the course only shows one at a time, and contains the options to give reputation points to other students, to change the leaderboard that should be presented on the banner, and to enable/disable the block. Since this class contains various form elements, it extends the class "moodleform".
- **classes/task/update_db.php**, which is class extending "scheduled_task" that contains a script executed weekly (the interval is defined in **db/tasks.php** and follows the cron syntax from Unix) whose purpose is to update the database. To make scheduled tasks work, it is necessary to run the cron scripts located outside the package of the block, in "admin/cli/cron.php".
- **lib.php**, which encompasses constants and methods that are used by all the other files.

In a sub package, there is also a file with all the strings used by the banner that are presented to users. The purpose of this file is to translate the plugin to other languages.

This plugin is course independent, which means each course has their own instance of the plugin with their own data. Figure 22 contains the most important files of the block in their respective packages.

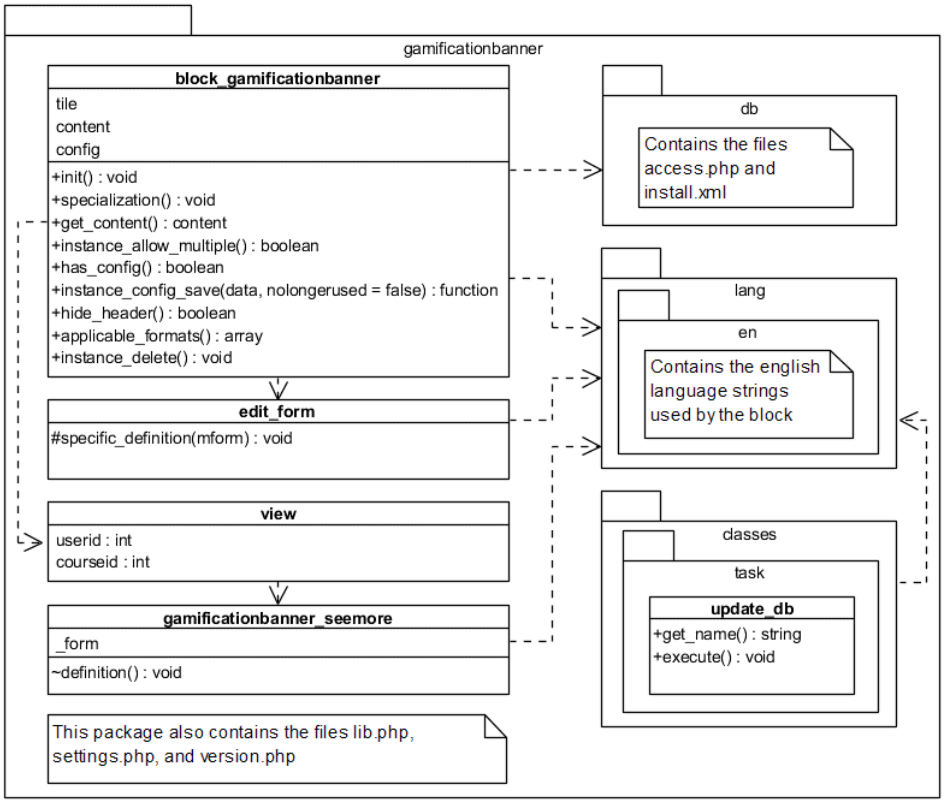

FIGURE 22 - PACKAGE DIAGRAM OF THE GAMIFICATION BANNER BLOCK

6.2.2. Core APIs used

The Moodle core contains numerous APIs that provide methods to use when developing plugins [49]. In the development of the Gamification Banner block, some of those APIs where essential. Those were:

- **Access API:** Used to define the capabilities of each user type. For instance, to define that only students can be given points, and not teachers;
- **Data manipulation API:** Used to read and write on the database;
- **Form API:** Used to create forms. The "See more" webpage where the user can define options of the block and give reputation points to other students is a form;
- **Page API:** Used to set up the webpages created and configure how they would be displayed;
- **Output API:** Used to render the HTML of the webpages;
- **String API:** Used to localize text strings used in the user interface;
- **Upgrade API:** Used to make the plugin upgrade and install itself, by keeping track of its version on the version.php file;
- **Moodlelib API:** Used to access general purpose functions and constants, such as configs, user preferences, time, login, and others.

Figure 23 is a component diagram illustrating the Gamification Banner block and all the core components it accesses.

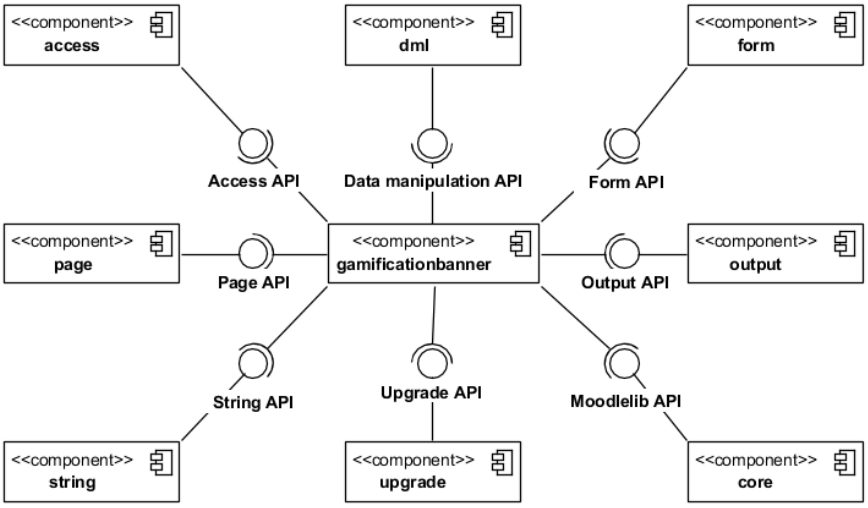

FIGURE 23 - COMPONENT DIAGRAM SHOWING THE DIFFERENT APIS ACCESSED BY THE BLOCK

6.2.3. Database

To hold user information related to the Gamification Banner block, a database table (mdl_block_gamificationbanner) was created using the XMLDB editor, a tool provided by Moodle to make the xml files that specify how the database tables should be set.

It was decided that all info will be in a single table because of simplicity and time constraints. Nevertheless, one table is enough to make the plugin function properly.

This table contains the current points of the users (points), points made in the previous week whose purpose is to calculate weekly scores (last_points), leaderboard positions of the previous week to check if the users are improving or not (last_position), points that have been gifted by other users (rep_received), and information indicating if the users have already given reputation points this week or not (rep_given), which leaderboard they want to have displayed in their main page for the course (display_board), and if they want the Gamification Banner to be enabled or not (active). If not enabled, not only will the user not be able to see leaderboards and weekly updates, they will also not appear on the Gamification Banner blocks of other users.

last_position, last_points, and rep_given are updated weekly by update_db.php. Current user leaderboard position is not needed, because it is easily calculated by sorting table rows by points.

The table also contains foreign keys to mdl_user, which contains all the users, and mdl_groups, which contains all the groups. Groups, which can function as classes, are associated to users by an intermediary table (mdl_groups_members), as they have a many-to-many relationship. This two tables hold many columns but, the ones containing information used by the Gamification Banner block are “username” from mdl_user, and “name” from mdl_groups.

mdl_block_gamificationbanner contains many users, but a user can only be in one of its rows. Groups, however, can be in many rows.

Figure 24 is an entity relationship diagram (ERD) synthetizing the relationships of some of the most relevant tables and columns used by the developed block.

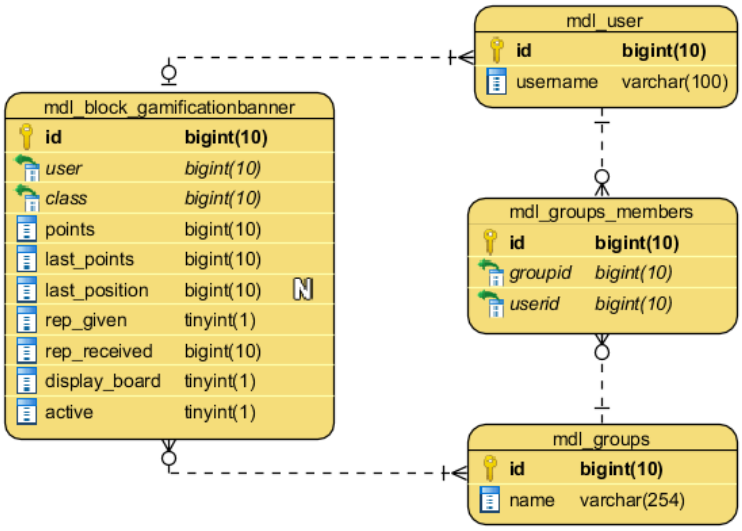

FIGURE 24 - ERD WITH THE MOST RELEVANT TABLES AND COLUMNS USED BY THE BLOCK

The mdl_block_gamificationbanner table had a row inserted manually, so that the first user testing the system already had a rival competing against them.

6.3. Processes Sequence

When a user opens a course with the Gamification Banner block, the init method of that block is triggered, immediately followed by the specialization method. The init method loads all the data from the mdl_block_gamificationbanner table, which includes not only data of the current user, but of every user who has seen the block. If the current user was not in the database, they will be inserted, otherwise, their database record will be updated with their current, recalculated points. Info from other users is used to build the leaderboards and weekly updates. The specialization method then sets configured block settings.

Next, the get_content method is prompted to draw the content of the block (leaderboard, weekly updates, and the “See more” button on the footer).

When the user clicks on the “See more” button, a new form (gamificationbanner_seemore) is instantiated and displayed as a webpage. In that page, the user can give reputation points to other students (if they have not yet given this week), check all the leaderboards (individual, weekly, and class leaderboard), and select options such as the leaderboard to present on the main page of the course, and if the block is enabled or disabled for the current user.

By pressing any of the submit buttons on that form, Moodle will get the data that was selected in the form elements as JSON, and using that data, the database is updated.

If the “Give Rep” button was pressed, the selected student will receive points and the current user will not be able to use that feature anymore during the running week. If the “Save changes” button is pressed, the settings the user selected will be applied.

In the end, the user is redirected to the main page of the course.

Figure 25 is a sequence diagram depicting a possible user interaction with the Gamification Banner block, the “Activate/Deactivate gamification” use case.

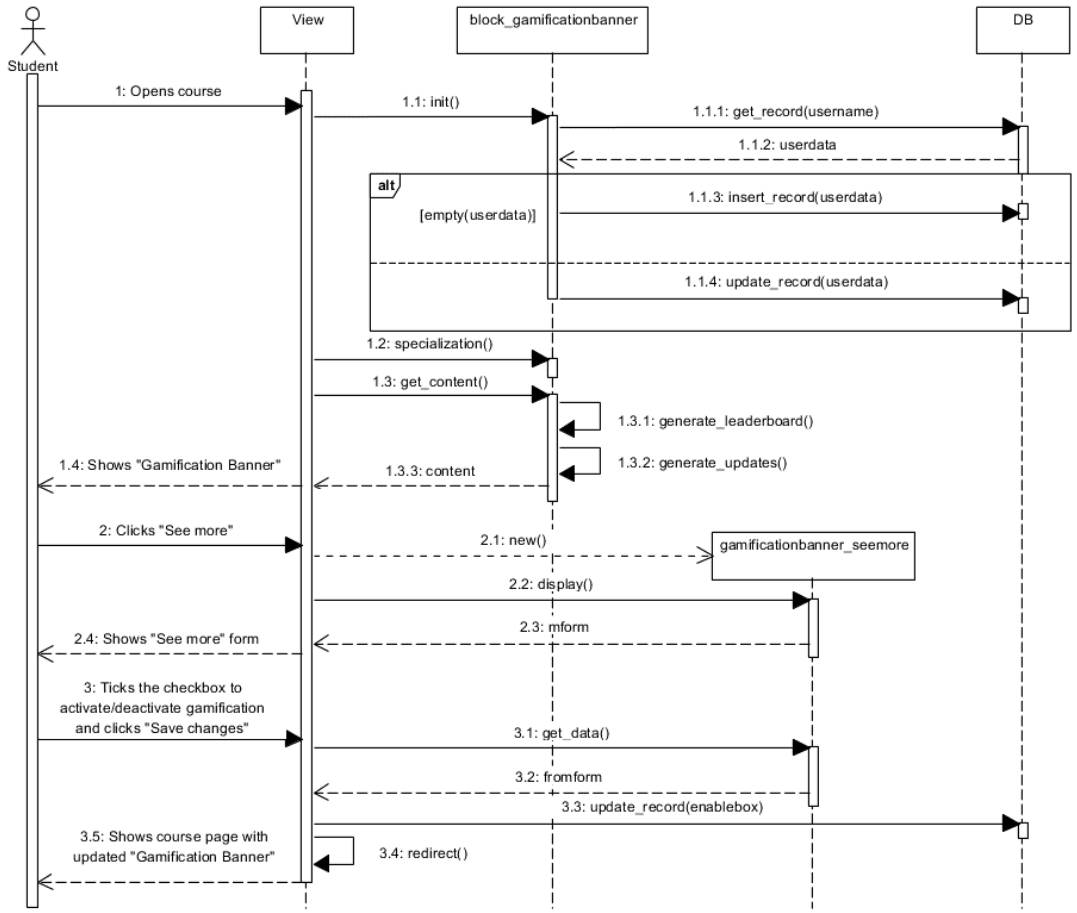

FIGURE 25 - SEQUENCE DIAGRAM FOR THE "ACTIVATE/DEACTIVATE GAMIFICATION" USE CASE

6.4. User Interface

The Gamification Banner block contains 2 sections: "Leaderboard" and "Weekly Updates".

The leaderboard displayed on the block can be for the general individual scores (points students scored during the semester), weekly individual scores (points students scored during the week), or total class scores (points classes scored during the semester). In a future version, more types of leaderboards, such as weekly class scores could be added. The leaderboards only show the top 25% students and 50% classes (35% and 100% respectively in the testing version) along with the nearest students to the user, and classes to their class. Individual leaderboards contain the user position, username, user points, and an arrow indicating if the user for each row is improving or not. The class leaderboard contains the class position, name, and class points (which is a sum of all points of the students in that class).

In the "Weekly Updates" section, it shows the student and class who obtained more points in the current week (Student of the week and Class of the week respectively), and the student who climbed more places in the leaderboard (Most improved). It also summarizes the performance of the user, either praising them or encouraging them to improve, while giving some hints on how to do so.

At the bottom of the block, in its footer, there is a "See More" link.

The idea of having everything on a single instance of the block instead of multiple instances was on purpose. The goal is to have all the gamification information related to scores condensed in a single reliable place.

A screenshot of the block can be seen in Figure 26.

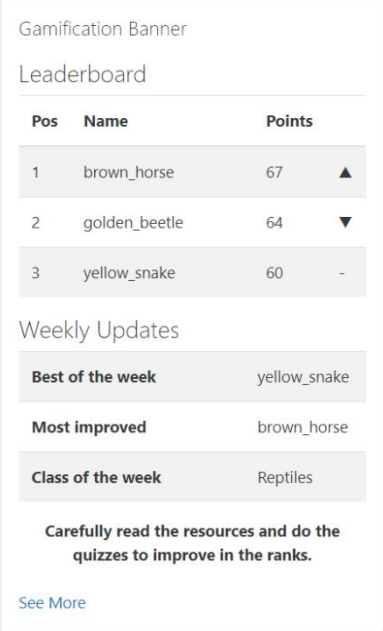

FIGURE 26 - GAMIFICATION BANNER BLOCK SCREENSHOT

When “See More” is clicked, a new webpage with a form is opened. This page is divided in 3 sections. “Give Reputation”, “Leaderboards”, and “Enable/Disable Gamification Banner”.

In the “Give Reputation” section, users can give reputation points to other students by selecting the username of the student they want to gift in an autocomplete combo box and pressing the “Give Rep” button. If the user had already given reputation points in the running week, a message stating that fact will appear instead of the combo box and button.

In the “Leaderboards” section, the user can check all the three types of leaderboards, unlike in the block where they can only see one at a time. In this section, users can also select in a combo box which leaderboard they want to see displayed on the Gamification Banner block.

Finally, in the “Enable/Disable Gamification Banner”, users can select in a checkbox if they want all the features of the Gamification Banner enabled or not. If they opt to disable them, instead of seeing a leaderboard and weekly updates in the block, they will see a message stating that these features are disabled, and in the “See More” webpage, they will only see the “Enable/Disable Gamification Banner” section. Users who disable the Gamification Banner will also not appear on the leaderboards and weekly updates of other users, nor will they count for the class scores calculation.

At the bottom of the page there are 2 buttons, “Save changes” and “Cancel”.

Figure 27 is a screenshot of the “See More” webpage.

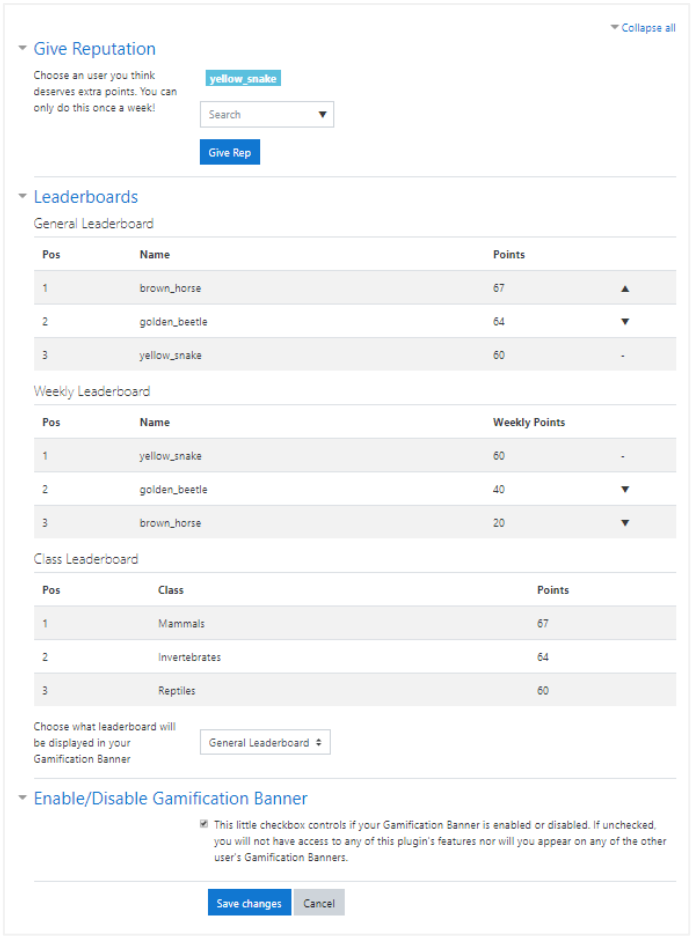

FIGURE 27 - "SEE MORE" FORM SCREENSHOT

Initially, it was planned to have a section with the user progression in the current week of the course. But since Moodle already offers a block that fairly does that, the "Course completion status", that block was used instead.

6.5. Non-Functional Features

In subsection 5.4.1 the non-functional requirements that needed to be covered by the developed plugin were projected. It can be concluded that they were respected in their entirety or at least partially.

From a security standpoint, the developed plugin does not pose any risks, as it does not access any external APIs, nor does it expose any critical information to the clients. The plugin always deals with important data on the server side.

To assure a good user experience, the UI was kept simple and with few information and uses commonly recognized elements such as checkboxes and dropdown lists. This allows users to instantly know what the purpose of each mechanic is.

To make the plugin reliable, scores and results are kept accurate by being calculated in real time, although the user does need to refresh the page to view them. Also, when an activity is completed, it may take up to a minute for it to be considered, as the scheduled task "Calculate regular completion data" needs to be executed [50]. However, this is the recommended update time stipulated by Moodle [51]. In addition, all the identified possible errors that may occur during the usage of the

plugin were properly prevented, and even if an unidentified error occurs, Moodle will just display a page with an informative message allowing the user to go back to the course.

For the plugin to have a good performance, the number of database queries it makes was kept as low as possible. Each query gets the most amount of information attainable in a single time, and then, that data is processed by the PHP classes.

And finally, supportability is easily addressed, as Moodle plugins are modular by default and can be effortlessly transported to other environments. The developed plugin is also testable as it is confirmed in chapter 7. As for the documentation, it can be found in the form of this dissertation, although when publishing the plugin, a smaller document should be created and uploaded to the distributing platforms.

However, in order to make the plugin publicly available at the Moodle plugins directory, some improvements still need to be done. A few bugs must be fixed, and the code must be adapted to be guaranteed it follows all the coding rules required by Moodle and the ideal plugin design. The way the database is structured should also have some improvements.

7. Evaluation

This chapter deals with the definition of evaluation metrics for the gamified system designed, since it was concluded that defining evaluation metrics should be one of the first steps taken when designing a gamified system.

The chapter starts by announcing the test groups, test methods, metrics, and hypotheses being evaluated and then, it exposes the results of the testing phase and questionnaires answered.

7.1. Test Plan

To evaluate the quality of the Moodle plugin developed and if the approach engaged to design a gamified system was successful three hypotheses tests were taken, with the metrics used being all quantitative.

Two test phases were planned, an alpha testing stage and beta stage, but only the alpha stage was carried.

7.1.1. Test subjects

Like it was stated, test subjects were southern European college students, since it was the preferences of that group that were analyzed, or southern Europeans who have left college recently (less than 5 years ago).

There was a total of 20 test subjects, 16 males and 4 females. 12 subjects were from informatics engineering or computer science and 8 from other courses, with their ages being all in between 20 years old and 30 years old.

For the alpha stage, tests were conducted in a testing laptop with Moodle being hosted locally. The main purpose of this stage was to find bugs and other software problems before reaching the end user, but the results were also used for an early evaluation of the gamified system. For the future beta stage, test should be conducted by more subjects, in a real environment, and in multiple computers. The purpose of that stage is to settle the final insights needed for a possible release of the product to the public.

7.1.2. Test procedure

Subjects were first presented with a non-gamified version of Moodle. That Moodle page contained a link to an on-line resource and another one to a document with 5 questions about the resource. Subjects were invited to explore the application at will but had to answer the questions from the document at the end. The documents used are in Annex 1 and Annex 2.

Next, subjects were presented with a gamified version of Moodle (having the developed plugin applied). This time, instead of a link to a document, there was an embedded quiz that had to be answered. Just like previously, subjects could explore the course at will.

The behavior of the subjects using both versions of Moodle was supervised the whole time and recorded to better perceive the difficulties encountered using the applications and the favorite options.

After subjects ended up testing, they were requested to answer a small questionnaire asking about personal information (age, gender, and course) and opinions about the applications tested. The questionnaire aimed to record data, verify possible discrepancies between subjects with different characteristics, and collect opinions about possible improvements for the gamified version

of Moodle. Two of the main questions from that questionnaire required to rate both versions of Moodle tested. The questionnaire used can be found in Annex 3.

7.1.3. Hypotheses tests

The problems tested were the following:

Problem 1: Does the gamified system increase engagement in relation to the non-gamified system?

This problem aimed to test if users felt more motivated to explore and learn about the system if it was gamified.

Metrics used:

$\boldsymbol{\mu_a}$: average time spent exploring the non-gamified version of Moodle (includes answering the questions from the document and reading the resource);

$\boldsymbol{\mu_b}$: average time spent exploring the gamified version of Moodle (includes playing the quiz and reading the resource).

The time subjects spent on both versions of Moodle (gamified/non-gamified) was recorded with the average being calculated.

The first version tested (the non-gamified version) had a small advantage in this point, as test subjects needed to spend time getting used to the system. This detail, however, is not bad, because it makes certain that if the gamified version scores higher, is because it is preferable and not because subjects are getting used to Moodle.

Hypotheses:

$\boldsymbol{H_0}$: $\mu_a \geq \mu_b$

$\boldsymbol{H_1}$: $\mu_a < \mu_b$

If H_0 is rejected, that means that subjects are more engaged by the gamified version of the system, meaning that the game elements present in that version can make users more curious to explore the system and take full profit of it.

Problem 2: Do users prefer the gamified system over the non-gamified system?

This point aimed to test if users personally like one version of the system over another. The reasons to prefer a system over another depends on the user, some might like a system because it is more fun, and some may like another because they believe it its more serious and does not cause distraction of what is important.

Metrics used:

$\boldsymbol{\mu_a}$: average score given by users to the non-gamified version of Moodle (based on the results from the questionnaires);

$\boldsymbol{\mu_b}$: average score given by users to the gamified version of Moodle (based on the results from the questionnaires).

This point was entirely based on the results from the questionnaire, namely from the questions asking to rate each version of the system from 1 to 5.

Hypotheses:

$\boldsymbol{H_0}$: $\mu_a \geq \mu_b$

$\boldsymbol{H_1}$: $\mu_a < \mu_b$

If H_0 is rejected, it means that subjects prefer the gamified version of the application, which means it can make users happier when using the system. However, it does not mean they will take full profit of the system or have better results.

Problem 3: Is the performance on the quizzes improved by using the gamified system?

This point aimed to test if the gamified version of the application was able to motivate subjects to pay more attention to the documents and links provided or to simply exert more effort responding the quizzes.

Metrics used:

$\boldsymbol{\mu_a}$: average score subjects got on the document with questions from the non-gamified version of Moodle;

$\boldsymbol{\mu_b}$: average score subjects got on the quiz from the gamified version of Moodle.

In this test, the scores subjects made answering the quiz on the gamified version of the application were compared with the scores they made on the non-gamified version.

Hypotheses:

$\boldsymbol{H_0}$: $\mu_a \geq \mu_b$

$\boldsymbol{H_1}$: $\mu_a < \mu_b$

If H_0 is rejected, that means that the game elements present in the gamified version of Moodle can make users more eager to have better results and thus, make them more interested in studying the documents and links provided.

7.2. Test Results

Even with just an alpha testing phase of 20 subjects, it was possible to gather interesting results and observations that must be used to improve future iterations of the developed gamified system.

The time spent and grade obtained by test subjects in each course are in Annex 4. Previously created student accounts were used, with their names being made of a color and an animal.

7.2.1. Observations

During the alpha testing phase, it was possible to observe that very few subjects explored the courses outside the main activities (the on-line resource, and the document with questions or quiz), meaning that they did not access their profile information, class information, and the chat. This indicates that these features are not well evidenced. It was also observed that although subjects were given freedom to consult every source they wanted while answering the mandatory questions, only 3 subjects consulted sources that were not part of the activities from the course. That might suggest that subjects thought they were obligated to only access what was in the Moodle course, but might also imply that students mainly check what is provided by teachers. This behavior supports the idea that looking up to other sources needs to be encouraged.

About the time spent and results obtained in both courses, it was observed that 12 subjects took more time exploring the gamified course than the non-gamified, while 7 did the opposite, and that 8 students had better grades on the quiz from the gamified course, while 6 did better on the questions from the non-gamified course. Even though it might be a coincidence due to the small sample of subjects, 3 out of the 6 subjects that had better grades on the non-gamified course were females, with only 1 female having better grades on the gamified course. This may show that the gamified system designed does not work as well for females as it does for males, and that a study of female preferences must be conducted.

From a technical standpoint, a bug related with the leaderboard arrows that indicate if a student is improving or not was detected. The behavior of those arrows was very confusing and needs to be dealt in future versions of the developed plugin.

7.2.2. Hypotheses tests results

After the alpha testing phase ended, the metrics needed to proceed with the hypotheses tests were measured, and as such, it was possible to verify which null hypotheses (H_0) could be rejected (indicating that the gamified system is better than the non-gamified for that specific problem) and which could not (indicating that the gamified system is not better than the non-gamified for that specific problem).

The standard significance level (α) of **0.05** was used to determine if the null hypotheses could be rejected. This meant that if the calculated probability (*p*-value) figured ended up being less than 0.05, there was a good level of certain to reject H_0. The significance level is the probability of incorrectly rejecting H_0 and the *p*-value is the probability of finding the observed results, or more extreme (in this case better) results than the observed, when H_0 of a specific problem is true [52].

To get the *p*-value, first it is necessary to calculate the standard score (z-score), which is the number of standard deviations from the mean that a data point is [53]. The formula used to figure the z-scores was [54]:

$$\mathrm{Z} = \frac{\mu_b - \mu_a}{\sigma/\sqrt{n}}$$

Where σ is the standard deviation of the samples used to measure μ_a and n is the size of the samples used to measure μ_b, which was always 20.

Finally, a z-table had to be consulted to get the *p*-values for each z-score. The results of the planned hypotheses tests were the following:

Problem 1: Does the gamified system increase engagement in relation to the non-gamified system?

Metrics used:
$\boldsymbol{\mu_a}$: 6.8 minutes;
$\boldsymbol{\mu_b}$: 7.95 minutes;
σ: 2.48 minutes.

Z-score:

$$\mathrm{Z} = \frac{7.95 - 6.8}{2.48/\sqrt{20}} = 2.071$$

Which gives us a *p*-value of about **0.02**. That value is less than α, so H_0 can be rejected. **The gamified system gives more motivation to explore the course than the non-gamified system.**

Problem 2: Do users prefer the gamified system over the non-gamified system?

Metrics used:
$\boldsymbol{\mu_a}$: 3.5 (out of 5);
$\boldsymbol{\mu_b}$: 4.4 (out of 5);
σ: 0.89.

Z-score:
$\mathrm{Z} = \frac{4.4-3.5}{0.89/\sqrt{20}} = 4.530$

Which gives us a *p*-value of nearly **0**, indicating that we can almost certainly reject H_0 without any risk. **Students prefer the gamified system over the non-gamified system**.

Problem 3: Is the performance on the quizzes improved by using the gamified system?

Metrics used:
$\boldsymbol{\mu_a}$: 16 (out of 20);
$\boldsymbol{\mu_b}$: 17.27 (out of 20);
σ: 4.17.

Z-score:
$\mathrm{Z} = \frac{17.27-16}{4.17/\sqrt{20}} = 1.357$

Which gives us a *p*-value of about **0.09**. That value is greater than α, so H_0 cannot be rejected. **The test does not support the possibility that the gamified system improves grades in relation to the non-gamified system**.

7.3. Questionnaire Results

After the subjects finished testing both Moodle courses, they answered a questionnaire with 12 questions.

The initial section of the questionnaire contained 3 questions about personal information. The purpose of that section was to register the diversity of the test subjects.

The first question asked the gender of the test subject. 80% answered that they were male while 20% answered female. The second question asked the age group in which the subject belonged, where half of the respondents answered that they had between 20 years old and 24 years old, while the other half answered that they had between 25 years old and 29 years old including. And finally, the third question asked what the university course of the subject was, with the results being the following:

- 12 subjects answered Informatics engineering/Computer science;
- 2 answered Sports;
- 1 answered Bioengineering;
- 1 answered Ecology and environment;
- 1 answered Economy;
- 1 answered Marketing;

- 1 answered Mechanical engineering;
- 1 answered Veterinarian medicine.

Most subjects were male and from courses related to informatics, which makes the sample homogeneous. For a future beta testing phase, a more diverse group of testers needs to be invoked. On the other hand, the ages of the subjects were accurate, as most college students are in the same age groups as the ones that were answered.

The next section was about the Moodle experience. There, subjects were asked to evaluate both courses (non-gamified and gamified) and to answer what were the implemented game mechanics they preferred, and which would they want to see added. The purpose of that section was to check if the gamified environment was well designed.

When asked to evaluate both Moodle courses from 1 to 5 (1 being very poor and 5 being very good), test subjects gave the answers that are depicted in Figure 28. The y axis contains the number of subjects that gave a specific answer.

FIGURE 28 - EVALUATIONS GIVEN BY TEST SUBJECTS TO BOTH MOODLE COURSES

From Figure 28, it can be concluded that the non-gamified course got mixed to positive reviews, while the gamified course only got positive reviews. This indicates that subjects preferred the gamified course.

The game mechanics that test subjects liked the most from the gamified Moodle course are shown in Figure 29, with the x axis being the number of subjects that voted on a particular mechanic.

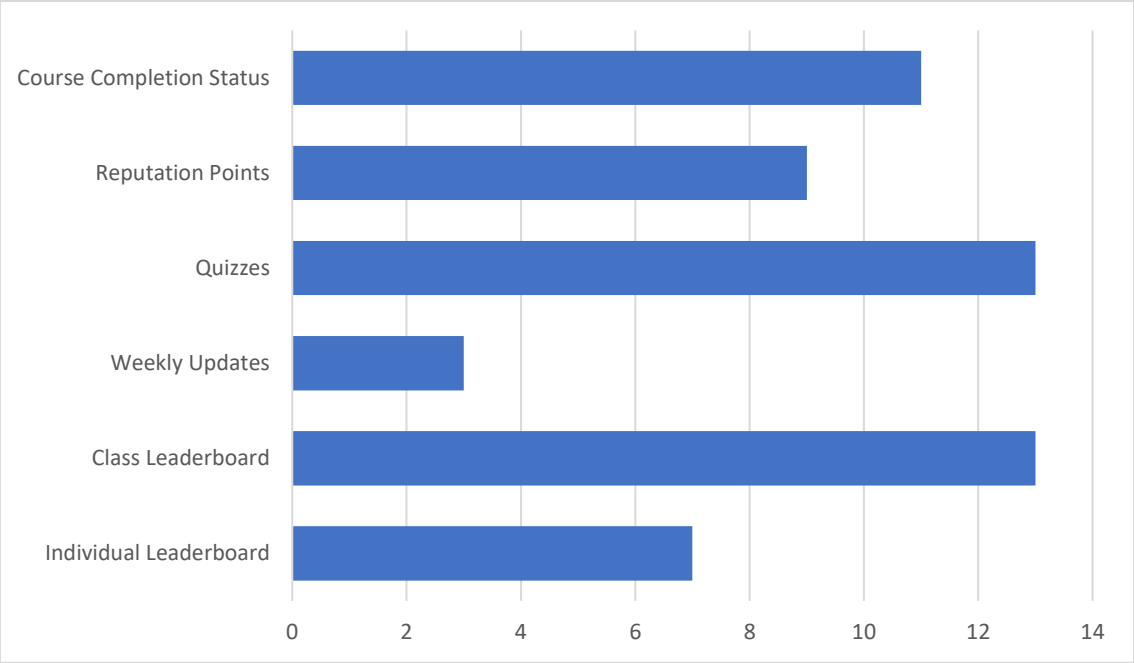

FIGURE 29 - IMPLEMENTED MECHANICS MOST LIKED BY TEST SUBJECTS

Class leaderboard and quizzes were the most liked mechanics, meaning that subjects liked both the social competition and the instant feedback provided by the quizzes. Reputation points and course completion status also did well for the same reasons. Weekly updates, on the other hand, did not do as well, meaning that its inclusion was not important, or that it simply was not evidenced enough.

Test subjects would like to see the mechanics from Figure 30 being implemented in future iterations of the gamified system. Again, with the x axis being the number of subjects.

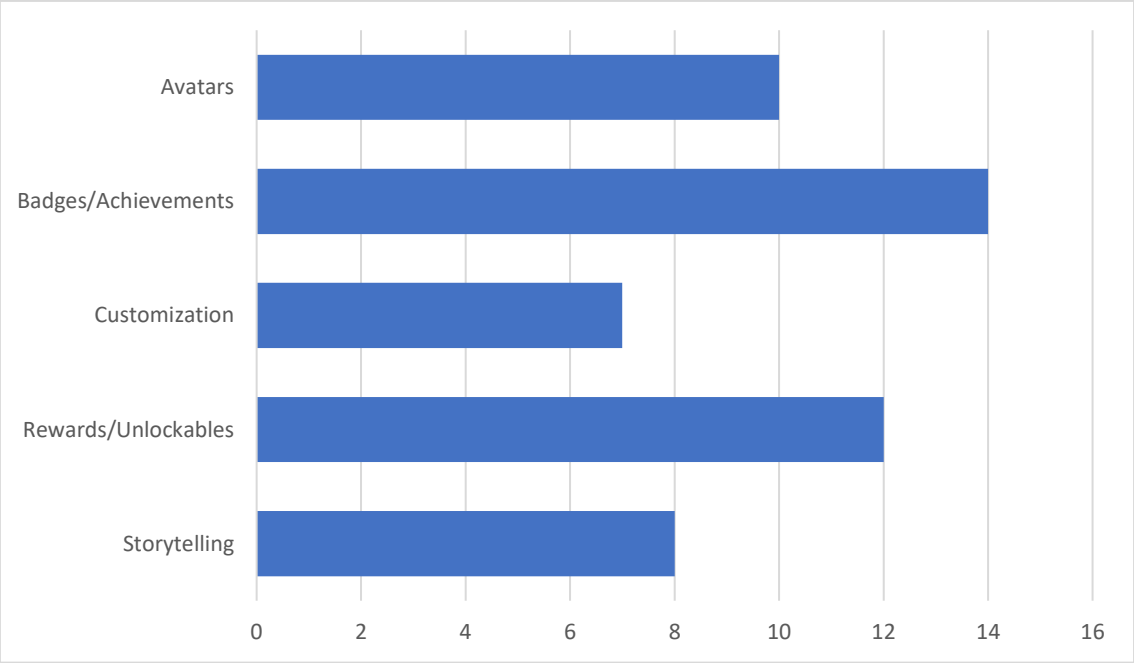

FIGURE 30 - GAME MECHANICS THAT TEST SUBJECTS WOULD LIKE TO SEE IMPLEMENTED

Badges/Achievements was the most voted mechanic, which is against the results of the study done in section 5.1. This fact may be explained by the study containing imperfections or by the mechanic being more recognizable by subjects. Rewards/Unlockables also had many votes, but while extrinsic motivation can be powerful at first, it loses its value after some time and can even become prejudicial if some motivators are removed [29]. Half of the subjects also voted in avatars, proving that self-representation is important.

Other answers included “tutorials about the theme of the course” and “comparing the moves with other users”. Those elements would increase assistance and socialization respectively.

The final section was about gamification in education, where subjects could give their honest opinions on how important can gamification be to education and how far could it go.

The first two questions of this section asked subjects to evaluate how much a gamified Moodle can improve their motivation, and how much it can improve their school results respectively, from a scale of 1 (nothing) to 5 (a lot). Their answers are portrayed in Figure 31, where the y axis contains the number of subjects.

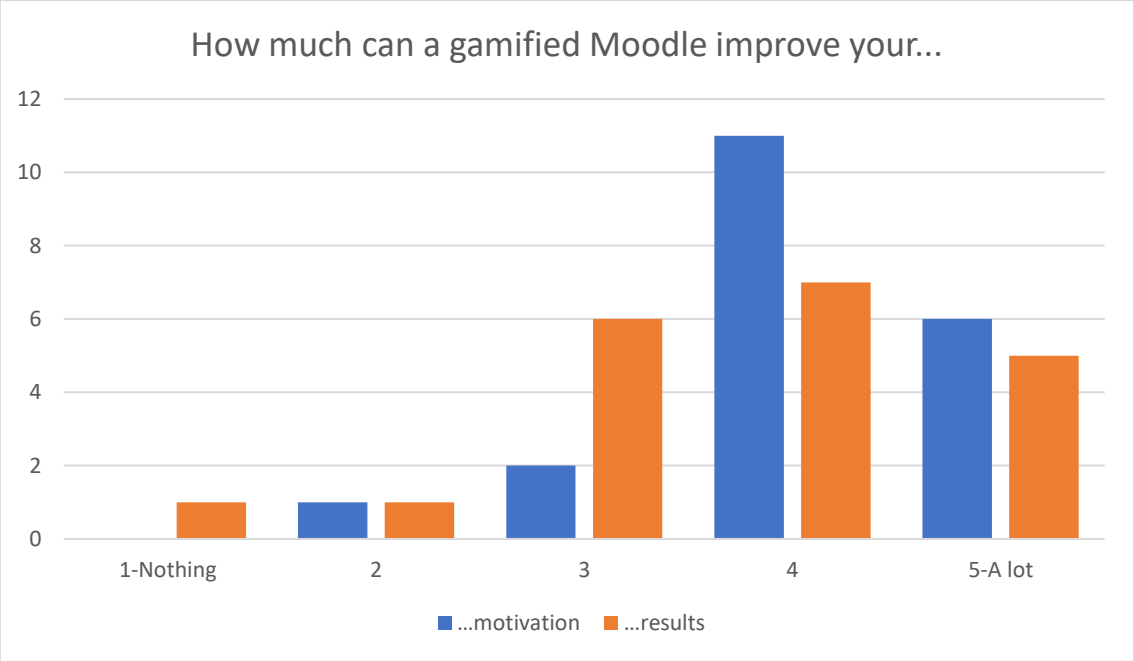

FIGURE 31 - OPINIONS OF THE TEST SUBJECTS ABOUT THE BENEFITS OF GAMIFICATION

About motivation, the answers were optimistic, meaning that subjects agreed that a gamified course could improve their motivation. However, about school results, while the answers were still mostly positive, there were more negative responses, meaning that many subjects believed that a gamified Moodle is not enough to improve their school results.

When asked to evaluate from 1 (should not be used) to 5 (should definitely be used) if a gamified Moodle should be used in real courses, and if the game elements should be used to evaluate students, subjects gave the answers depicted in Figure 32, the y axis containing the number of subjects.

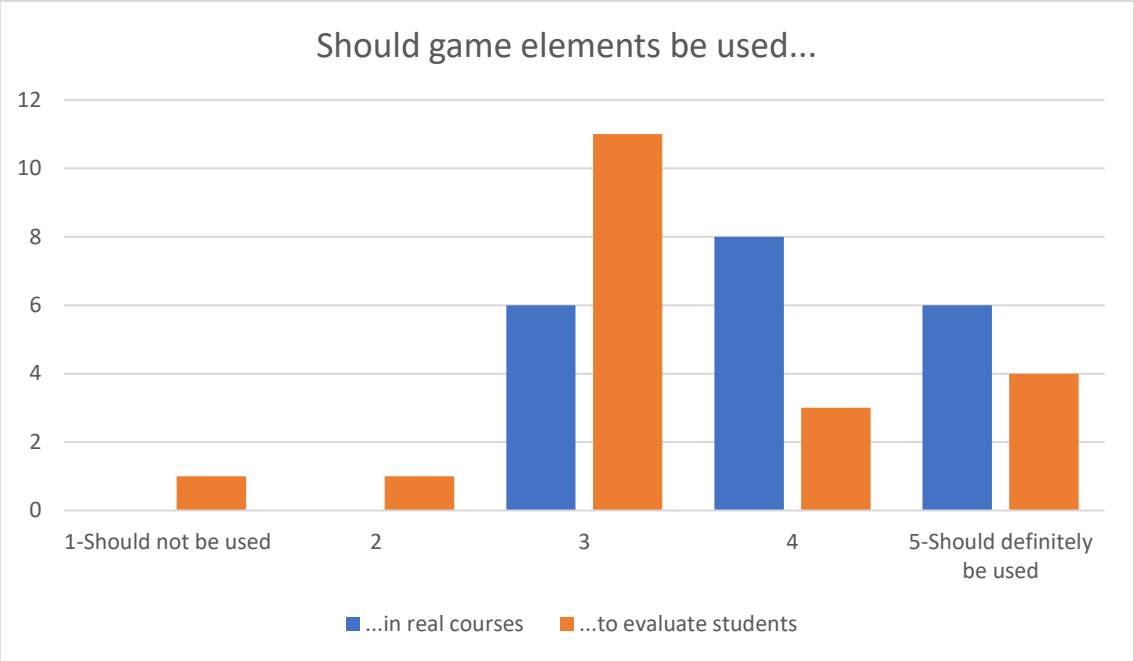

FIGURE 32 - OPINIONS OF THE TEST SUBJECTS ABOUT THE USAGE OF GAME ELEMENTS IN REAL COURSES

Here, test subjects mostly agreed that a gamified Moodle should be used in real courses, but there was not a consensus if the game elements should be used to evaluate students. This means that while subjects liked the idea of gamification in education, many believed that game elements are not a good way of evaluating students and might not represent their knowledge very well.

Finally, at the end of the questionnaire, there was a segment where test subjects could add a comment about anything related to their experience testing the system. In that segment, some subjects reiterated about how much they liked some of the features from the system, and that they believed gamification could improve the motivation of students, while others remarked that some game elements could create a bad competition where students try to get points as fast as they can without actually learning anything. One subject noted that instead of using game elements to evaluate students, they could be used to track how much students are learning, with the purpose of giving them guidance. Another subject also added that students should be able to see their points without looking at the leaderboards, reinforcing the idea that the mechanic of “points” has value for the targeted group.

8. Conclusion

This chapter contains a retrospective and summary of the whole document.

First, it states how the objectives presented in the first chapter were achieved. Then, it explains the limitations of this work and what needs to be done in the future to improve it. And finally, it concludes the document by expressing some opinions about the solution obtained and the concept of gamification.

8.1. Objectives Achieved

It is safe to state, that the objectives defined in section 1.3 were either totally completed or at least partially completed. Some challenges related to gamification design were identified as soon as section 1.2, with the common problems of the existing frameworks being hard to avoid, while others were identified during the development of the module used to test the proposed integrative guidelines. Further big challenges, not including the actual coding of the Gamification Banner block, were the analysis of the targeted users and which game elements are more suited to them, the conception of the micro and macro level loops, and the evaluation process, which includes finding a good group of test subjects to properly evaluate the solution.

Some gamification design frameworks, including well-known ones such as Six Steps to Gamification and Octalysis, were analyzed and compared in section 4.1. This comparison was important to understand how to correctly engineer gamification guidelines. So, as a result, the proposed set of integrative design guidelines was presented immediately after that analysis.

Like it was planned, the proposed guidelines were used to design a Moodle plugin and its surrounding learning environment, which involved suggesting ways to structure a course. The developed gamified system was then evaluated using various test subjects and conclusions were inferred, with some of them being expressed later in this chapter (section 8.3).

What ended up not being totally achieved, was how to create a good set of design guidelines. In fact, the proposed guidelines rely too much on other methods and do not have a strong scientific base sustaining some of its steps like other parts of this document have, such as the selection of game elements for a targeted group.

8.2. Limitations and Future Work

Basically, the limitations of the proposed guidelines are directly related with the limitations of the developed gamified module, because if the gamified system could not be properly evaluated, then the guidelines that were used to design it cannot be properly evaluated either.

The gamified system should have been tested for an entire semester with a larger and more diverse test group, so that it would be possible to examine the behavior of the students during their journey and engagement loops. This was not possible, so more evaluation experiments are needed. A continuous evaluation of the system could even change the result of the hypothesis test that concluded that the gamified system may not be enough to improve grades. With the test procedure done, it would be very difficult to demonstrate that 20 people using a system for a few minutes and then answering a test of 5 questions would have better grades if that system was gamified.

Due to time constraints, it was also not possible to implement in the Gamification Banner other game elements that would make sense for the targeted group. “Unlockable titles” is an example of a mechanic that was initially planned but later cut from the system.

In the future, the developed system must be improved according to the results of the evaluation chapter, with the study of the targeted user group being amended, especially for female users. Then, a beta testing session with a larger and more diverse test group needs to be conducted. For that testing session, the Moodle application will have to be hosted in a real online server instead of locally on a testing computer.

Finally, the code of the Gamification Banner has to be refactored in order to follow all of the coding guidelines required by Moodle and added to their plugin library. There, if users give it good ratings, it may catch the attention of Moodle administrators and be added to their courses. A metric system could be implemented in the plugin to verify which of its features are most used, in order to improve it in future iterations.

8.3. Final Remarks

Regardless of the limitations stated, the solution achieved accomplished a moderate level of success. The developed system, although it cannot be proven that it improves grades, had very positive reviews from testers, with most believing that a system like that should be used in real courses, if only to motivate students and give them guidance. This means that the guidelines that were followed have some worth. As such, this work is being considered for inclusion in a book about education and videogame elements as a chapter, but still with no final editorial decision.

Despite being difficult to guarantee if they can improve gamification in non-educational scenarios, it can be concluded that the points the proposed guidelines took in consideration and that are ignored by other frameworks, are important and should be considered more often by designers in order to combat poor gamification design.

The proposed guidelines owe many of their accomplishments to the existing frameworks, which proved to be very good tools, but they are distinguished for specifically stating what needs to be done in each step, with a big focus on how to select the game elements, and how to evaluate the solution. The methods recommended, which were the ones used for the development of the gamified Moodle environment, revolve around concrete scientific procedures instead of opinions, giving more value to the choices made.

Gamification is a powerful tool that can be easily used for education even if just to improve the general happiness of the students. But if a longer testing period proved that the proposed guidelines are capable of helping design a gamified system that can raise grades, maybe people would be more open to the idea of using game elements to evaluate students instead of the current system. The traditional grading system is flawed [36] and is being used for too long, so perhaps, just like a gamified application, it needs to be refreshed.

Applying gamification with consideration of several factors discussed in this document could cause fewer gamified systems to fail their purpose.

References

[1] K. Seaborna and D. I. Fels, "Gamification in theory and action: A survey," *International Journal of human-computer studies,* no. 74, pp. 14-31, 2015.

[2] D. Dicheva, C. Dichev, G. Agre and G. Angelova, "Gamification in Education: A Systematic Mapping Study," *Educational Technology & Society,* pp. 75-89, July 2015.

[3] J. Hamari, J. Koivisto and H. Sarsa, "Does Gamification Work? — A Literature Review of Empirical Studies on Gamification," *47th Hawaii International Conference on System Sciences,* pp. 3025-3034, January 2014.

[4] A. Mora, D. Riera, C. González and J. Arnedo-Moreno, "Gamification: a systematic review of design frameworks," in *Journal of Computing in Higher Education*, New York, Springer Science+Business Media, 2017, pp. 516-548.

[5] G. F. Tondello, A. Mora and L. E. Nacke, "Elements of Gameful Design Emerging from User Preferences," *Proceedings of the Annual Symposium on Computer-Human Interaction in Play,* pp. 129-142, October 2017.

[6] Gartner, Inc., "Gartner Says by 2014, 80 Percent of Current Gamified Applications Will Fail to Meet Business Objectives Primarily Due to Poor Design," Gartner, Inc., 27 November 2012. [Online]. Available: https://www.gartner.com/newsroom/id/2251015. [Accessed 15 October 2018].

[7] C. J. Costa, M. Aparicio, S. Aparicio and J. T. Aparicio, "Gamification usage ecology," *Proceedings of the 35th ACM International Conference on the Design of Communication,* p. 2, August 2017.

[8] Z. Trenholm, "Points, badges, and leaderboards: The Gamification Fallacy," Yu-kai Chou: Gamification & Behavioral Design, [Online]. Available: https://yukaichou.com/gamification-study/points-badges-and-leaderboards-the-gamification-fallacy/. [Accessed 22 October 2018].

[9] Z. Fitz-Walter, P. Wyeth, D. W. Tjondronegoro and B. Scott-Parker, "Driven to drive: Designing gamification for a learner logbook smartphone application," *Proceedings of the 1st International Conference on Gameful Design, Research, and Applications, Gamification 2013 [ACM International Conference Proceeding Series],* pp. 42-49, October 2013.

[10] S. Deterding, "The lens of intrinsic skill atoms: A method for gameful design," *Human–Computer Interaction,* no. 30, pp. 294-335, 2015.

[11] S. Silva, "Quase 30% dos estudantes abandonam o ensino superior," Público, 4 April 2018. [Online]. Available: https://www.publico.pt/2018/04/04/sociedade/noticia/quase-30-dos-estudantes-abandonam-o-ensino-superior-1808996. [Accessed 1 September 2019].

[12] MoodleDocs, "About Moodle," Moodle, 16 November 2018. [Online]. Available: https://docs.moodle.org/35/en/About_Moodle. [Accessed 25 November 2018].

[13] J. Kumar, M. Herger and R. Dam, "Measuring the Mechanics in Gamification," Interaction Design Foundation, 2017. [Online]. Available: https://www.interaction-design.org/literature/article/measuring-the-mechanics-in-gamification. [Accessed 22 October 2018].

[14] BusinessDictionary.com, "What is value analysis? definition and meaning," WebFinance Inc., [Online]. Available: http://www.businessdictionary.com/definition/value-analysis.html. [Accessed 25 December 2018].

[15] Martin, "The Innovation Process: Definition, Models, Risks & Opportunities, Tips," Cleverism, 22 January 2017. [Online]. Available: https://www.cleverism.com/innovation-process-definition-models-tips/. [Accessed 28 December 2018].

[16] P. Koen, "Front End Innovation - FEI," Front End Innovation, [Online]. Available: http://www.frontendinnovation.com/fei. [Accessed 28 December 2018].

[17] P. A. Koen, G. M. Ajamian, S. Boyce, A. Clamen, E. Fisher, S. Fountoulakis, A. Johnson, P. Puri and R. Seibert, "1 Fuzzy Front End: Effective Methods, Tools, and Techniques," in *The PDMA ToolBook for New Product Development*, Paul Belliveau, Abbie Griffin, Stephen Somermeyer, 2002, pp. 5-35.

[18] BusinessDictionary.com, "What is best value? definition and meaning," WebFinance Inc., [Online]. Available: http://www.businessdictionary.com/definition/best-value.html. [Accessed 25 December 2018].

[19] Indium Software, "Business Value of Gamification," EuroSTAR Huddle, 28 December 2017. [Online]. Available: https://huddle.eurostarsoftwaretesting.com/business-value-of-gamification/. [Accessed 25 December 2018].

[20] BusinessDictionary.com, "What is perceived value? definition and meaning," WebFinance Inc., [Online]. Available: http://www.businessdictionary.com/definition/perceived-value.html. [Accessed 25 December 2018].

[21] V. Allee, "What is Value Network Analysis?," Value Networks, LLC, 2011.

[22] Canvanizer.com, "Create a new Business Model Canvas," Canvanizer, [Online]. Available: https://canvanizer.com/new/business-model-canvas. [Accessed 28 December 2018].

[23] R. Hunicke, M. Leblanc and R. Zubek, "MDA: A Formal Approach to Game Design and Game Research," *Proceedings of the AAAI Workshop on Challenges in Game AI,* vol. IV, no. 1, p. 1722, July 2004.

[24] K. L. Bevins and C. D. Howard, "Game mechanics and why they are employed: What we know about gamification so far," *Issues and Trends in Educational Technology,* 11 March 2018.

[25] M. Wu, "Intrinsic vs. Extrinsic Rewards (and Their Differences from Motivations)," Lithium Community, 18 February 2014. [Online]. Available: https://community.khoros.com/t5/Science-of-Social-Blog/Intrinsic-vs-Extrinsic-Rewards-and-Their-Differences-from/ba-p/128969. [Accessed 25 September 2019].

[26] M. Prensky, "Fun, Play and Games: What Makes Games Engaging," in *Digital Game-Based Learning*, McGraw-Hill, 2001, pp. 5-31.

[27] S. Baron, "Cognitive Flow: The Psychology of Great Game Design," Gamasutra, 22 March 2012. [Online]. Available: https://www.gamasutra.com/view/feature/166972/cognitive_flow_the_psychology_of_.php. [Accessed 23 December 2018].

[28] K. Werbach, Interviewee, *GC01: 6 Steps to Effective Gamification.* [Interview]. 30 April 2013.

[29] Y.-k. Chou, "Octalysis: Complete Gamification Framework," Yu-kai Chou: Gamification & Behavioral Design, [Online]. Available: https://yukaichou.com/gamification-examples/octalysis-complete-gamification-framework/. [Accessed 12 December 2018].

[30] A. Marczewski, "A Simple Gamification Framework / Cheat Sheet," Gamified UK, [Online]. Available: https://www.gamified.uk/gamification-framework/. [Accessed 15 December 2018].

[31] B. Morschheuser, K. Werder, J. Hamari and J. Abe, "How to gamify? A method for designing gamification," in *50th Hawaii International Conference on System Sciences*, Hawaii, 2017.

[32] Cambridge Dictionary, "PERSONA | meaning in the Cambridge English Dictionary," Cambridge University, [Online]. Available: https://dictionary.cambridge.org/dictionary/english/persona. [Accessed 16 December 2018].

[33] CallidusCloud, "Sales Motivation Software | Motivate Sales Team | SalesMotivate by CallidusCloud," Callidus Software Inc., [Online]. Available: https://www.calliduscloud.com/salesmotivate. [Accessed 16 December 2018].

[34] IActionable, "Employee Gamification & Performance Management Software," IActionable, 2017. [Online]. Available: http://iactionable.com/. [Accessed 16 December 2018].

[35] Vocabulary.com Dictionary, "GPA - Dictionary Definition," Vocabulary.com, [Online]. Available: https://www.vocabulary.com/dictionary/GPA. [Accessed 17 September 2019].

[36] J. Dougherty, "Gamification: Rethinking The Grading Process (Part 3 of 6)," Teq, 30 April 2015. [Online]. Available: https://www.teq.com/uncategorized/gamification-rethinking-grading-process-part-3-5/. [Accessed 17 September 2019].

[37] Moodle, "Moodle plugins directory: Set: Gamification," Moodle, [Online]. Available: https://moodle.org/plugins/browse.php?list=set&id=88. [Accessed 23 February 2019].

[38] A. Mora, D. Riera, C. González and J. Arnedo-Moreno, "A literature review of gamification design frameworks," *2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games),* pp. 1-8, 2015.

[39] selfdeterminationtheory.org, "An Approach to human motivation & personality," selfdeterminationtheory.org, [Online]. Available: http://selfdeterminationtheory.org/. [Accessed 10 February 2019].

[40] S. Nicola, "Análise de valor," ISEP Instituto Superior de Engenharia do Porto, Porto, 2018.

[41] D. P. Schmitt, J. Allik, R. R. McCrae and V. Benet-Martínez, "The geographic distribution of Big Five personality traits: Patterns and profiles of human self-description across 56 nations," *Journal of cross-cultural psychology,* no. 38, pp. 173-212, 2007.

[42] G. Tondello, "The Gamification User Types Hexad Scale," Gameful Bits, 14 September 2016. [Online]. Available: http://blog.gamefulbits.com/2016/09/14/gamification-user-types-hexad-scale/. [Accessed 23 January 2019].

[43] S. Nicola, "Multi-Criteria Decision Making TOPSIS Method," ISEP Instituto Superior de Engenharia do Porto, Porto, 2018.

[44] MoodleDocs, "Moodle architecture," Moodle, 22 August 2018. [Online]. Available: https://docs.moodle.org/dev/Moodle_architecture. [Accessed 15 February 2019].

[45] MoodleDocs, "Communication Between Components," Moodle, 22 May 2017. [Online]. Available: https://docs.moodle.org/dev/Communication_Between_Components. [Accessed 15 February 2019].

[46] P. Eeles, "Capturing Architectural Requirements," IBM Developer, 15 November 2005. [Online]. Available: https://www.ibm.com/developerworks/rational/library/4706.html#N100A7. [Accessed 16 February 2019].

[47] Apache Friends, "XAMPP Installers and Downloads for Apache Friends," Apache Friends, [Online]. Available: https://www.apachefriends.org/index.html. [Accessed 15 February 2019].

[48] J. Papaioannou and G. J. Preece, "Blocks - MoodleDocs," MoodleDocs, 13 March 2019. [Online]. Available: https://docs.moodle.org/dev/Blocks. [Accessed 14 July 2019].

[49] MoodleDocs, "Core APIs," Moodle, 15 January 2019. [Online]. Available: https://docs.moodle.org/dev/Core_APIs. [Accessed 24 August 2019].

[50] MoodleDocs, "Course completion FAQ," Moodle, 27 May 2019. [Online]. Available: https://docs.moodle.org/37/en/Course_completion_FAQ. [Accessed 31 August 2019].

[51] MoodleDocs, "Cron," Moodle, 9 April 2019. [Online]. Available: https://docs.moodle.org/37/en/Cron. [Accessed 31 August 2019].

[52] StatsDirect, "P Values (Calculated Probability) and Hypothesis Testing," StatsDirect Limited, [Online]. Available: https://www.statsdirect.com/help/basics/p_values.htm. [Accessed 29 September 2019].

[53] S. Glen, "Z-Score: Definition, Formula and Calculation," Statistics How To, [Online]. Available: https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/z-score/. [Accessed 29 September 2019].

[54] S. Glen, "Hypothesis Testing," Statistics How To, [Online]. Available: https://www.statisticshowto.datasciencecentral.com/probability-and-statistics/hypothesis-testing/. [Accessed 29 September 2019].

[55] Gartner, Inc., "Hype Cycle for Emerging Technologies," 2014.

Annex 1: Document used to evaluate test subjects (version 1)

Gamification Test

The purpose of this test is not to evaluate the students' knowledge about Gamification but to validate if their results can be improved by a simple gamified environment.

The results will only be used to make that validation.

Name: _____

1.) Select only one answer:

Gamification can be defined as:

- ☐ Applying game elements in non-game contexts
- ☐ Turning applications into games
- ☐ Making games more fun
- ☐ Using games to solve problems

2.) Say if the following statements are true (T) or false (F):

- ☐ Gamification can encourage unintended behaviors.
- ☐ Points, badges and leaderboards are typical game design elements.
- ☐ Gamification was invented by Sebastian Deterding.

3.) Match:

Flow	•	• Concept improved by Gamification
Meaningful Stories	•	• Common application of Gamification
Technology Design	•	• Common game design element

Annex 2: Document used to evaluate test subjects (version 2)

Moodle Test

The purpose of this test is not to evaluate the students' knowledge about Moodle but to validate if their results can be improved by a simple gamified environment.

The results will only be used to make that validation.

Name: _____

1.) **Select only one answer:**

Moodle is written in:

- ☐ C#
- ☐ Java
- ☐ Node.js
- ☐ PHP

2.) **Say if the following statements are true (T) or false (F):**

- ☐ Moodle is an LMS.
- ☐ Moodle is closed source.
- ☐ Moodle stands for "*Modular Open-Source Online Dynamic Learning Environment*".

3.) **Match:**

MoodleMoot	•	•	e-learning standard adopted by Moodle
SCORM	•	•	Moodle conference
Moodle Community	•	•	One of Moodle's developers

Annex 3: Questionnaire answered by the test subjects

Moodle Test Questionnaire

Please answer a few questions about your experience using the Moodle test courses.

* Required

Personal Information

These questions will only be used for statistics.

1. Gender *

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Other

2. Age Group *

Mark only one oval.

- ◯ <20
- ◯ 20-24
- ◯ 25-29
- ◯ >=30

3. University Course *

_____

Opinions about the Moodle Experience

4. How do you evaluate your experience in the non-gamified Moodle course? *

Mark only one oval.

	1	2	3	4	5	
Very Poor	◯	◯	◯	◯	◯	Very Good

5. How do you evaluate your experience in the gamified Moodle course? *

Mark only one oval.

	1	2	3	4	5	
Very Poor	◯	◯	◯	◯	◯	Very Good

6. **What where your favourite game elements from the gamified Moodle course?**
   Check all that apply.

- [ ] Individual Leaderboard
- [ ] Class Leaderboard
- [ ] Weekly Updates
- [ ] Quizzes
- [ ] Reputation Points
- [ ] Course Completion Status

7. **Which other game elements would you like to see applyed in a Moodle course?**
   Check all that apply.

- [ ] Avatars
- [ ] Badges/Achievements
- [ ] Customization
- [ ] Rewards/Unlockables
- [ ] Storytelling
- [ ] Other: _____

Opinions about Gamification in Education

8. **How much can game elements improve your motivation for using Moodle?** *
   Mark only one oval.

	1	2	3	4	5	
Nothing	◯	◯	◯	◯	◯	A lot

9. **How much do you believe a gamified Moodle can improve your school results?** *
   Mark only one oval.

	1	2	3	4	5	
Nothing	◯	◯	◯	◯	◯	A lot

10. **How much do you believe a gamified Moodle can be used in real courses?** *
    Mark only one oval.

	1	2	3	4	5	
It should not be used	◯	◯	◯	◯	◯	It should definitely be used

11. How much do you believe points or leaderboards can be used to evaluate students? *

Mark only one oval.

	1	2	3	4	5	
They should not be used	◯	◯	◯	◯	◯	They should definitely be used

12. If you wish, give some final remarks and opinions about your experience.

Annex 4: Time spent and grades obtained by test subjects on both Moodle courses

	Standard Course	Gamified Course
Brown horse	6m	10m
	16/20	13.33/20
Yellow snake	5m	13m
	20/20	20/20
Red hawk	8m	9m
	12/20	16/20
Black clownfish	5m	8m
	16/20	16/20
Blue slug	7m	6m
	20/20	20/20
Black lion	4m	8m
	16/20	20/20
Blue lizard	12m	11m
	20/20	20/20
Yellow parakeet	7m	5m
	8/20	17.33/20
Brown sardine	3m	4m
	12/20	20/20
Gray snail	3m	3m
	5.33/20	13.33/20
Purple elephant	8m	9m
	16/20	13.33/20
Gray crocodile	8m	6m
	17.33/20	16/20
Pink parrot	6m	7m
	16/20	20/20
Purple redfish	9m	7m
	20/20	13.33/20
Green butterfly	8m	18m
	16/20	20/20
Green giraffe	5m	6m
	20/20	17.33/20
Orange turtle	8m	6m
	13.33/20	9.33/20
Transparent stork	5m	7m
	20/20	20/20
White whiteshark	12m	4m
	16/20	20/20
Brown ladybug	7m	12m
	20/20	20/20