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Leonardo Dalmina

GAMIPROM: A GAMIFICATION MODEL BASED ON PROFILE MANAGEMENT

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Dissertação apresentada como requisito parcial para a obtenção do título de Mestre pelo Programa de Pós-Graduação em Computação Aplicada da Universidade do Vale do Rio dos Sinos — UNISINOS

Advisor:
Prof. Dr. Jorge Luis Victória Barbosa

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RESUMO

O uso de elementos de *design* de jogos em contextos não relacionados a jogos, definido como gamificação, está sendo cada vez mais usado para aumentar a motivação e o engajamento dos usuários quando eles precisam executar uma tarefa em um ambiente não relacionado a jogo, como o local de trabalho, a escola ou uma aplicação de software. No entanto, quando a gamificação precisa ser implementada, um desafio enfrentado pelos desenvolvedores é identificar quais elementos do jogos engajarão efetivamente os usuários de um software com base em seus perfis de usuário e características motivacionais. Frequentemente, muitas pesquisas tendem a não incluir ou apenas apoiar os tipos de usuário e fatores motivacionais mais comuns. Em resposta a este desafio, esta dissertação propõe um modelo de gamificação genérico intitulado GamiProM que permite um desenvolvedor de software criar uma solução gamificada adaptativa para qualquer área fazendo uso de ontologias e regras, visando fornecer representação do conhecimento bem como adicionar um valor semântico à informação gerada pela gamificação e gerenciamento de perfil. O modelo é avaliado com um teste de correlação que identifica a existência de qualquer associação entre as necessidades psicológicas básicas dos usuários e suas motivações coletadas com a aplicação gamificada, desenvolvida para implementar o modelo proposto. Os resultados mostraram que as motivações coletadas dos perfis gamificados dos usuários têm uma correlação acima de 80% com as necessidades psicológicas básicas analisadas.

Palavras-chave: Adaptabilidade. Gamificação. Ontologias. Personalização. Perfis de Usuário.

ABSTRACT

The use of game design elements in non-game contexts, defined as gamification, is being increasingly used to raise the motivation and engagement of users when they have to execute a task in a non-game environment, such as the workplace, the school or a software application. However, when gamification needs to be implemented, a challenge faced by developers is to identify what game elements will effectively engage the users of a software based on their user profiles and motivational characteristics. Often, many researches tend to not include or only support the most common user types and motivational factors. In response to this challenge, this thesis proposes a generic gamification model entitled GamiProM that allows a software developer to build an adaptive gamified solution for any area by making use of ontologies and rules, aiming to provide knowledge representation as well as add a semantic value to the information generated by gamification and profile management. The model is evaluated with a correlation test that identifies the existence of any association between the basic psychological needs of the users and their motivations collected with the gamified application, developed to implement the proposed model. The results showed that the motivations collected from the gamified profiles of the users have a correlation above 80% with the basic psychological needs analyzed.

Keywords: Adaptability. Gamification. Ontologies. Personalization. User Profiles.

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LIST OF ABBREVIATIONS

Gm. Gamification

Ref. Reference

LIST OF ACRONYMS

ACM	Association for Computing Machinery
API	Application Programming Interface
CSS	Cascading Style Sheets
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronics Engineers
FQ	Focused Question
FR	Functional Requirement
GUI	Graphical User Interface
GQ	General Question
HTML	HyperText Markup Language
MEI	Mechanic or Element or Idea
OWL	Web Ontology Language
PHP	PHP Hypertext Preprocessor
RDF	Resource Description Framework
SPARQL	SPARQL Protocol And RDF Query Language
SQ	Statistical Question
SQL	Structured Query Language
SWRL	Semantic Web Rule Language
UML	Unified Modeling Language
XML	eXtensible Markup Language

CONTENTS

1 INTRODUCTION

The word gamification has been defined by DETERDING et al. (2011) as “the use of game design elements in non-game contexts”. By making use of game mechanics and elements, gamification aims to increase the motivation and engagement of users when they have to execute a task in a non-game environment, such as the workplace, the school or a software application.

The gamification field has grown significantly and its popularity increased over the years, thus being applied in several areas (DETERDING et al., 2011; ZICHERMANN; CUNNINGHAM, 2011; WERBACH; HUNTER, 2012; MACMILLAN, 2011; HAMARI; KOIVISTO; SARSA, 2014). Nowadays, there is a considerable amount of gamification works providing a variety of motivational solutions for users. These works often describe what gamification mechanics / elements are included, the supported area, and sometimes what type of user the work supports. Once the main key of gamification is increase the engagement of users, a variety of motivational factors are connected to different user types, leading to another field of gamification: adaptability / personalization.

Personalization means the individual adaptation of products, services and information. Personalization technology usually involves programs that learn a user’s patterns, habits, and preferences. The main purpose of modern personalization systems is offer to users what they want without requiring them to explicitly state this (MULVENNA; ANAND; BÜCHNER, 2000). A way to obtain the users’ preferences is by storing their actions on profiles. Profiles with useful stored information are the key to identify the behavior of the users, their interests and, combined with a profile manager, also make suggestions regarding future actions (WAGNER; BARBOSA; BARBOSA, 2014).

When gamification needs to be implemented, a challenge faced by developers is to identify what game elements (supported by an application) will actually engage the users of the software based on their respective user profiles. In response to this challenge, this thesis proposes a gamification model entitled GamiProM (Gamification based on Profile Management) that allows software developers to integrate gamification on different applications, building gamified solutions (gamification models) for any area based on the motivational characteristics of the users, being capable to identify their user types (gamified profiles) thus supporting adaptability.

1.1 Motivation

According to DETERDING et al. (2011), gamification is being used by many applications to increase the motivation of users to use them. The main purpose to gamify these applications is to make their users more engaged. Every gamification solution developed for an application integrates a set of elements and mechanics that will gamify the available features the software can provide. Users will interact with such elements and feel motivated to receive the different rewards they can offer. A benefit of have an engaged audience is the opportunity to improve the

application with users' usage data, helping developers to wisely choose the next features that will be implemented. Applications with the ability to identify and manage the users' gamified behavior based on their gamified actions are capable to provide richer usage data, thus being able to use this data to personalize the gamification at runtime.

The ideal solution to gamify a software is to follow a design that organizes every gamification element mapping it to an engagement factor and user type. Once following a design, the gamification structure can be expanded to generate useful information about the users and their gamified activities, such as gamified usage data provided by the interaction between users and gamification elements. Additionally, the analysis of such information could be used to adapt and personalize the gamification elements available for users based on their behaviors and user profiles (FERRO; WALZ; GREUTER, 2013).

The integration of all the aforementioned concepts can be organized and maintained in the form of ontologies. According to GRUBER (1995), an ontology is an explicit specification of a conceptualization. The term is borrowed from philosophy, where an Ontology is a systematic account of Existence. In AI systems, what "exists" is that which can be represented. When the knowledge of a domain is represented in a declarative formalism, the set of objects that can be represented is called the universe of discourse. This set of objects, and the describable relationships among them, are reflected in the representational vocabulary with which a knowledge-based program represents knowledge. The knowledge, in the proposed model, refers to the concepts and ideas involving gamification, user profiles and their engagement factors gathered to support adaptability.

1.2 Problems and questions

A gamification solution usually tends to work with specific domains and user types. This happens because users have different engagement factors, thus being motivated by different gamification elements. A study presented in the chapter 3 presents the results of a systematic mapping about gamification models, indicating that there is a considerable amount of gamified applications that implement only the most common gamification elements, such as leaderboards and achievements that may not reach the engagement expected. The motivation in this case is completely subjected to match the random user profiles that are using an application. Therefore, a few questions can be generated from the aforementioned problems, such as:

- Is it possible to generate different gamification models oriented to motivational factors supporting different areas of application?
- How to turn non-gamified activities into gamified activities?
- How to identify the motivation of users while using a gamified application?
- How to support adaptability on gamified solutions?

These difficulties justify the development of a gamification model with generic purposes able to provide all the resources necessary to answer these questions, being implemented as a gamification solution that embeds not only the gamification knowledge but also the motivational characteristics involved. In this way, the model not only enhance its usability but provides a semantic value, also offering means to be evaluated.

1.3 Objectives

This research work has as main objective to provide a gamification model with generic purposes oriented to motivational factors, supporting different users types and offering knowledge representation about the concepts of the model. To achieve this main objective, the following specific objectives are defined:

- Analyze the background of the gamification area;
- Characterize the state of art of related works;
- Specify the gamification model and architecture;
- Implement a prototype of gamified application that is built based on the gamified solution generated by the model;
- Validate the model based on the data collected from the prototype.

1.4 Methodology

To elaborate this research work, initially a preliminary research was carried out to identify the technologies, techniques and concepts that offer a theoretical background needed to conceptualize a gamification model that attends to the proposed objectives. This research resulted in some gamification designs that help to solve the identified problems. The theoretical background present in the researches that implement these designs was important to embed useful knowledge in the development of the ontological model.

Once the ontological model was designed, an initial specification about the application contained in the full model was created, providing a detailed view about its functional requirements. It was also developed the architecture of the model that covers the application, the ontological model and implementation aspects, in order to address the aforementioned problems, thus reaching the desired objectives and identified requirements.

Since the preliminary research resulted only in a few researches meeting the criteria needed for this work, a systematic mapping study was conducted to obtain a structured view of the state of the art in the field of gamification models, under the aspects related to this work. This leaded to opportunities present in the gamification field thereby resulting in a better refinement of the model.

After the conclusion of all these steps, the specification of the model was completed. At that stage, the application that works along with the ontology was developed and its features were tested.

A prototype of a gamified application was developed following the specifications contained in the gamified solution generated by the gamification model, also including a set of motivations that were included in the prototype.

The evaluation of the model was performed correlating the motivation of the users that used the prototype with their basic psychological needs identified by a separated form.

1.5 Outline

This thesis is organized in seven chapters. The second chapter discusses the background and basic concepts that are relevant to this work. The third chapter details the complete process of the systematic mapping study utilized to identify studies that are related to this research and opportunities for improvement in the gamification area. The gamification model, its architecture and features are presented in the fourth chapter. The fifth chapter presents the implementation of the prototype. The sixth chapter describes the evaluation of the model and the results obtained from it. Lastly, the seventh and final chapter presents the final considerations and possible future works.

2 BACKGROUND AND BASIC CONCEPTS

This chapter presents the background and basic concepts related to the terminologies utilized in this research. The text is organized in five sections, described as follows. The first section presents an overview of Gamification from its first definition to recent gamification designs and some negative results present in the literature. Section two explains information about personalization and adaptability, also highlighting how they can be connected to this research. The third section describes concepts about Profile Management, complementing the information introduced in the previous section and commenting relevant works making use of this technique. Section four provides basic information about ontologies, they origin, usability reasons and an usage example of the main components required for a better understanding of the semantic concept. At last, the fifth section presents the considerations about the chapter highlighting the most relevant aspect approached in each section.

2.1 Gamification

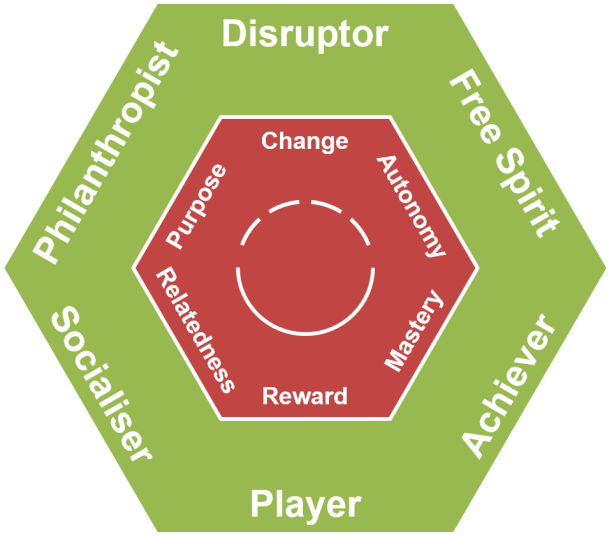
The term gamification was first used by PELLING (2011) in 2002, when he wanted to make non-game related interfaces more like games, with a preliminary definition of “Applying game-like accelerated user interface design to make electronic transactions both enjoyable and fast”. However, this term only started to gain attention in 2010 (DETERDING et al., 2011), being popularized by industry applications and conferences on the topic, which emerged in new definitions about the concept. DETERDING et al. (2011) expressed the first official definition of gamification as “The use of game design elements in non-game contexts”. Another definition was made by WERBACH (2014), stating that gamification is “The process of making activities more game-like”.

With the wide usage and popularization of gamification, many game elements and mechanics were included in this concept. Nevertheless, gamification still do not have a consolidated list or classification of these game elements in literature. As an example, some researches present in the literature identifies terms like challenges and rewards as distinct game elements or mechanics. However, DUBOIS; TAMBURRELLI (2013) mixed both terms stating that the most elementary gamification element, also known as challenge, consists of a reward mechanism that awards people in response to the accomplishment of certain activities that need to be encouraged.

On the other hand, many researchers tried to establish a common organization of these concepts. These organization techniques can be referred as gamification designs, once they try to design a variety of ideas in a single visualization image. One of the most recent gamification designs, which reuses different old designs works and also covers every gamification concept is Hexad, created by MARCZEWSKI (2015). The Hexad designs gamification in a perspective of motivation, the main psychological need that gamification tries to reach with the use of

game-design elements. In his work, MARCZEWSKI (2015) tried to group every gamification element, mechanic or idea under a motivational factor, also highlighting different user types that are motivated by these motivational factors, as can be seen in Figure 1.

Figure 1: Gamification design Hexad



Source: MARCZEWSKI (2015)

In software development organizations, the increase of motivation provided by gamification can help to create a better environment that can impact directly on productivity and software quality, since software design and development is intrinsically a human-centric and brain-intensive activity in which the experience, motivation, and discipline of developers represent crucial ingredients (DUBOIS; TAMBURRELLI, 2013). Following this concept, SINGER; SCHNEIDER (2012) utilized gamification to propose an experiment that consists in encourage computer science students to make more frequent commits to version control by using a social software application. The experiment resulted in a majority of positive statements provided by the students.

Recently, XU; BUHALIS; WEBER (2017) examined gaming in general terms and the application of it in specific tourism fields, identifying game design elements that can contribute to a meaningful gamification. The work presented a few cases of best practices to show how this concept can benefit tourism marketing, also discussing potential implications and future research recommendations.

Although many experiments result in a positive feedback, some might receive a negative result. As will be described in the next chapter, there's a highly inclined trend to be followed by gamification researches and implementations that aims on the same gamification elements and mechanics for different scenarios, without considering the real motivation that players (users) need. This is often referred as the term "pointsification", which describes the act of creating rewards as points or badges / achievements without strategy or true meaning for the players. This is pointed out by DETERDING (2011) as a potential pitfall of gamification. In this scenario,

gamification is not planned, thus not providing a real fun, pleasure, or challenges to players.

2.2 Personalization and Adaptability

Another field of gamification present in the literature is personalization, sometimes accompanied by the term "calm technology". According to WEISER; BROWN (1996), calm technology is a kind of technology that engages both the center and the periphery of our attention, moving back and forth between the two, being "periphery" the name used to define what we are attuned to without attending to explicitly. Directing this to the gamification scenario, it could be a gamified application that indirectly collects useful information of the users only requiring the periphery attention of them.

A pervasive computing system that strives to be minimally intrusive has to be context-aware, thus being able to recognize its user's state and surroundings, modifying its behavior based on this information (SATYANARAYANAN, 2001). A user's context can be quite rich, consisting of attributes such as physical location, physiological state (i.e. body temperature and heart rate), emotional state (i.e. angry, distraught, or calm), personal history, daily behavioral patterns, and so on. These richness of context examples can be expanded to gamification, where the interactions of the user with gamification mechanics, preferred elements, identified motivations and historical data usage can also be identified as gamified context information. According to SATYANARAYANAN (2001), if a human assistant were given such context, he or she would make decisions in a proactive fashion, anticipating user needs. This could be used, for example, to provide an adaptation of gamified elements displayed for users based on their actions and choices using an application.

According to MULVENNA; ANAND; BÜCHNER (2000), the goal of personalization systems is to provide users with what they want or need without requiring them to ask for it explicitly. In this way, personalization is the provision to the individual of tailored products, services, information or information relating to products or service. The coverage is extensive, including recommender systems, customization, and adaptive applications.

In short, personalization technology involves software that learns patterns, habits, and preferences (MULVENNA; ANAND; BÜCHNER, 2000). This learning process is used to provide personalized information for users based on their specific needs and also adapt the application to the user when necessary.

For this research provide support for the adaptive characteristics and personalization technology aforementioned, a set of concepts were defined to meet these requirements. These definitions are described in details in section 4.3.2.

A recent research that makes use of adaptation is ORACON (ROSA; BARBOSA; RIBEIRO, 2016). ORACON is an adaptive model for context prediction that adapts itself in order to apply the best algorithm to the case. The adaptive behavior is the main contribution of the model, differentiating it from other related works. In addition, ORACON supports other important as-

pects of ubiquitous computing, such as, context formal representation and privacy. As part of the research it was built a functional prototype that allowed the conduction of two experiments. The first experiment successfully tested the main functionalities provided by ORACON to support context prediction and privacy aspects. The test used context histories generated with a location database that contains 22 millions check-ins across 220,000 users in the location sharing services Foursquare and Twitter. The second experiment assessed the adaptive feature of ORACON. The test simulated the behavior of 30 users for a period of 30 days, using context histories generated by a particular simulator. The simulator generated data for the evaluation and the comparison of machine learning methods in mobile context-aware settings. ROSA; BARBOSA; RIBEIRO (2016) concluded that ORACON chose the most accurate prediction algorithm in the simulated scenario, proving that the model reached the main contribution sought by the research.

Another work focusing on adaptability is the research of ABECH et al. (2016), proposing an architectural model entitled EduAdapt for the adaptation of learning objects considering device characteristics, learning style and other student's context information. The adaptation was provided by the use of inferences and rules in a proposed ontology, named OntoAdapt. The purpose of the ontology is to help recommending learning objects to students or adapt these objects according to the context (context-aware computing). The model received a two steps evaluation, by firstly use scenarios and metrics to assess the ontology and secondly being developed a prototype of the model further submitted to a class of 20 students with the intention of evaluating the usability and adherence to adapted objects, resulting in a 78% of acceptance. ABECH et al. (2016) concluded that the evaluation indicates that the proposed model would be useful in the learning process.

2.3 Profile Management

According to VIVIANI; BENNANI; EGYED-ZSIGMOND (2010), many different applications collect information about users for service personalization, and the main purpose of this information collection is to enable the applications of understanding the users, their preferences and their interests in order to provide them with personalized services. Additionally, the number of areas where the idea of personalization is regarded as crucial is increasing every day: digital libraries, search engines, e-learning, online databases, e-commerce, social networks, and so on.

Motivated by the aforementioned reasons, different applications in different areas organize user properties, preferences and assumptions based on the user state, in user profiles, where each application saves users information independently from others, based on a specific user model. The information collection can be implicit, where the information can be derived by studying users behavior while using the services of an application, or explicit, where the information can be gathered by a direct intervention of the users themselves by filling some kind of predefined forms (VIVIANI; BENNANI; EGYED-ZSIGMOND, 2010).

Following this line, KIM; LEE (2008) proposed a profile management method to provide personalized services to the user. The profile was configured with various user related information that use Web Services to exchange profiles among client device, profile repository, and services server, also applying meta-data and dynamic configuration techniques for efficient profile management. The authors concluded, after the result of a performance evaluation, that the proposed techniques in the profile management framework were efficient to manage the profiles.

Focusing on multimedia services that must perform automatic actions / operations to adapt the delivered content to the user expectations and his environment capabilities, also ensuring the best quality of experience, CHELLOUCHE; ARNAUD; NÉGRU (2010) conducted a research to facilitate the adaptation process by introducing a flexible context-sensitive user profile model that gathers static and dynamic data characterizing the user and his operational context. The authors also proposed an efficient framework for managing and delivering the user profile, creating a context-dependent user profile instance for each application according to its adaptation process needs.

Recently, WAGNER; BARBOSA; BARBOSA (2014) proposed a model that allows applications to register entities' actions in trails and infer profile information from these trails, using semantic interoperability and allowing different applications to share information and infer a unified profile. From this research, an application was also developed and integrated with two different softwares in a scenario of ubiquitous learning, where the student profiles were dynamically updated, allowing them to better adapt to the environment.

As aforementioned, Profiles gather useful information of users in order to offer knowledge about their personal characteristics. Nowadays, a way to represent this knowledge is by the use of ontologies.

2.4 Ontologies

While phenomenally successful in terms of amount of accessible content and number of users, today's Web is a relatively simple artifact. Web content consists mainly of distributed hypertext and hypermedia, accessible via keyword-based search and link navigation. Simplicity is one of the Web's great strengths and an important factor in its popularity and growth, where even naive users quickly learn to use it and even create their own content (HORROCKS, 2008). However, this large amount of content also highlights serious issues in the hypertext paradigm. The required content becomes increasingly difficult to locate via search and browse, like finding information about people with common names. This problem only exists because the semantic data about these names can not be considered in regular search engines. To identify two identical names as different persons, the semantic data about these individuals also needs to be considered. This semantic data, also known as knowledge, can be provided by the use of ontologies.

An ontology, in its original meaning in philosophy, is a branch of metaphysics and denotes

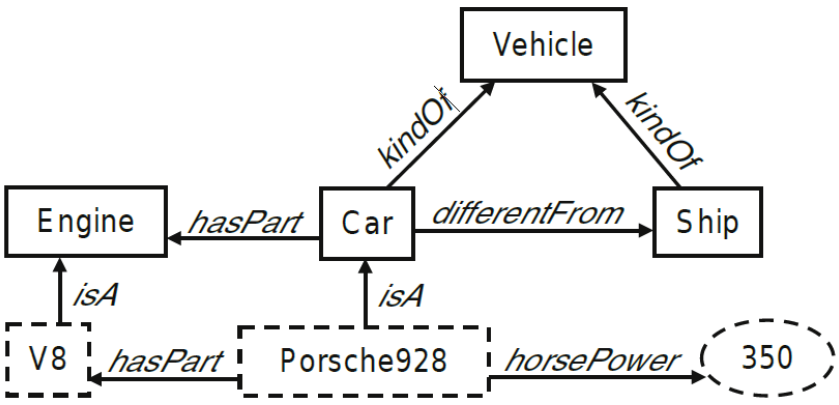
the philosophical investigation of existence. It is concerned with the fundamental question of "what kinds of things are there?" and leads to studying general categories for all things that exist dating back to the times of Aristotle (CRAIG, 1998).

Transferred to knowledge representation and Computer Science, information systems can benefit from the idea of ontological categorization. When applied to a limited domain of interest in the scope of a concrete application scenario, ontology can be restricted to cover a special subset of the world. Some examples of ontological categories in the technical vehicular domain are *Vehicle*, *Car* or *Engine*. In this sense, ontology provides a semantic vocabulary to define the meaning of things (GRIMM et al., 2011).

In short, ontologies are composed by the following items:

- **Classes:** they represent domain concepts, also being identified as *Thing*. In Figure 2, *Car*, *Engine*, *Ship* and *Vehicle* are examples of Classes;
- **Axioms:** they are restrictions applied on specific ontology elements, usually defined to delimit the knowledge domain;
- **Instances:** also known as *Individuals*, they represent the object or *Thing* of a class in the real world. In Figure 2, *Porsche928* and *V8* are examples of Instances;
- **Object properties:** they are the relationships between Classes. In Figure 2, *hasPart*, *differentFrom*, *kindOf* and *isA* are examples of Object properties;
- **Data properties:** they consist in relationships between a Class and a data type (i. e. number, string, URI). In Figure 2, *horsePower* is an example of Data property.

Figure 2: An example ontology as semantic network



Source: GRIMM et al. (2011)

According to NOY; MCGUINNESS et al. (2001), some of the reasons to develop an ontology are: share common understanding of the structure of information among people or software

agents, enable reuse of domain knowledge, make domain assumptions explicit, separate domain knowledge from the operational knowledge, analyze domain knowledge, and so on.

Exemplifying, the research of MIRANDA et al. (2017) proposes an ontology-based model for the representation of competences able to support a wide range of scenarios where it is fundamental to model, organize and represent professional competences, enable interoperability and co-operation among different and heterogeneous tools and, lastly, execute queries and inference operations over these competences. In his model, he started from the outcomes of the specialized literature and the related R & D projects and produced a novel integrated model that represents both job offers and demands to support recruiting initiatives and to develop employability strategies aiming at a best matching as well as a careful skill gap analysis.

2.5 Considerations about the chapter

This chapter presented the background and basic concepts of the terms utilized in this research. The first section pointed why the planning and design, main requirements of this research, are important to keep gamification in a successful path. The following section highlighted the main advantages of use personalization and adaptability with gamification. The third section described a way to implement adaptability and personalization by making use of Profile Management. As last, the fourth section described the main reasons to add a semantic value on all the technologies and concepts explained throughout this chapter.

3 RELATED WORKS

In this chapter is presented the whole process of a research technique used to map in the gamification field works related to this research. A total of 17 studies resulted from this technique. Each study was carefully classified under different aspects and categories. In this way, this chapter is organized in 7 sections. Sections 1 to 6 present information strictly related to the research technique performed, with further details about these sections explained in the first section. Section 7 presents the considerations about the chapter comparing the characteristics of the related works with the GamiProM model, further describing the most related work identified throughout the mapping process and highlighting important differences in relation to this research.

3.1 Systematic mapping study

With the objective of analyze in the existing literature gamification models with characteristics related to the ideas mentioned in the first chapter of this work, a systematic mapping was carried out. The aim is to provide a more structured view of the state of the art in the field and to identify possible trends, existing gaps and weaknesses (BUDGEN et al., 2008; COOPER, 2016; PETERSEN; VAKKALANKA; KUZNIARZ, 2015). Systematic mapping is a methodology that involves searching the literature to verify the nature, extent and number of studies published in the area of interest (PETERSEN et al., 2008). The next sections are structured as follows: section 2 presents the related systematic mappings. Section 3 describes how systematic mapping was planned. In Section 4 is presented the results obtained during the study, providing answers for the research questions. Section 5 discusses the results obtained in the study and section 6 presents the conclusions of the mapping with challenges that may lead to future works.

3.2 Related systematic mappings

To the best of my knowledge, in the relevant literature there are no systematic mapping studies about gamification models oriented to motivational characteristics. However, it is possible to find works providing the state of art in specific fields of gamification. In this line, PEDREIRA et al. (2015) conducted a systematic mapping study on gamification in the area of Software Engineering with the aim of characterizing the state of art in this field, identifying gaps and opportunities for future research. The author concluded that to analyze the impact of gamification in the area of Software Engineering, more research works in this field will need to be performed.

Systematic mapping studies about gamification focused on education are also present in the literature. The study of KLOCK et al. (2015), for example, performs a systematic map-

ping about the individual characteristics in the gamification of virtual learning environments, in order to verify if students with different characteristics react differently to the gamification elements. At the end of the study, the authors identified that characteristics such as age, gender, motivation, and many others can influence in the gamification of a virtual learning environment. The study of SOUSA BORGES et al. (2014) carries out a systematic mapping whose objective is to synthesize an overview about the area of gamification applied to Education. The authors concluded that the overview obtained through the mapping process suggests that most studies focused on investigating how gamification can be used to motivate students, improve their skills, and maximize learning.

3.3 Planning of the systematic mapping

The purpose of this study is to determine and characterize the state of art of gamification models with motivational characteristics, analyzing the existing proposals and research work and thus identifying potential gaps and opportunities for future research. Therefore, the main research question of this study is:

What is the state of art of Gamification Models oriented to motivational characteristics?

To carry out this systematic mapping, the recommendations of PETERSEN et al. (2008) were followed. In this section is presented the planning of each step of the study: research questions, data sources and search strategy, along with the classification criteria.

3.3.1 Research methods and questions

The research questions selected for this study attempt to provide specific information related to the relevant aspects of existing gamification models oriented to motivational characteristics. These include questions about the areas that the gamification models have been applied, what are the motivational factors included, what type of users are supported, which gamification mechanics and elements have been used in existing work, what designs have been used by the models, and what methods have been used to validate them. In an attempt to analyze more specific information about these models, focused questions were established to identify what models are generic, what are presented in the form of ontologies, what have adaptive or personalized characteristics, and what models support profiles. Statistical questions were also defined to identify how many models have appeared in recent years and in which type of research forums these works have been published. The research questions of this systematic mapping study are presented in Table 1.

Table 1: Research questions of the study

Ref.	Research question
General Questions	
GQ1	In what areas are the gamification models applied?
GQ2	What motivational factors are included in the gamification models?
GQ3	What user types the gamification models support?
GQ4	What are the gamification mechanics and elements present in the current models?
GQ5	What gamification designs the models follow?
GQ6	What methods are used to validate the models?
Focused Questions	
FQ1	What are the existing generic gamification models?
FQ2	What models are presented in the form of ontologies?
FQ3	What models have adaptive or personalized characteristic?
FQ4	What models support profiles?
Statistical Questions	
SQ1	How many gamification models have appeared in recent years?
SQ2	Where the gamification models have been published?

Source: Elaborated by the author.

3.3.2 Data sources and search strategy

To build the search string it was chosen the major search terms “Gamification” and “Model”. However, since the search process and filtering options available differ among the different search engines, the studies that include these two terms are not always returned, due to the way in which such terms are distributed throughout the studies. In this way, from these two terms, different “alternative terms” have been derived, thus providing the build of a broader search string, which was used similarly in all search engines, only being inserted in different ways according to the tools offered by each search engine. The search string, as well as the relationship of the main terms and their respective alternative terms can be seen in Table 2.

Table 2: Search string

Major terms	Alternative terms
Gamification	(("gamification" OR "gamified")
	AND
Model	("model" OR "ontology" OR "profile" OR "profile management" OR "profiles" OR "personalized" OR "customized" OR "adaptive"))

Source: Elaborated by the author.

Table 3 demonstrates the search strategy used in this study. The scope of the search considers academic publications (journals, conferences and workshops) over six different search engines (*ACM Digital Library*, *IEEE Explore*, *Science Direct*, *Scopus*, *Springer Link* and *Wiley Online Library*), applying the terms of the search string to abstracts, keywords and titles.

The study included papers that met all of the following criteria: have a gamification work

Table 3: Summary of the search strategy

Search strategy	
Academic databases searched	• ACM Digital Library
	• IEEE Explore
	• Science Direct
	• Scopus
	• Springer Link
	• Wiley Online Library
Target items	• Conference papers
	• Journal papers
	• Workshop papers
Search applied to	• Abstract
	• Keywords
	• Title
Language	• Papers written in English
Publication period	• Until September 2016

Source: Elaborated by the author.

represented as model, make use of the Software Engineering area, include motivational factors or user types, were published until September 2016. It was excluded every paper that met some of the following criteria: work consists in a literature review or systematic mapping study, not written in English, not accessible in full-text, book or gray literature, duplicated work. The selection strategy is presented in Table 4.

Table 4: Summary of the selection strategy

Selection strategy	
Inclusion criteria	
IC1	Gamification works represented as models
IC2	Works in the area of Software Engineering
IC3	Works that include motivational factors or user types / personalities
IC4	Works published until September 2016
Exclusion criteria	
EC1	Works consisting in literature reviews or systematic mapping studies
EC2	Works not written in English
EC3	Works not accessible in full-text
EC4	Books and gray literature
EC5	Duplicate works returned by different search engines

Source: Elaborated by the author.

3.3.3 Classification

Throughout the study, the papers were organized under twelve classification categories, corresponding to each of the research questions of the systematic mapping, including focused and statistical questions. In details, the classification highlighted from the papers are the following

data:

1. *Applied Area*: The area where the model was applied, independently of its specificity. This field is related to GQ1.

2. *Motivational Factor*: The motivational or engagement factors included in the model. Since there is no commonly-accepted taxonomy, the terms were standardized based on the most recent gamification design (MARCZEWSKI, 2015). This field is related to GQ2.

3. *User Type Supported*: The user types (or gamified user types) supported by the model, generally establishing a relation with a motivational factor. The taxonomy changes according to the gamification design, so the terms were also standardized based on the same design of GQ2 (MARCZEWSKI, 2015). Although user personalities are no user types, their relations are very similar to the motivational factors, so models supporting user personalities were also considered in the study. This field is related to GQ3.

4. *Gamification Mechanics / Elements*: This term has the most extensive variation among all of the classified data, since every model name is based on different sources of study (Points, Experience Points, XP). For such, the terms as usual were standardized based on the same design of GQ2 (MARCZEWSKI, 2015). This field is related to GQ4.

5. *Design Followed*: The gamification design followed by the model. Although there are many motivational designs that can be used to develop gamification models, only those that were developed with focus on gamification or gamified user types were considered. This field is related to GQ5.

6. *Validation Method*: Any official method used to validate or evaluate the model. This field is related to GQ6.

7. *Generic Model*: The specificity of the model, if it is generic or not, independently of its applied area. This field is related to FQ1.

8. *Ontology Representation*: If the model is represented in the form of ontologies. This field is related to FQ2.

9. *Adaptive / Personalized Model*: It determines if the model has any adaptive or personalized characteristic or purpose. This field is related to FQ3.

10. *Profiles Support*: It identifies if the model contains profiles on its concept or stores user related information on profiles. This field is related to FQ4.

11. *Year of publication*: The year that the study was published or presented. This field is related to SQ1.

12. *Type of publication*: The type of forum where the study was published. It can be academic journals, conferences or workshops. This field is related to SQ2.

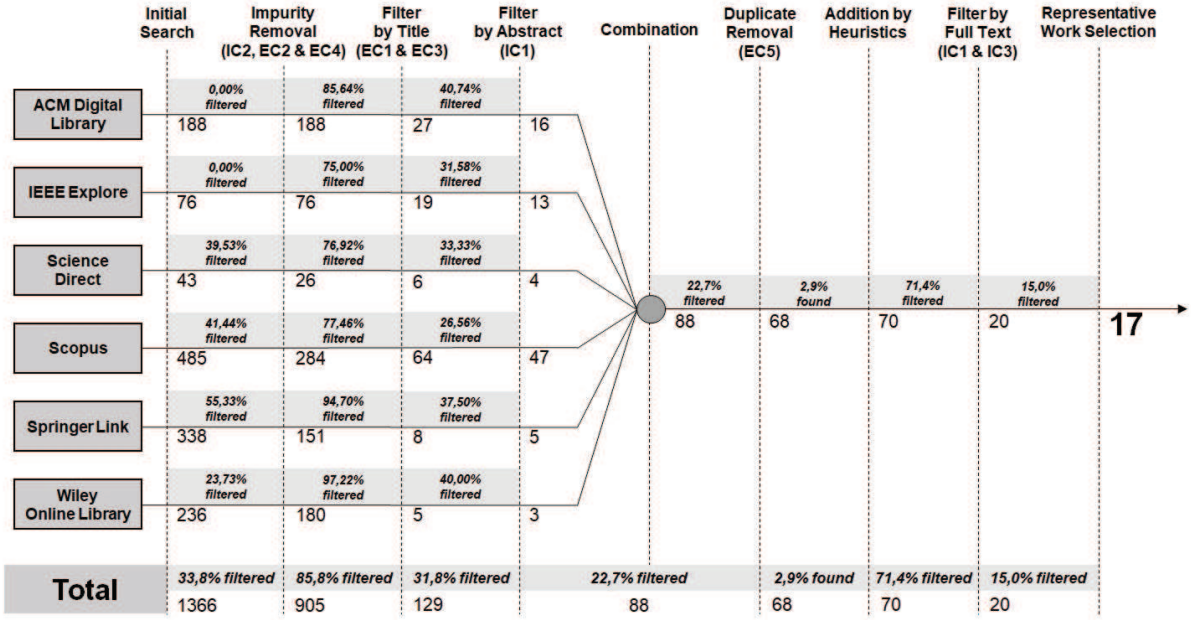
3.4 Results of the systematic mapping

In this section are presented the results of the systematic mapping. At first, the results of the search are explained, describing how the studies were filtered. Lastly, the data extracted from the studies are presented to answer each research question of the systematic mapping.

3.4.1 Results of the search

Figure 3 shows the different steps present in the studies filtering process. The searches were performed following the search string shown in Table 2 and in the Initial Search step a total of 1366 articles were returned over six different search engines. The searches were conducted at the end of September 2016, and no search filter was applied in this first return, such as a publication date limit period.

Figure 3: Studies filtering



Source: Elaborated by the author.

In the second filtering step, it was performed an Impurity Removal, this time applying the inclusion criteria (IC2) and the exclusion criteria (EC2) and (EC4), resulting in a reduction of the total number of results in 33.8%, totaling 905 works at the end of this step.

Subsequently, the studies were filtered by title, where the exclusion criteria (EC1) and (EC3) were applied. This step was the most thorough since it required a careful reading of each title in order to try to identify the main purpose of each work. As a result, it was possible to reduce the number of works to be mapped by 85.8%, which resulted in a total of 129 works.

In the fourth step, it was performed a filtering by abstract, applying the inclusion criteria (IC1). After the unification of results from different search engines (Combination step), a

reduction of 31.8% in the total number of results was observed, totaling 88 papers.

In the subsequent step, it was applied the exclusion criteria (EC5) to remove the duplicate studies, eliminating 22.7% (20) of the works resulting from the previous step.

In the next step (Addition by Heuristics), 2 papers compatible with the inclusion and exclusion criteria of the systematic mapping that were not returned in any of the search engines were added, increasing the number of results by 2.9% .

From the 70 papers resulting from the previous step, 71.4% of them were removed by applying the inclusion criteria (IC1) and (IC3) throughout the text (Filter by Full Text step), resulting in a total of 20 selected papers.

Analyzing the 20 works selected in the filtering step, it was observed that some studies from the same author or research group were technically similar, being updates of previously published studies. Thus, only the most representative study was selected and the remainder removed. Consequently, 3 studies were excluded (15%), totaling 17 selected representative works, which are listed in Appendix A.

3.4.2 Research questions

In this section, it was performed an analysis of the primary studies obtained from the results of the studies filtering process. Each information related to the gamification model present in the studies was classified and organized according to the research questions that have been outlined previously. The answers to the research questions, which include general questions (GQ), focused questions (FQ) and statistical questions (SQ) are described as follows:

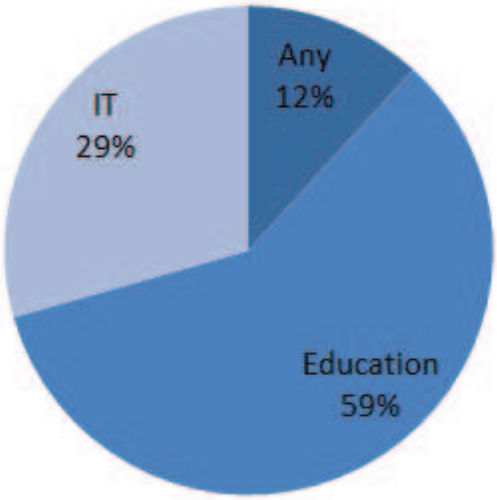
3.4.2.1 GQ1. In what areas are the gamification models applied?

Figure 4 shows the distribution of the primary studies according to the area that the gamification models were applied. The results of this classification show that 88% of the models were developed for and/or applied on a specific area, with the Education area being the target of more than half of the primary studies, where most of them present a gamification model to increase the motivation of learning processes.

Another area identified in this classification is the Information Technology (IT). This term (IT) was used to encompass related fields such as Information Systems, Computer Science, and so on. Five models were developed for this area, thus representing 29% of the representative studies.

The remaining models (12%) were classified under Any area due to the models not be focused or applied to a specific area. The classification of each primary study is described in Table 5.

Figure 4: Distribution of primary studies by applied area



Source: Elaborated by the author.

Table 5: Distribution of primary studies by applied area

Applied Area	Studies
Any	[A1], [A2]
Education	[A3], [A4], [A5], [A6], [A7], [A8], [A9], [A10], [A11], [A12]
IT	[A13], [A14], [A15], [A16], [A17]

Source: Elaborated by the author.

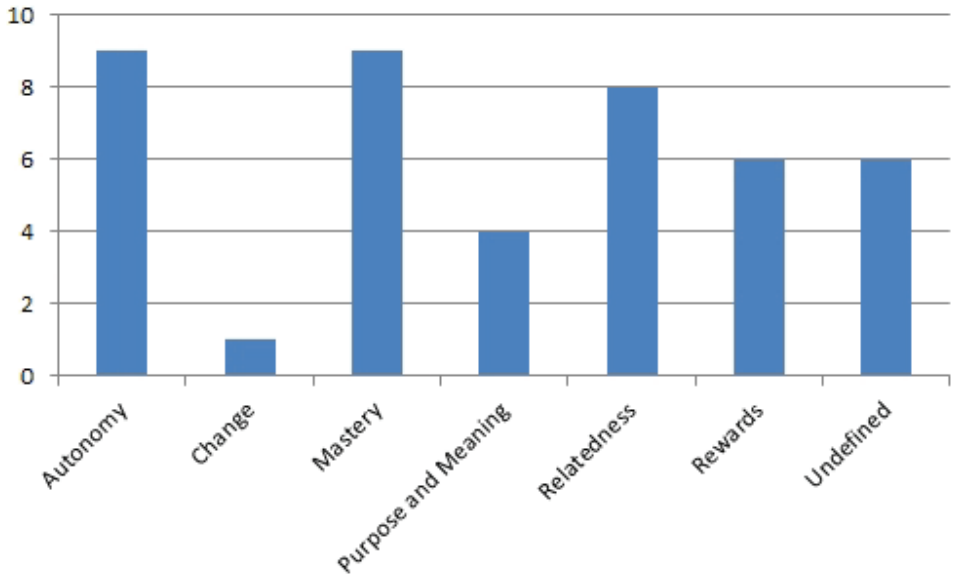
3.4.2.2 GQ2. What motivational factors are included in the gamification models?

The motivational factors mapped in this work followed the definitions present in the gamification design Hexad (MARCZEWSKI, 2015). In short, they can be defined as:

- *Autonomy*: The need to feel independence or freedom;
- *Change*: The desire to perform positive or negative changes;
- *Mastery*: The desire to learn new skills and develop expertise in them;
- *Purpose and Meaning*: The feeling of greater meaning or a desire to be altruistic;
- *Relatedness*: The desire to be connected to others;
- *Rewards*: The desire to collect rewards.

Figure 5 shows the distribution of the primary studies according to the motivational factors identified throughout the models. Among the 17 studies selected, a total of 43 motivational factor occurrences was identified (after the terms' standardization). Autonomy and Mastery are the main motivations used by the models, with 20.9% of the occurrences each.

Figure 5: Distribution of primary studies by motivational factor



Source: Elaborated by the author.

The less used motivations by the models are Change and "Purpose and Meaning", with only 2.3% and 9.3%, respectively. However, 35.3% of the studies did not mention motivational factors in their models, thus representing 14% of the total occurrences and being classified as "Undefined". The classification of each primary study is described in Table 6.

Table 6: Distribution of primary studies by motivational factor

Motivational Factor	Studies
Autonomy	[A1], [A3], [A4], [A6], [A8], [A9], [A11], [A14], [A16]
Change	[A11]
Mastery	[A1], [A3], [A4], [A6], [A7], [A8], [A9], [A12], [A14]
Purpose and Meaning	[A3], [A6], [A8], [A12]
Relatedness	[A1], [A3], [A4], [A7], [A9], [A11], [A14], [A16]
Rewards	[A3], [A4], [A8], [A11], [A12], [A16]
Undefined	[A2], [A5], [A10], [A13], [A15], [A17]

Source: Elaborated by the author.

3.4.2.3 GQ3. What user types the gamification models support?

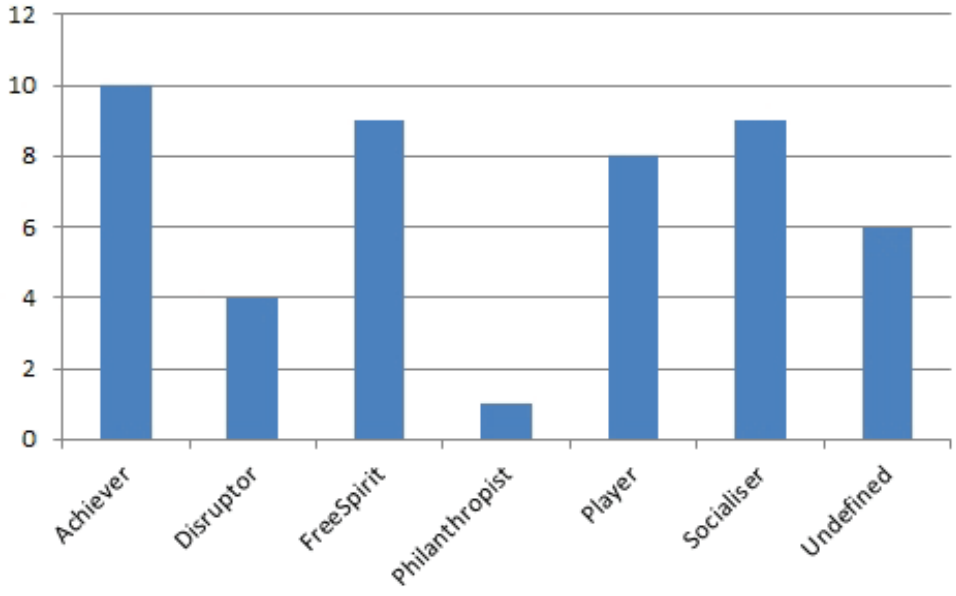
To adopt the same organization utilized in GQ2, the user types mapped followed the definitions present in the gamification design Hexad (MARCZEWSKI, 2015). In brief, they can be defined as:

- *Achiever*: It looks to gain knowledge, learn new skills and improve itself. It usually wants challenges to overcome;

- *Disruptor*: It wants to disrupt a system, either directly or through other users to force positive or negative change;
- *FreeSpirit*: It wants to create and explore;
- *Philanthropist*: It is altruistic, wanting to give to other people and enrich the lives of others in some way (with no expectation of reward);
- *Player*: It will do what is needed to collect rewards from a system and not much more. It is in it for itself;
- *Socialiser*: It wants to interact with others and create social connections.

Figure 6 shows the distribution of the primary studies according to the gamification user types identified throughout the models. Among the 17 studies selected, a total of 47 user type occurrences was identified (after the terms' standardization). Achiever, FreeSpirit and Socialiser are the main user types used by the models, with 21.3% and equally 19.1% of the occurrences, respectively.

Figure 6: Distribution of primary studies by user type



Source: Elaborated by the author.

The less used user types by the models are Disruptor and Philanthropist, with only 8.5% and 2.1%, respectively.

According to the design selected to standardize the terms in this study (MARCZEWSKI, 2015), the motivational factors and user types relate with each other with a cardinality of one-to-one. Nevertheless, there is a variation present in the amount of results, due to some studies do not make use of both terms. Despite of that relation, it was also identified that 35.3% of the studies did not mention user types in their models, thus representing 12.8% of the total

occurrences and being classified as “Undefined”. The classification of each primary study is described in Table 7.

Table 7: Distribution of primary studies by user type

User Type	Studies
Achiever	[A2], [A3], [A4], [A5], [A6], [A7], [A10], [A13], [A15], [A17]
Disruptor	[A2], [A5], [A6], [A11]
FreeSpirit	[A2], [A3], [A4], [A5], [A6], [A10], [A11], [A15], [A17]
Philanthropist	[A3]
Player	[A2], [A4], [A5], [A6], [A10], [A11], [A13], [A17]
Socialiser	[A2], [A3], [A4], [A5], [A6], [A7], [A10], [A11], [A17]
Undefined	[A1], [A8], [A9], [A12], [A14], [A16]

Source: Elaborated by the author.

3.4.2.4 GQ4. What are the gamification mechanics and elements present in the current models?

Figure 7 presents the distribution of the primary studies according to the gamification mechanic or element identified throughout the models. After the terms’ standardization, a total of 137 occurrences was identified among the 17 studies selected. *Badges/Achievements*, *Points/ExperiencePoints(XP)* and *Leaderboards/Ladders* are the main gamification elements and mechanics used by the models, with equally 9.5% and 8.8% of the occurrences, respectively.

The less used gamification elements and mechanics by the models are *Collect&Trade*, *Learning/NewSkills*, *Meaning/Purpose*, *Theme* and *TimePressure*, with 0.7% of the occurrences each.

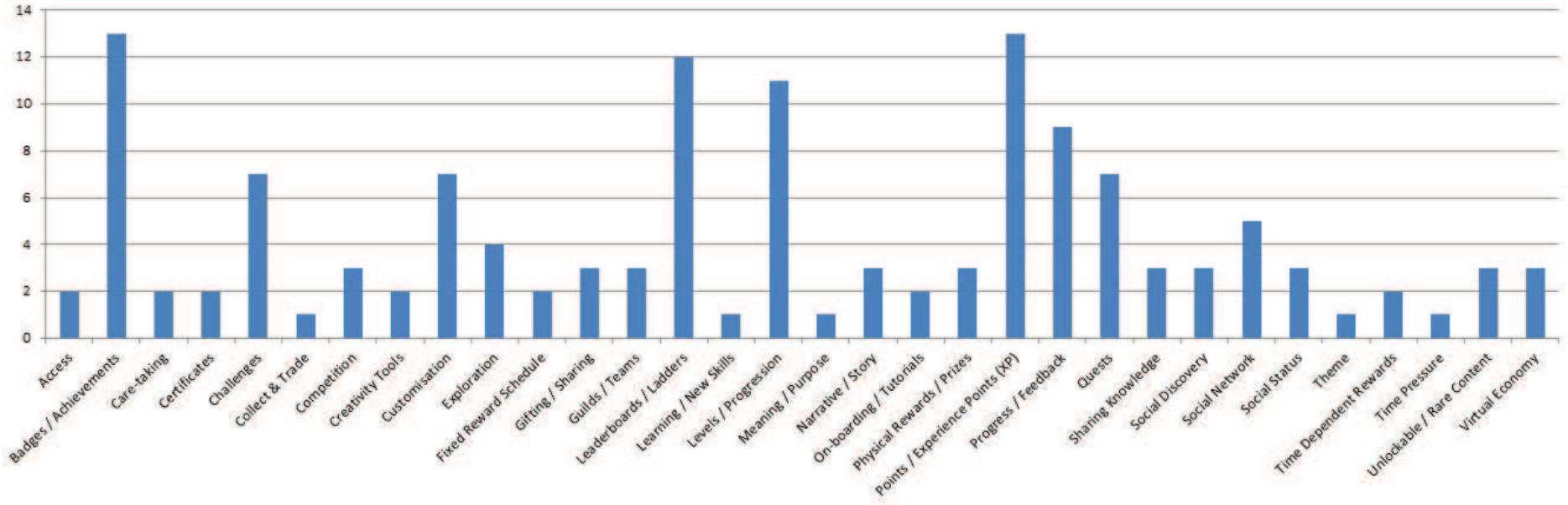
Even with a considerable variety of gamification mechanics and elements (totalling 32) identified in the models, 15 terms present in the design of MARCZEWSKI (2015) were not used, thus concluding that the resulting models of this study cover 68.1% of the complete set of gamification mechanics and elements available.

3.4.2.5 GQ5. What gamification designs the models follow?

Figure 8 shows the distribution of the primary studies according to the gamification design followed by the models. The results of this classification show that 41.2% of the studies do not follow any externals gamification design, thus representing 31.8% of the total occurrences and being presented as “Unclassified”, since they can be following their own design.

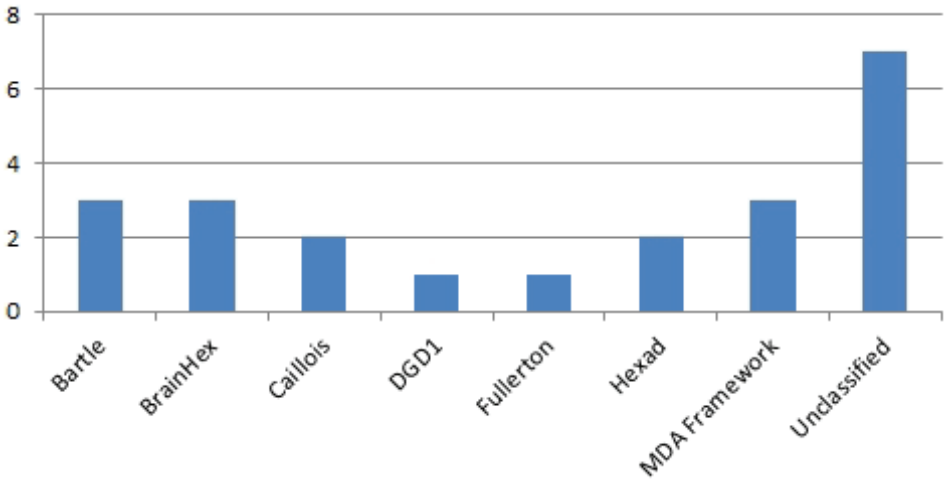
The less used gamification designs by the models were DGD1 (Demographic Game Design) and Fullerton, with 4.5% of the occurrences each. Some gamification designs do not have an official name, so for such studies the name of the author who created the gamification design

Figure 7: Distribution of primary studies by gamification mechanic / element



Source: Elaborated by the author.

Figure 8: Distribution of primary studies by design followed



Source: Elaborated by the author.

was used.

It is also important to highlight that some designs provided by the results of this study were built or inspired on other (and previous) designs, by making use of some ideas and concepts, so future research in the next years could help to identify the most followed gamification design over the time. The classification of each primary study is described in Table 8.

Table 8: Distribution of primary studies by design followed

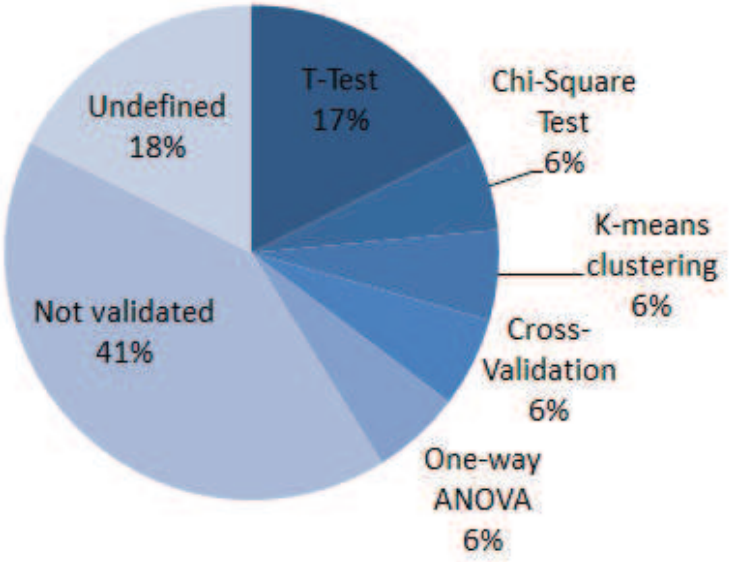
Design Followed	**Studies**
Bartle	[A2], [A10], [A15]
BrainHex	[A2], [A5], [A6]
Caillois	[A2], [A11]
DGD1	[A2]
Fullerton	[A2]
Hexad	[A3], [A4]
MDA Framework	[A8], [A10], [A12]
Unclassified	[A1], [A7], [A9], [A13], [A14], [A16], [A17]

Source: Elaborated by the author.

3.4.2.6 GQ6. What methods are used to validate the models?

Figure 9 presents the distribution of the primary studies according to the methods used to validate the models. The results of this classification show that 59% of the models were not validated or at least did not mention throughout the text any validation method used, being classified in this study as “Not validated” and “Undefined”, respectively. A factor that justifies this elevated percentage is the fact that some studies were still on their conceptual stage, thus resulting in premature models.

Figure 9: Distribution of primary studies by validation method



Source: Elaborated by the author.

Five different validation methods were identified among the remaining models (41%). The validations were used not only to verify if the model accomplishes its purpose but also to evaluate among the different uses provided by the model where it succeeds or fails. The classification of each primary study is described in Table 9.

Table 9: Distribution of primary studies by validation method

Validation Method	Studies
T-Test	[A5], [A13], [A16]
Chi-Square Test	[A10]
K-means clustering	[A4]
Cross-Validation	[A6]
One-way ANOVA	[A17]
Not validated	[A1], [A2], [A7], [A9], [A11], [A12], [A15]
Undefined	[A3], [A8], [A14]

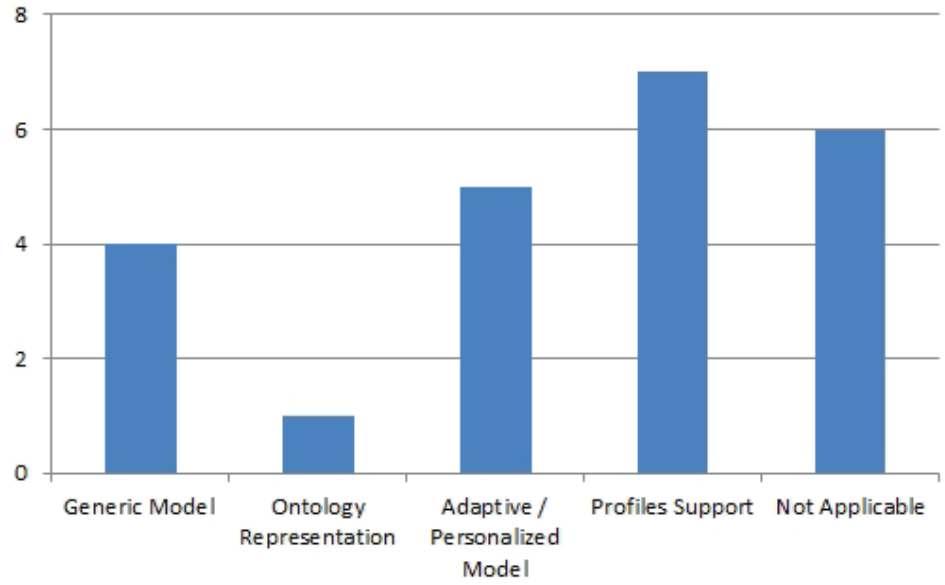
Source: Elaborated by the author.

3.4.2.7 FQ1. What are the existing generic gamification models?

Figure 10 presents the distribution of the primary studies organized by the focused question identified in the models. For a better viewing, all of the questions were presented in the same figure, including an extra data representing the studies that did not answer positively to any of the focused questions, thus being grouped as "Not Applicable". The classification of each primary study is described in Table 10.

The results of this classification show that 4 studies developed a generic gamification model, thus representing 23.5% of the total studies.

Figure 10: Distribution of primary studies by focused question



Source: Elaborated by the author.

Table 10: Distribution of primary studies by focused question

Focused Question	Studies
What are the existing generic gamification models?	[A1], [A2], [A3], [A5]
What models are presented in the form of ontologies?	[A7]
What models have adaptive or personalized characteristic?	[A5], [A6], [A7], [A9], [A15]
What models support profiles?	[A4], [A5], [A6], [A9], [A14], [A15], [A17]
Not Applicable	[A8], [A10], [A11], [A12], [A13], [A16]

Source: Elaborated by the author.

The classification decision used to answer this question is provided by the studies that explicitly informed that their models had an generic purpose or use, despite of the area they were (if applicable) designed to.

3.4.2.8 FQ2. What models are presented in the form of ontologies?

The results of this classification show that only 1 study developed a gamification model represented by an ontology, resulting in only 5.9% of the total studies.

The classification decision used to answer this question is provided by the studies that used ontologies as a core component of their models, making use of their advantages to provide a gamification model with knowledge representation.

3.4.2.9 FQ3. What models have adaptive or personalized characteristic?

The results of this classification show that 5 studies developed an adaptive or personalized gamification model, thus representing 29.4% of the total studies.

The classification decision used to answer this question is provided by the studies which the main purpose is to provide adaptive or personalized gamification or that explicitly informed that their models contain such characteristic. Most of these studies also make use of profiles as a mean to provide adaptability or personalization.

3.4.2.10 FQ4. What models support profiles?

The results of this classification show that 7 studies developed a gamification model that supports profiles, being the highest percentage of positive results among the studies (41.2% of the total studies).

The classification decision used to answer this question is provided by the studies which explicitly stated that their models support user profiles or can keep user related information on profiles, even for those that in first instance do not make use of that information.

A total of 6 "Not Applicable" studies also resulted from the classification process, representing 35.3% of the models that do not answer positively to any of the focused questions selected for this study.

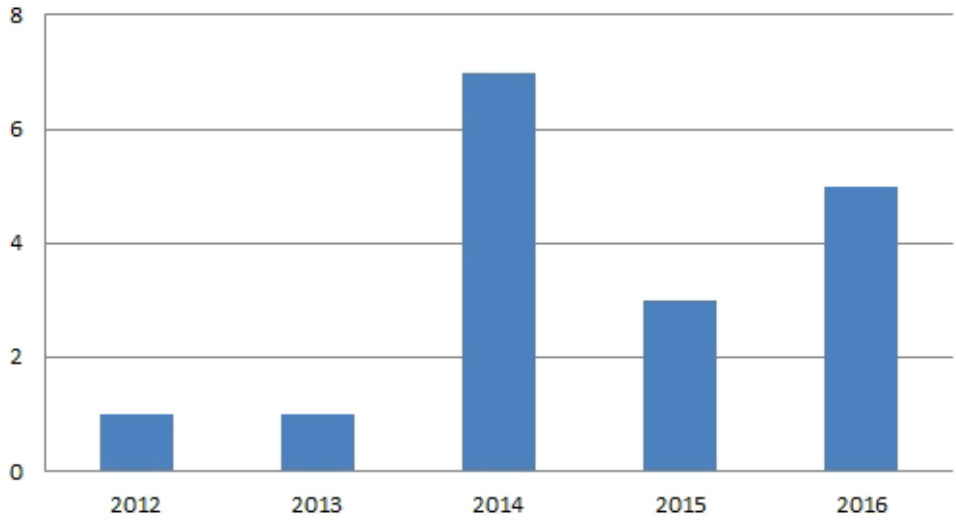
3.4.2.11 SQ1. How many gamification models have appeared in recent years?

Figure 11 presents the distribution of the studies classified by the year they were published. The first primary study presenting a gamification model that follows the criteria of this Systematic Mapping Study appeared in 2012. The same result appeared in the subsequent year. The number of studies published in 2014 is seven times bigger than in 2013, and the number was less than a half in 2015 compared to the previous year. However, the number of primary studies published in the first three quarters of 2016 already exceeds the number of papers published in 2015. This result seems to follow the same growth trend of gamification in general (Google Trends, 2017), that is not specifically focused on models. According to WERBACH; HUNTER (2012), the first use of gamification as it is nowadays understood happened in the year 2003. On the other hand, and according to DETERDING et al. (2011), the first documented use of the term "gamification" happened in 2008.

3.4.2.12 SQ2. Where the gamification models have been published?

Figure 12 presents the distribution of primary studies by the type of forum in which they have been published. The classification shows that 77% of them were published as conference

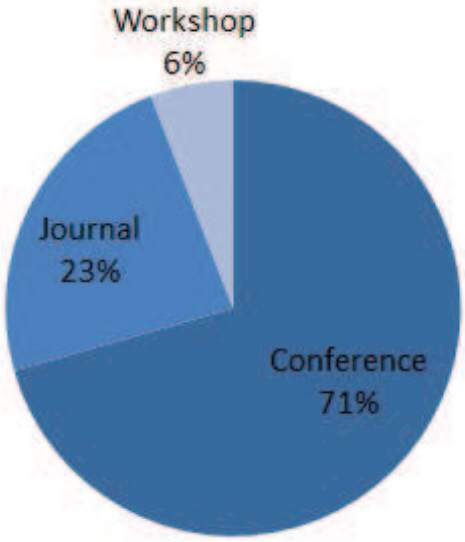
Figure 11: Distribution of primary studies by year



Source: Elaborated by the author.

or workshop papers, being 71% in conferences and only 6% in workshops.

Figure 12: Distribution of primary studies by type of forum



Source: Elaborated by the author.

Almost one-quarter of the papers were published in journals, representing 23% of the total results and indicating that the majority of the research under these aspects is still somehow preliminary. Table 11 presents the primary studies for each type of forum.

Another interesting information to analyze are the conference's occurrences. Whilst many of them present only 1 representative study, 3 studies ([A9], [A11] and [A15]) were presented in the same conference, entitled as *Proceedings of the Second International Conference on Technological Ecosystems for Enhancing Multiculturality*. This certainly indicates that gamification received a particular focus on that event.

Table 11: Distribution of primary studies by type of forum

Type of Forum	Studies
Conference	[A1], [A2], [A3], [A4], [A5], [A9], [A11], [A12], [A13], [A15], [A16], [A17]
Journal	[A6], [A8], [A10], [A14]
Workshop	[A7]

Source: Elaborated by the author.

3.5 Discussion

In this section is discussed the results obtained from the classification and analysis of the studies, along with an identification of gaps and opportunities for future research.

As a result of this analysis, the first point to highlight in this work is the lack of material in the literature concerning gamification models oriented to motivational characteristics, which is the main research question of this study. After many filtering steps, from the 1366 results obtained in the Initial Search, only 17 studies were approved throughout the filtering process, representing only 1.25%. It is true, however, that many models available do not consider including motivational characteristics, since if this restriction were removed, the representative work selection would have been a way bigger (more than 2 times the current amount).

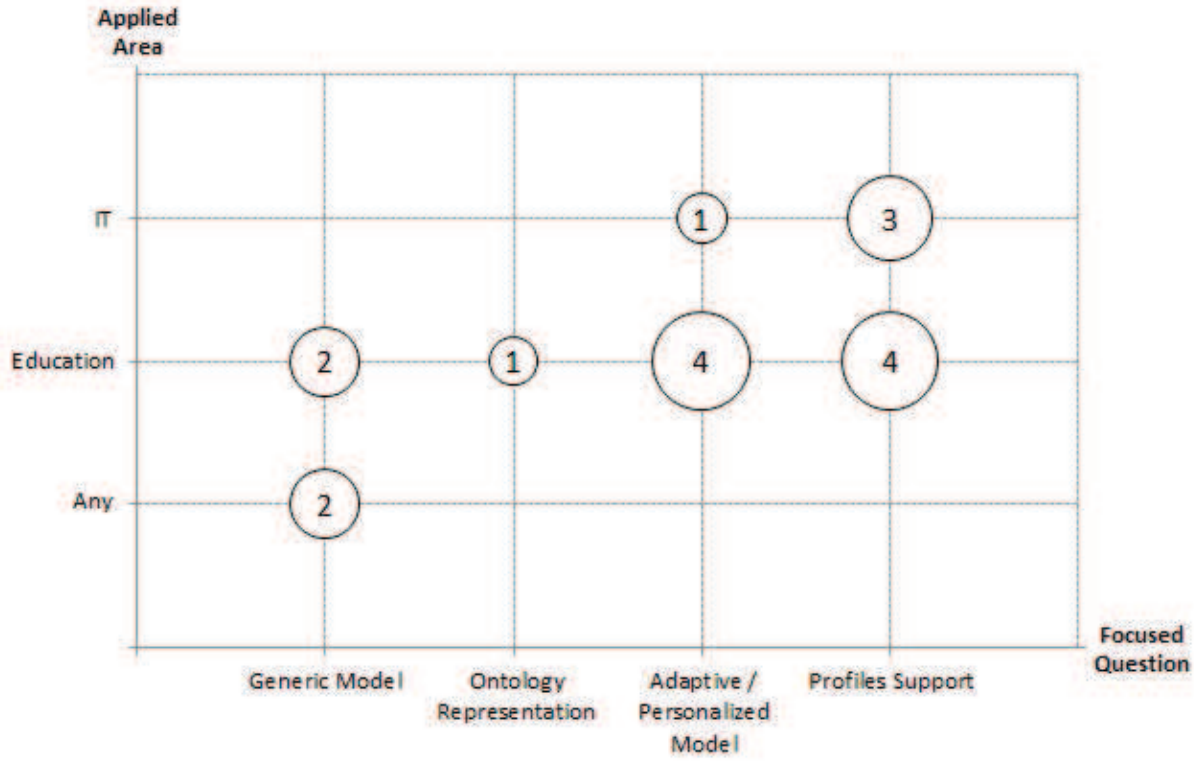
As mentioned before, it was also observed that only a small part of the studies selected have been published as journal articles, which indicates that the status of the research is somehow preliminary, reinforced by the fact that almost 60% of the studies do not validate or evaluate their models.

Another important result collected from this study is the focus of the works on the Education area. It is very conclusive that the literature is interested in different attempts to increase the motivation of learning processes, as can be seen in Figure 13. It is the only area with studies covering all the focused questions of this study, although they are provided by different studies, once it was not found a unique study answering positively to all of the focused questions.

A possible gap found in this analysis is the use of ontologies to represent the knowledge of the models. Only 1 study (5.9% over all studies) developed a gamification model using ontologies. With an extensive amount of gamification mechanics and elements, motivational factors and user types available in the gamification field, ontologies and its applicability can be a powerful tool to engage future researches and provide new possibilities for gamification models.

A tendency found in this study is the common choice of motivational factors and user types applied in the models, identified throughout the data extraction process. As mentioned before, the terms were standardized in order to be able to provide statistical data about the information collected from the models. In short, this standardization creates a relation between the motivational factor and the user type, where a specific motivational factor motivates a specific user type. Even with that relation not being present in many models, once some of them make exclu-

Figure 13: Summary of classification (Applied Area by Focused Question)



Source: Elaborated by the author.

sive use of motivational factor or user type, the results confirmed the aforementioned relation. The most used motivational factors by the models are Autonomy, Mastery and Relatedness, which means that the most motivated user types by the models are FreeSpirit, Achiever and Socialiser.

Gamification is indeed very effective and can provide an increase of motivation, but will it be effective when implemented randomly or following a poor gamification model? In previous years, Gartner (PETTEY; MEULEN, 2012) predicted that "80% of current gamified applications will fail to meet business objectives primarily due to poor design". As stated previously, more than 40% of the models resulted from this study do not follow any known gamification design, also indicating that even models might follow the same success rate path of gamified applications.

A second analysis studying the applied area of gamification models was made, now focusing on the gamification mechanics and elements selected, as can be seen in Figure 14. Following the same pattern observed in Figure 13, the area which provides most coverage is Education. But a dubious question remains: are the selected mechanics and elements the best choice for their models? There is a strong tendency to choose the mechanics and elements identified as *Badges/Achievements*, *Points/ExperiencePoints(XP)*, *Leaderboards/Ladders* and *Levels/Progression* as the main option to be applied in these models, but will they reach their goal in the Education area? With many segments under the Education area, will these choices

be the safest way to build a successful model? Moreover, which of these elements have their effectiveness proven on their application area? Among an enormous variation of mechanics and elements available, developers must be very careful with their choices, considering psychological needs of the users, their types and personalities, factors that motivate them and most important: “do not follow any path just because everybody’s doing it” (DAVIS, 1993).

3.6 Conclusions of the systematic mapping and future work

In this section is presented the conclusion about the systematic mapping study conducted to characterize the state of art of gamification models with motivational characteristics. After carrying out the search for primary studies, they were classified according to eight categories, namely the areas that the gamification models have been applied, what motivational factors were included, what type of users they supported, which gamification mechanics and elements have been used, what designs the models followed, what methods have been used to validate them, how many models have appeared in recent years and in which type of research forums they were published. It was also created an additional classification according to four categories (in response to the focused questions of the study), namely the models that are generic, what are presented in the form of ontologies, what have adaptive or personalized characteristic and what models support profiles.

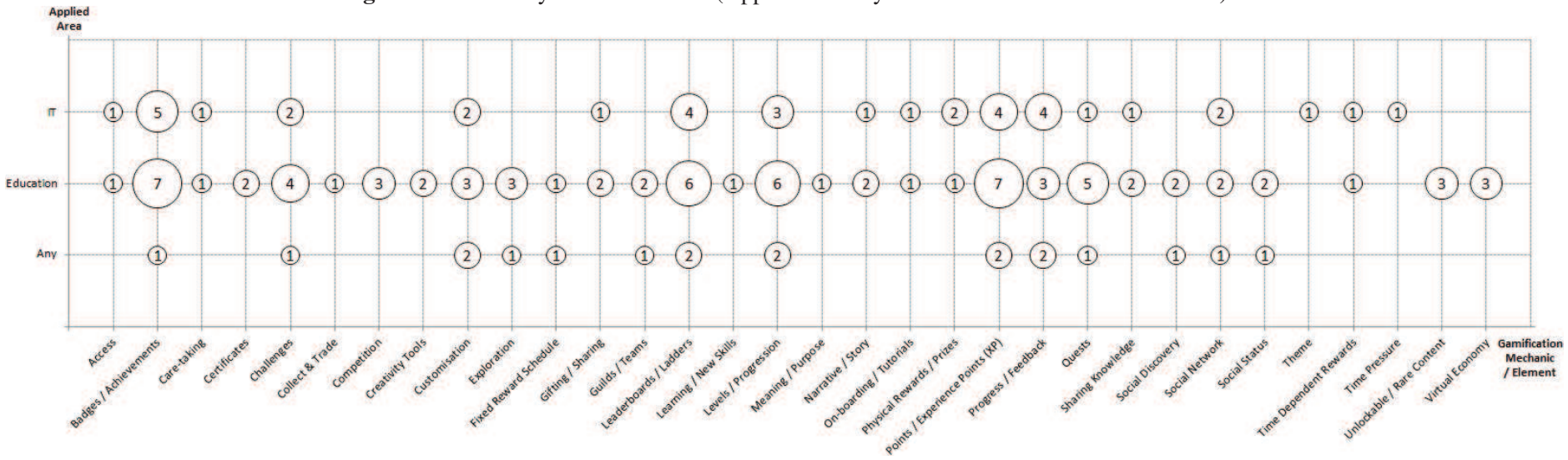
The results obtained during the analysis of the primary studies show that the existing research of gamification models is somehow preliminary and immature, since most studies have been published in workshops or conferences, and few of them were validated or evaluated due to be in a conceptual stage of development. Further research providing empirical results about the application of these models would provide richer information about the effectiveness of their gamification proposals.

Most of the analyzed studies focus on Education, commonly referred as “Gamification of Learning”. This leads to an important gap in the field, since gamification by itself offers mechanics and elements to be applied on diversified areas, and Education is not the only area which suffers with lack of motivation by the users.

Another aspect that deserves further research effort is the gamification design to be followed when a model is being created. As an opinion, it was concluded that gamification designs offer an opened way to build a model, not referring to the implementation itself but to the gamification knowledge that needs to be carefully analyzed. More than 40% of the models did not follow a gamification design, resulting in similar choices of gamification mechanics and elements between them, so different options should have been considered and explored a little more.

Another research gap found during the study is the lack of user type analysis. Although some models analyzed the whole scenario of possibilities, many of them followed the same trend, thus also choosing the same motivational factors. Unpopular user types like Disruptor

Figure 14: Summary of classification (Applied Area by Gamification Mechanic / Element)



Source: Elaborated by the author.

and Philanthropist certainly have a space in some areas, although they were completely ignored by many models.

A research opportunity found is the development of gamification models that comply with all of the focused questions proposed in this study. Many combinations were identified, but with most of them only answering positively in up to half of the questions. It is believable that a model with generic purposes, making use of the benefits of ontologies, organizing all of the gamification user types and their motivations in profiles to provide adaptability and personalization, surely covers the existing research gaps highlighted in this work and deserves a full evaluation to validate the aforementioned concepts, thus proving its applicability.

From the results of the systematic mapping, it is possible to conclude that the development of gamification models is still growing, and more areas and uncovered gamification mechanics and elements should appear in future researches, as well as the number of studies and the completeness of their ideas.

3.7 Considerations about the chapter

This chapter presented a variety of results obtained from a systematic mapping study performed in the gamification field. In order to provide a simplified view of the characteristics analyzed in the representative studies in comparison with this research, a comparison table was created to highlight the main differences among the studies and in relation to the GamiProM model. These characteristics, described in Table 12, are used to identify if the gamification model presented in the representative study follows a gamification design, is validated, has a generic purpose, is represented in the form of ontologies, provides personalization / adaptability and makes use of user profiles. The model proposed in this research is mainly focused on support gamified profiles by managing and identifying the different motivations of the users, but it also answer positively to the others characteristics, once it follows a gamification design (Hexad), has generic purposes, is represented in the form of ontologies, has support for adaptability and most importantly, is validated.

Although every representative study is identified as a related work of this research, the study indexed as the entry [A7] in the Appendix A can be considered the most similar work by make use of similar resources such as ontologies to organize the concepts and knowledge of the gamification model, also providing a semantic value for it. However, even the model having adaptive / personalized characteristics, it does not inform if the information about the users is organized in profiles. Also, the model is directed to the Education area, focusing on Collaborative Learning, what differs from this research that has a generic purpose, described with more details in the next chapter.

Table 12: Related works characteristics comparison

Research Work	Follows Design	Validated Model	Generic Model	Ontology Representation	Personalized / Adaptive Model	Profiles Support
[A1]	*No*	*No*	**YES**	*No*	*No*	*No*
[A2]	**YES**	*No*	**YES**	*No*	*No*	*No*
[A3]	**YES**	*No*	**YES**	*No*	*No*	*No*
[A4]	**YES**	**YES**	*No*	*No*	*No*	**YES**
[A5]	**YES**	**YES**	**YES**	*No*	**YES**	**YES**
[A6]	**YES**	**YES**	*No*	*No*	**YES**	**YES**
[A7]	*No*	*No*	*No*	**YES**	**YES**	*No*
[A8]	**YES**	*No*	*No*	*No*	*No*	*No*
[A9]	*No*	*No*	*No*	*No*	**YES**	**YES**
[A10]	**YES**	**YES**	*No*	*No*	*No*	*No*
[A11]	**YES**	*No*	*No*	*No*	*No*	*No*
[A12]	**YES**	*No*	*No*	*No*	*No*	*No*
[A13]	*No*	**YES**	*No*	*No*	*No*	*No*
[A14]	*No*	*No*	*No*	*No*	*No*	**YES**
[A15]	**YES**	*No*	*No*	*No*	**YES**	**YES**
[A16]	*No*	**YES**	*No*	*No*	*No*	*No*
[A17]	*No*	**YES**	*No*	*No*	*No*	**YES**
GamiProM	**YES**	**YES**	**YES**	**YES**	**YES**	**YES**

Source: Elaborated by the author.

4 THE GAMIPROM MODEL

This chapter presents the model of this research, entitled GamiProM, describing the modeling of the system and important artifacts related to it. At first, the architecture of the model is presented. Subsequently, the GamiProM Ontology and its importance in the system is described in details, explaining the methodology used in the development process, its composition and structure, the inference rule created and an example of executable semantic query. At last, the GamiProM Application is presented, explaining its functional requirements, the respective unfolded UML diagrams, the Graphical User Interface, the different modules it contains, and some details of the OWL API.

4.1 Overview

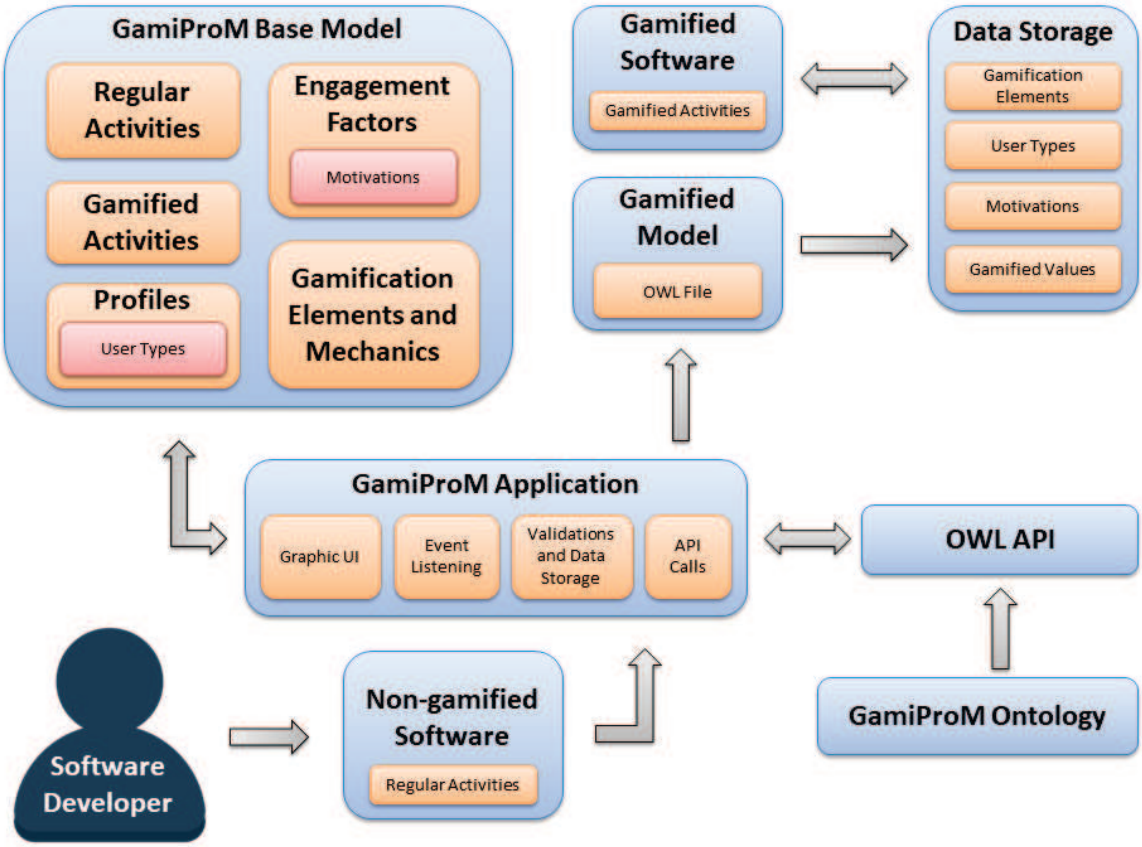
The work of this research, entitled as GamiProM, is a model composed by an application that combined with an ontology helps developers to build a gamified solution for any software. Although there are some gamification ontologies available online (Data Science Lab, 2016), they are very limited in terms of Classes and Object Properties, which means a limited amount of gamification elements available and no motivations or user types are present. Due to this reason, the reuse of other gamification ontologies was discarded and the GamiProM Ontology was created from scratch, following the gamification design of MARCZEWSKI (2015), which gives to it the ability to properly organize its gamification knowledge and relations among its different elements, also clearly highlighting the different user types motivated by these elements.

The main objective of GamiProM is to generate, after the execution of specific steps, gamified solutions supporting motivations and providing gamified knowledge in a semantic format from a list of activities informed by the user (in this case, the software developer). This gamified knowledge is an OWL file containing the gamification model that will be integrated in the developer's application. It has not only the gamified activities and respective gamification elements that need to be created, but also from which activities they were originated, the user types that are going to be motivated by these elements, the motivational factors involved and most important, a structured organization adjusted by the developer to provide and maintain adaptability at runtime in the final application.

4.2 Architecture

This section presents the architecture of the GamiProm model. It is composed by eight components, identified as *Non-gamified Software*, *GamiProM Application*, *OWL API*, *GamiProM Ontology*, *GamiProM Base Model*, *Gamified Model*, *Data Storage* and *Gamified Software*. A visual representation of the architecture, exhibiting the organization of the components can be seen in Figure 15.

Figure 15: Model Architecture



Source: Elaborated by the author.

A brief detail about each component is described as follows:

1. **Non-gamified Software:** it represents the software that is going to be gamified, whether it is still in the development stages or already implemented and executing. The regular (non-gamified) activities of this software are used to create the gamified activities of the generated model;

2. **GamiProM Application:** the application displayed as a GUI responsible to offer all the required interactions needed to build the gamified model, including the input and output of data, event listening, validations and API calls;

3. **OWL API:** the API responsible to provide access and manipulate ontologies, returning the results to the GamiProm Application. It offers means of communication between the GamiProM Application and the GamiProM Ontology, also managing requests that demand semantic content generation;

4. **GamiProM Ontology:** it contains the gamification design and information required by the application to build the adaptive gamified model, such as *Classes*, *Object Properties*, *Data Properties* etc;

5. **GamiProM Base Model:** it represents the ontological gamified model built in memory that groups all of the information related to the gamified solution generated in the GamiProM Application, such as the regular activities registered, the engagement factors (motivations) selected, the gamified activities created along with their respective gamification elements and mechanics retrieved from the GamiProM Ontology and the Profiles (User Types) motivated by the selected engagement factors;

6. **Gamified Model:** it is the gamification solution exported by the GamiProM Application as an OWL File using the RDF/XML Syntax;

7. **Data Storage:** it represents the storage component of the software that will be gamified. Independently of its structure, whether it is a relational database or purely a plain text file, is must store the essential gamified data contained in the exported model. This data is composed by the Gamification Elements representing the Gamified Activities, the Motivations provided by the elements, the User Types associated to those Motivations and most importantly, the Gamified Values defined on each Gamified Activity;

8. **Gamified Software:** it consists in the "front-end" or "view layer" of the Gamified Software. It must be adjusted to access all of the new gamified information contained in the Data Storage component, as well as implement the necessary requests that will generate the new profiles (user types) of each user utilizing the gamified software.

4.3 GamiProM Ontology

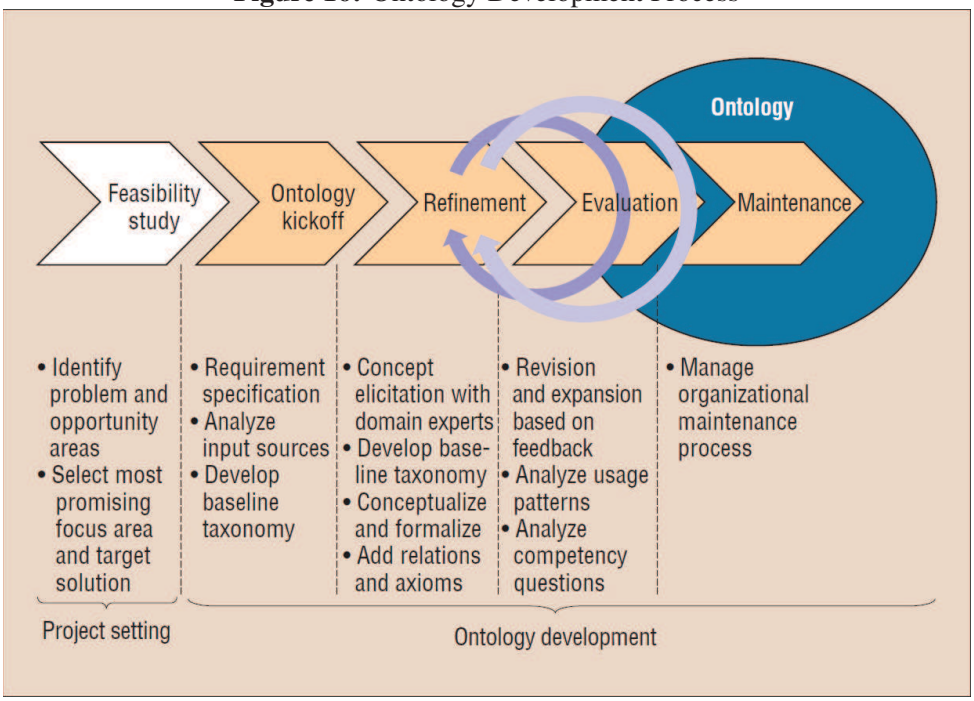
As mentioned in the first section of this chapter, the GamiProM Ontology is one of the main components of the GamiProM model and it is based on the gamification design of MARCZEWSKI (2015). The development process of the GamiProM Ontology was based on the recommendations present in the methodology of STAAB et al. (2001), where the conceptual phases are briefly explained in Figure 16.

A more detailed description about each phase of the development process applied in the ontology of this research is listed as follows:

- **Feasibility study:** in this phase it was identified the common problem involving gamification models and also gathered the required information to build a solution for the opportunity area that involves adaptive models oriented to motivational factors;

- **Ontology kickoff:** in this phase the requirements of the ontology were specified, which includes the ontology's goal, its domain and scope, supported applications and usage scenarios. The competence questions and relevant terms of the ontology are listed in the Appendix B and C, respectively. It was also searched for reusable ontologies, but none proper for reuse under the structure of this research was found;

Figure 16: Ontology Development Process



Source: STAAB et al. (2001)

- **Refinement:** in this phase the connections and restrictions present in the gamification design were mapped as relations and axioms in the ontology. Some of the relations were implicit, thus being mapped as inference rules;
- **Evaluation:** in this phase the ontology was analyzed in order to verify its adherence in relation to the competence questions listed in the Appendix B;
- **Maintenance:** from the evaluation phase onward, no changes or adjustments were needed.

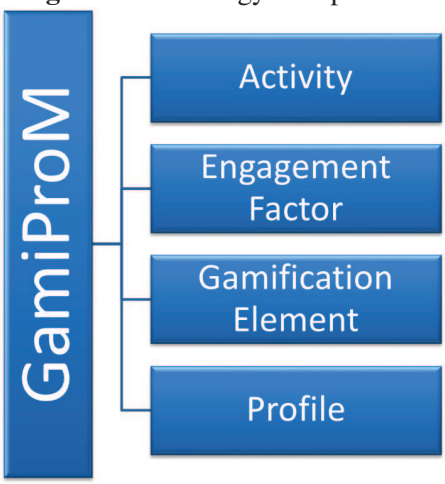
4.3.1 Composition

The major composition of the GamiProM ontology is presented in Figure 17, illustrating the essential information needed for an initial understanding of the gamification model.

The basic relations of each information is listed as follows:

- **Activity:** it contains the instances of every activity present in the non-gamified application that will be integrated to a gamification element, mechanic or idea to generate a gamified activity;
- **Engagement Factor:** it is the type of motivation provided by a gamified activity that will motivates a specific user type;
- **Gamification Element:** it is the generic representation (superclass) of an extensive variation of gamification elements, mechanics and ideas, i. e. Leaderboards or Achievements,

Figure 17: Ontology Composition



Source: Elaborated by the author.

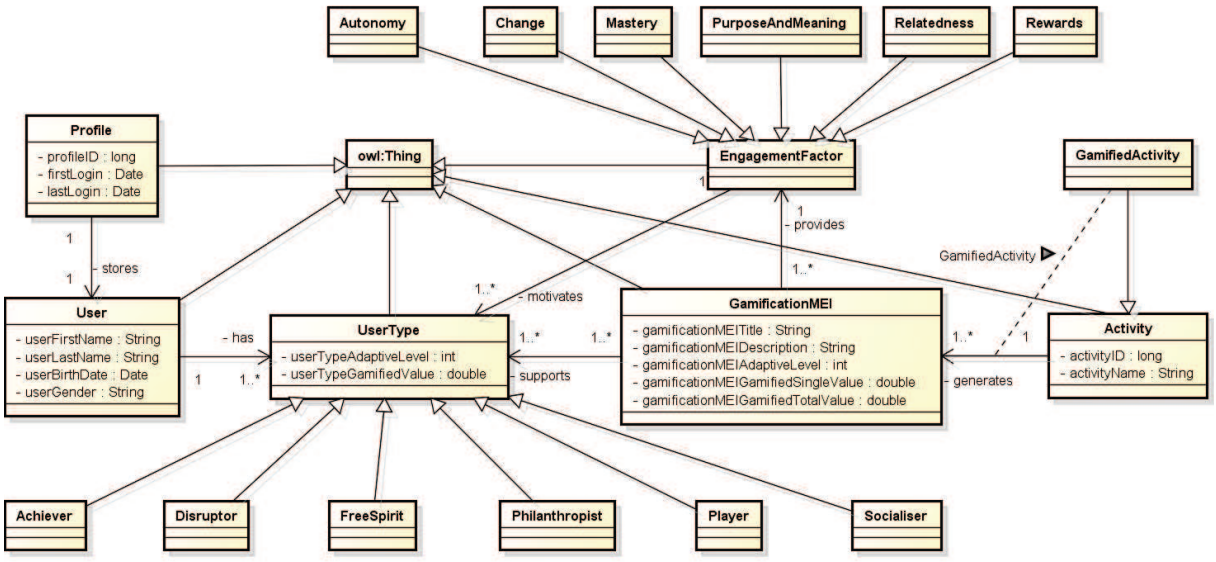
which supports different user types and integrates with non-gamified activities;

- **Profile:** it is the main record of a user, storing essential data about the user and all of its relations, i. e. user types.

4.3.2 Structure

The complete view of the ontology's classes, relations and cardinalities is illustrated in Figure 18. The class *GamificationMEI* is collapsed due to the high amount of subclasses it contains (i. e. *Quests*, *Challenges*, *Achievements*, *Leaderboards*).

Figure 18: Ontology Class Diagram



Source: Elaborated by the author.

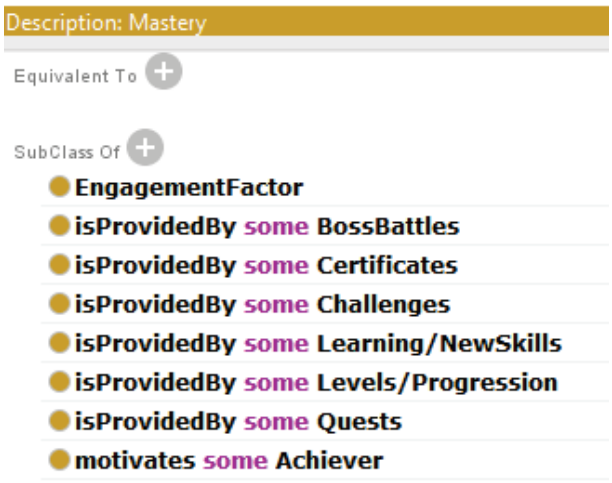
The GamiProM Ontology is based on six main classes, where three of them are specifically

related to gamification concepts. Every gamification element is mapped as a subclass of *GamificationMEI*, being "*MEI*" an abbreviation of mechanic, element or idea. The other two classes are *EngagementFactor* and *UserType*. The object properties used by these classes are provides, motivates and supports, where *GamificationMEI* provides *EngagementFactor*, *EngagementFactor* motivates *UserType* and *GamificationMEI* supports *UserType*. Both *GamificationMEI* and *UserType* classes contain data properties required to track the user's gamified behavior with personalization.

The classes related to profile management are *Profile* and *User*. The *Profile* class is responsible for keeping data related to the application. The *User* class contains data related to the person using the application. The object property used by these classes is stores, where *Profile* stores *User*. The gamified profile of a *User* is associated by the object property has, defining a relation between *User* and *UserType*, where *User* has *UserType*.

Some concepts present in the gamification design applied in the GamiProM ontology were converted into relationships among the subclasses of *GamificationMEI*, *EngagementFactor* and *UserType*. The relationships are required to define the domain and range of these subclasses in order to make the design compatible with adaptability and profile management. An example of the relationships of *Mastery* (*EngagementFactor* subclass) can be seen in Figure 19.

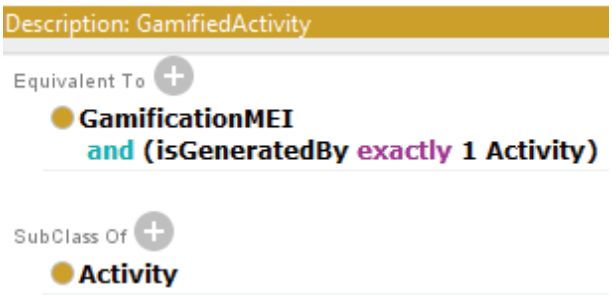
Figure 19: Relationships of Mastery (EngagementFactor subclass)



Source: Elaborated by the author.

The main focus of the GamiProM ontology is to provide enough knowledge to help developers to create gamified activities in their applications, thus making them gamified applications. To reach this objective, the first step to be executed is select what activities performed by the users of the non-gamified application can be converted into gamified activities by the integrating them with specific *GamificationMEI* subclasses. This concept can be semantically defined as an equivalence axiom stating that every instance of *GamificationMEI* that has a relationship named as *isGeneratedBy* with exactly one instance of *Activity* is also an instance of *GamifiedActivity*, as can be seen in Figure 20.

Figure 20: Equivalence Axiom of GamifiedActivity



Source: Elaborated by the author.

As an exemplification, let's consider an educational app that has an activity where the user must correctly answer all the questions. It is possible to convert it into a gamified activity by assigning a badge or achievement to this activity, thereby allowing it to provide the engagement factor *Rewards*, which supports users of the type *Player*, once in the ontology the gamified activity will also be identified as an instance of the *Badges/Achievements* class.

The data property *gamificationMEIAdaptiveLevel* is a metric used to personalize what gamified elements are displayed by the app for a specific user based on his behavior and the value stored in the data property *userTypeAdaptiveLevel*. Both *gamificationMEIAdaptiveLevel* and *userTypeAdaptiveLevel* are data properties that store an integer based number that starts from 1.

The data property *gamificationMEIGamifiedTotalValue* is a positive decimal based number that when summed with the equivalent data property of others *GamificationMEI's* subclasses which support the same *UserType* and have the same *gamificationMEIAdaptiveLevel* must not exceed 1. This value works as a "weight" for the elements and is used to properly distribute the amount of instances (individuals) of a given element (class) among all the others elements from the same engagement factor, assuring the effort required by the user to complete tasks linked to it will be the closest possible compared to the elements of others engagement factors, eliminating the possibility of an element have some "execution advantage or facility" over another element. The data property *gamificationMEIGamifiedSingleValue* is also a positive decimal based number and is used to define the single value of an instance (individual) of a given element (class), thus composing the *gamificationMEIGamifiedTotalValue* of that class. This is mandatory to track and maintain a consistent profile progress view of every user.

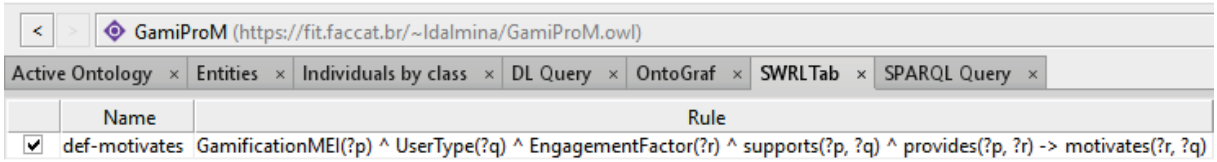
The GamiProM ontology also has specific data properties for use on *UserType's* subclasses, identified as *userTypeAdaptiveLevel* and *userTypeGamifiedValue*. Every time a user completes a gamified activity on an app, the *userTypeGamifiedValue* is increased based on the *gamificationMEIGamifiedSingleValue* of that gamified activity. If the user doesn't have a *UserType*, it will be created based on the *EngagementFactor* that motivates it. Once the *userTypeGamifiedValue* reaches the same value of *userTypeAdaptiveLevel*, the *userTypeAdaptiveLevel* will be increased by 1, so the more a user interacts with a gamified element, the bigger its user type *gamifiedValue* and *adaptiveLevel* will be, thus making available for it gamified activities that

have higher *gamificationMEIAdaptiveLevel*.

4.3.3 Inferences

Any gamified scenario present in the GamiProM ontology is widely navigable due to the use of the inverse property *inverseOf* by all of the object properties created, allowing the reasoner to perform inferences over these relations. However, for relationships that need a sequence of conditions be satisfied to exist, an inference rule written in SWRL was created. The Figure 21 shows the rule *def-motivates*, used by the reasoner to infer which instances implicitly have the relationship identified as *motivates*.

Figure 21: Inference rule def-motivates



Source: Elaborated by the author.

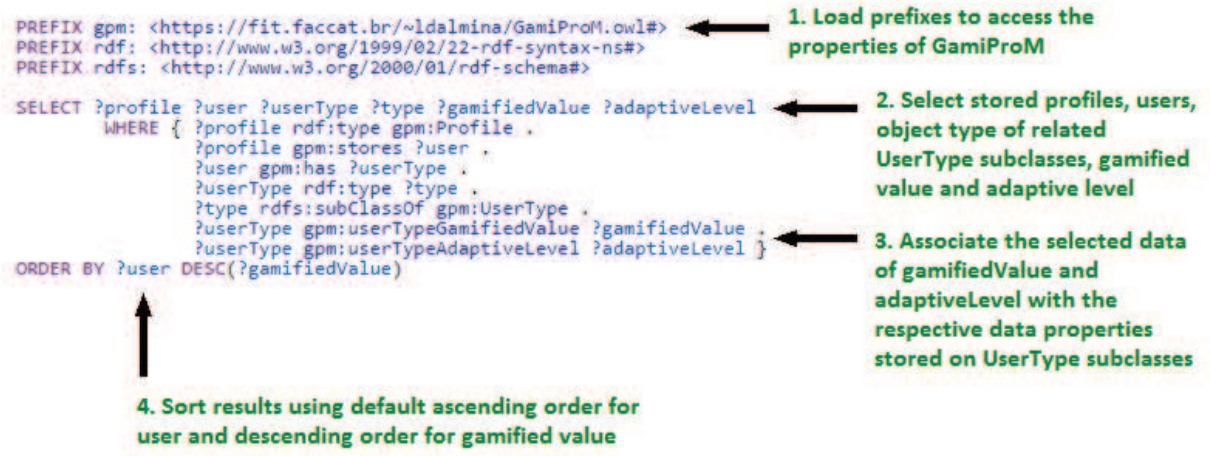
4.3.4 Queries

Once the knowledge present in the GamiProM ontology is structured in a semantic format, it is possible to perform queries in the stored data. If the software developer maintain over the time the consistency of the OWL structure generated by the GamiProM application, after the collection of the first results obtained by the gamified application, queries already can be executed to identify additional information about the collected data. Figure 22 shows an example of SPARQL query which informs every profile and respective user, user type, gamified value and adaptive level stored in the ontology, ordered by user and sorted by a descending order of gamified value.

4.4 GamiProM Application

Another component of this model is the GamiProM Application, responsible to generate the gamified solution using all of the others components of this model. The application contains a variety of concepts and elements, named as Functional Requirements, UseCase Diagrams, Sequence Diagram, Graphical User Interface, Modules and *OWL API*, explained in details in the following subsections.

Figure 22: SPARQL query example



Source: Elaborated by the author.

4.4.1 Functional Requirements

The functional requirements presented in this section define the features of the application contained in the model also describing its functions. A list of these functions is explained as follows:

- **Register Activity:** the application must be able to register the existing activities of the software (or project) that is going to be gamified;
- **Select Desired Motivation:** the application must offer six different motivational factors to be manually chosen;
- **Select Gamification Elements:** when at least one motivational factor is selected, the application must display and allow the selection of the respective gamification elements that are related to these motivational factors;
- **Request Gamification Design:** the application must be able to retrieve from GamiProM ontology all the classes that have a relation with the motivation selected;
- **Generate Gamified Activities:** the application must provide an interface able to generate gamified activities originated from the integration of an activity and a gamification element;
- **Generate Default Gamified Levels:** the application must generate a default gamified level for each gamified activity created;
- **Organize Adaptive Levels:** the application must allow the definition and organization of adaptive levels for gamified activities;

- **Verify Gamified Model:** the application must allow the verification of the gamified model;

- **Validate Gamified Levels:** when a verification is requested, the application must validate every gamified activity and its adaptive level associated following specific constraints;

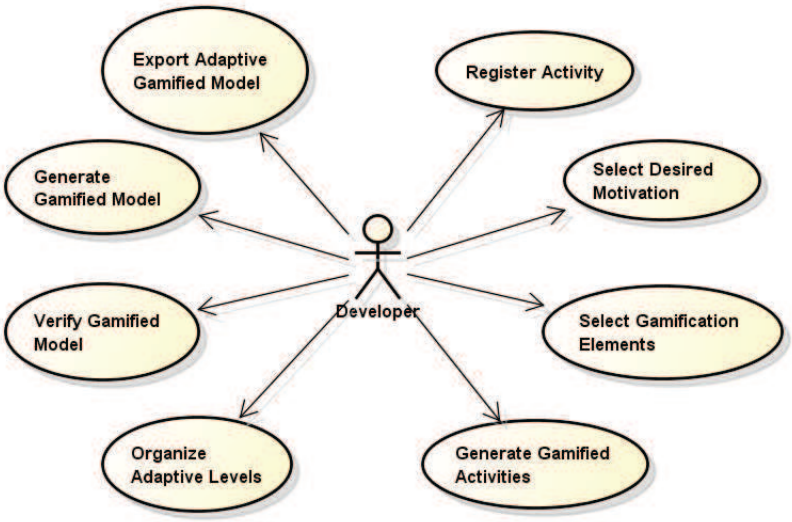
- **Generate Gamified Model:** the application must be able to generate the gamified model with all the definitions provided by the user;

- **Export Adaptive Gamified Model:** the application must be able to export the final adaptive gamified model providing an OWL file to the user.

4.4.2 UseCase Diagrams

After the specification of all functional requirements, the UseCase diagrams were created. Two actors were identified for this research, one being identified as the *Developer* and the other the *Application*. Figure 23 shows the UseCase diagram where the actions of the *Developer* actor are illustrated.

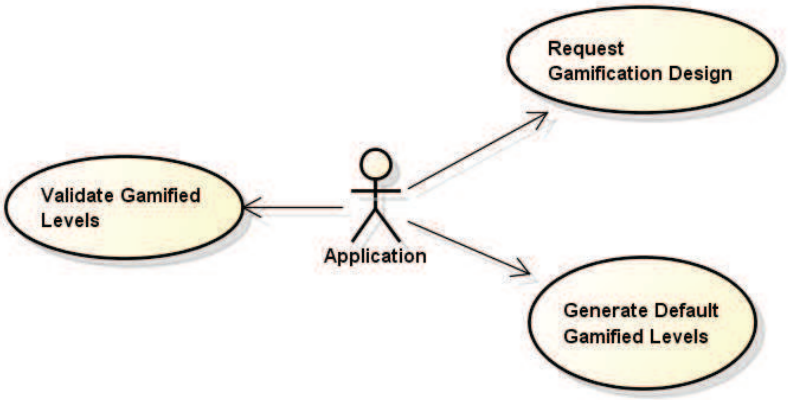
Figure 23: UseCase Diagram (Client)



Source: Elaborated by the author.

As a convention, UseCase diagrams usually refers to the actors as *Client* and *Server*. In this research, the *Client* is the *Developer* and the *Server* is the *Application*. As follows, Figure 24 shows the UseCase diagram where the actions of the *Application* actor are illustrated.

Figure 24: UseCase Diagram (Server)



Source: Elaborated by the author.

4.4.3 Sequence Diagram

Another useful artifact provided by UML is the Sequence Diagram. It allows in a single view the exhibition of messages exchanged by different entities of the system, also highlighting the sequence where they happen. The entities, in this model, refers to the *Developer*, the *Application* and the *GamiProM Ontology*. To better document the sequence of actions performed by the system, it was created a Sequence Diagram of the application contained in the GamiProM model, as can be seen in Figure 25.

4.4.4 GUI

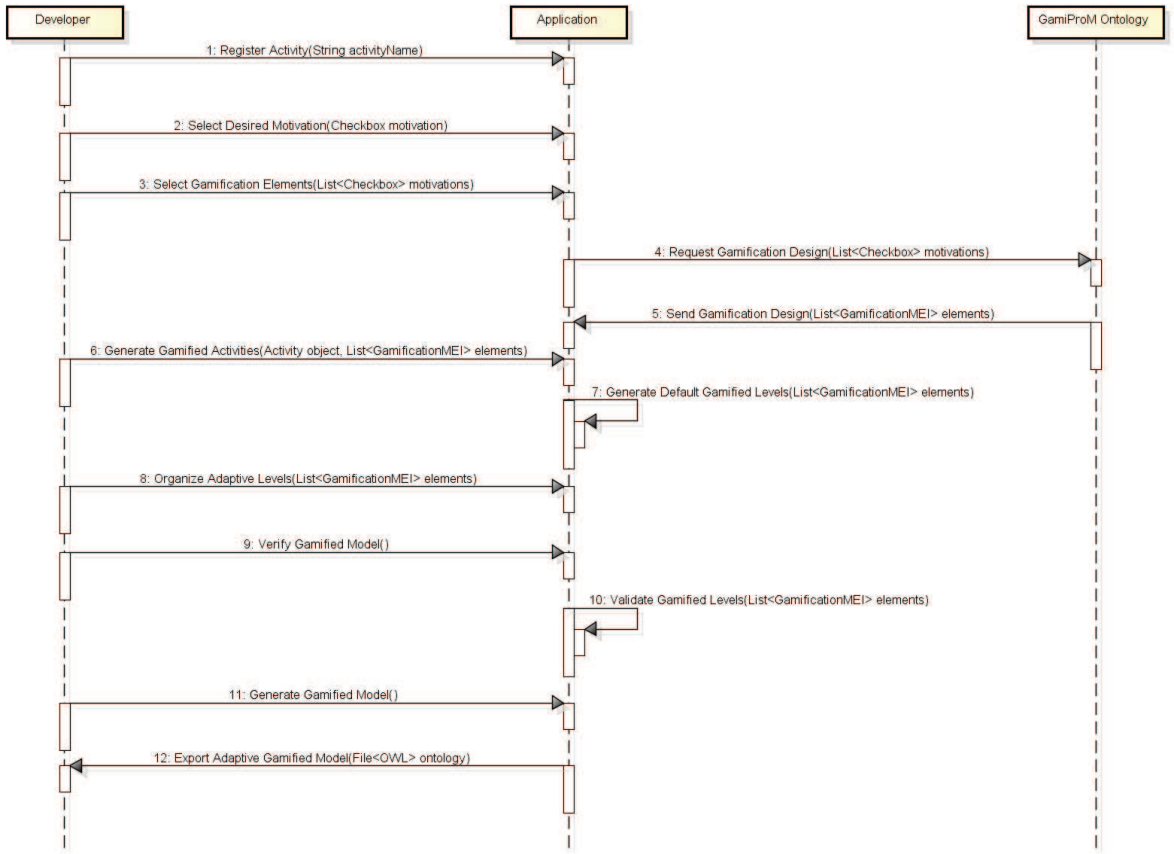
Identified as the Graphical User Interface, this element interacts directly with the software developer, receiving the input data and handling all the events that reproduce a code execution for specific routines. The GUI was build in a Java SE Project, making use of Java Swing to display the graphical components and organizing all the dependencies with Maven, a software project management. The GUI of the GamiProM Application is composed by a single *JForm* containing a set of components like *JFrame*, *JPanel*, *JLabel*, *JTextField*, *JButton* etc. The screen of the application is presented in Figure 26.

4.4.5 Modules

The GamiProM Application is organized in 7 different modules, numbered by the sequence of execution in order to generate the gamified models (as can be seen in Figure 26). Each module is represented as a *JPanel* component in the application, containing a set of other components within it.

Details about each of these modules are described as follows:

Figure 25: Sequence Diagram



Source: Elaborated by the author.

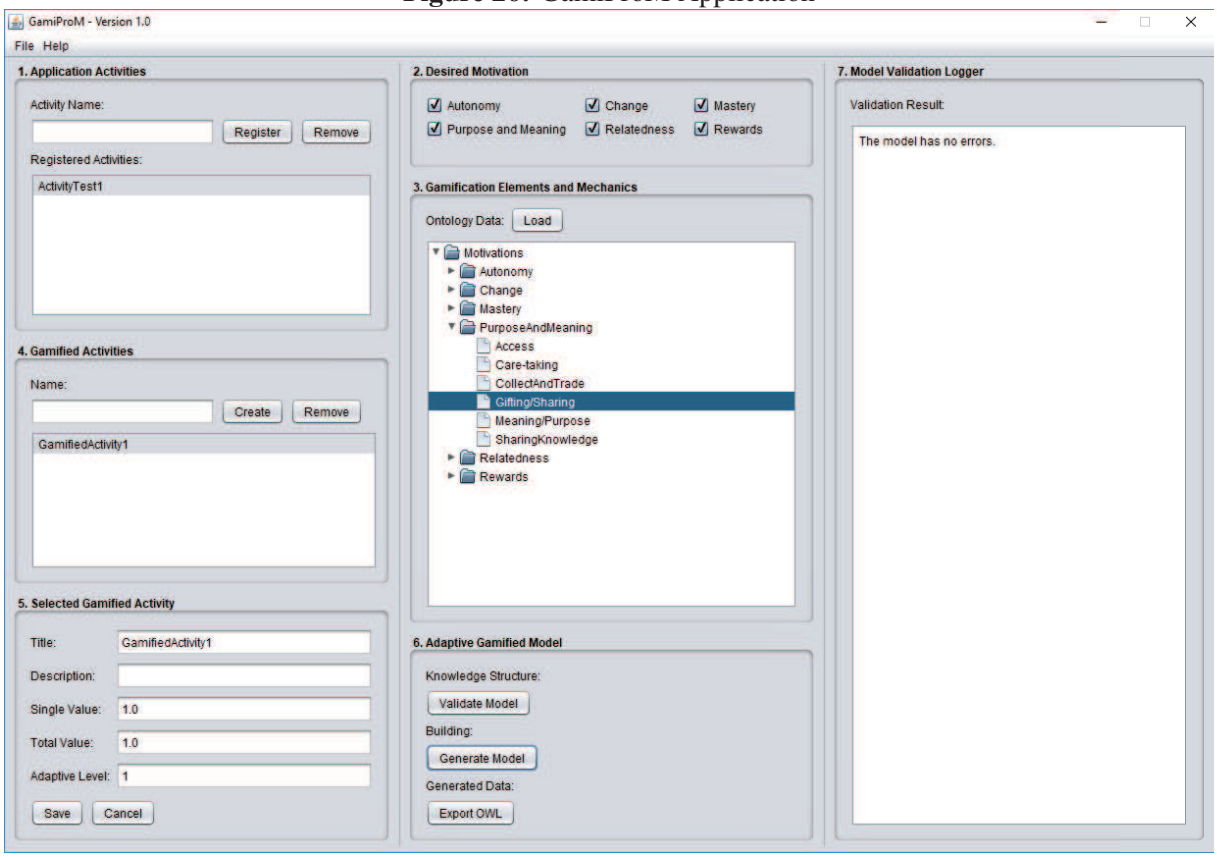
1. **Application Activities:** it manages the activities list, allowing the user to register new activities or remove existing ones. An activity cannot be removed while it is associated to a gamified activity;

2. **Desired Motivations:** it provides to the user up to 6 different motivations (engagement factors) to be selected. The motivations work as filters to limit the variety of gamification elements and mechanics that will be retrieved on the module 3;

3. **Gamification Elements and Mechanics:** it creates a motivations tree containing all of the objects (GamificationMEI subclasses) that matched the motivations selected in module 2. This tree reflects part of the structure present in the GamiProM ontology, where each leaf node of the tree is grouped under its respective provided motivation;

4. **Gamified Activities:** it manages the gamified activities list, allowing the user to create new gamified activities or remove existing ones. In order to create a gamified activity, the user must selected a non-gamified activity (module 1) and a leaf node from the motivations tree (module 3). This is mandatory to maintain the equivalence axiom of the object *GamifiedActivity* (Figure 20), meaning that a gamified activity can only be cre-

Figure 26: GamiProM Application



Source: Elaborated by the author.

ated when a gamification element and a non-gamified activity are associated to it. Each gamified activity is represented in the application as an instance of a java class named *GamifiedActivity*;

5. **Selected Gamified Activity:** it contains all the components required to receive the input data that belongs to a gamified activity, working as its properties. This data reflects the data properties present in the GamiProM ontology that contains the domain *GamificationMEI*, as well as the type of the data stored. In summary, this module stores the title, description, single value, total value and adaptive level of a gamified activity;

6. **Adaptive Gamified Model:** it performs the final steps of the gamified model generation. At first, the model is validated following the data properties restrictions explained previously. When successfully validated, the ontology model is generated, meaning that all of the data stored in the instances of the class *GamifiedActivity* and associated classes are now converted to ontology classes that belong to the *OWL API*. Subsequently, the changes are applied to the *OWLOntology* object that handles all the ontology information. At last, the model can be exported as an OWL file to a directory chosen by the user using the component *JFileChooser*;

7. **Model Validation Logger:** it displays any errors found throughout the validation process.

If multiple errors are generated, they are listed in order of appearance. If no errors were found, a successful message is displayed.

4.4.6 OWL API

The *OWL API* is a Java API used to create, manipulate and serialize OWL Ontologies. In this research, it is used to access the knowledge contained in the GamiProM Ontology and to convert the data inserted in the GamiProM Application in semantic information, thus storing it in OWL files. The interfaces and methods of the *OWL API* used to read the information from the GamiProM Ontology and to insert it in the motivations tree contained in the Module 3 of the GamiProM Application are explained as follows (in order of usage):

- **tboxAxioms():** it gets the axioms that form the TBox of the GamiProM Ontology, returning a stream of *OWLAxiom* objects;
- **OWLAxiom:** it represents axioms in the OWL 2 specification;
- **getAxiomType():** it is the method that identifies the axiom type of an *OWLAxiom* object, being used in this research to filter only the axioms "*SubClassOf*";
- **nestedClassExpressions():** it gets all of the nested (includes top level) class expressions relative to the respective *OWLAxiom* object of the GamiProM Ontology, returning a stream of *OWLClassExpression* objects;
- **OWLClassExpression:** it represents class expressions in the OWL 2 specification;
- **isOWLClass():** it is a method that determines if the instance is an *OWLClass*;
- **asOWLClass():** it is a method that casts an *OWLClassExpression* object into *OWLClass*, being used in this research always then the method *isOWLClass()* returns a *true* value, in order to verify if the *domain class* of the relationship is equals to the specific desired motivation selected in the Module 2 of the GamiProM Application;
- **signature():** it represents the signature of an *OWLClassExpression* object, returning a stream of *OWLEntity* objects. In this research, the signature is used to identify specific entities (equivalent to *axiom* and *range class*) contained in these *OWLClassExpression* objects, also representing their relationships, as previously showed in Figure 19.

To convert the data inserted in the GamiProM Application in semantic information, the following classes of the *OWL API* are used (in order of usage):

- **OWLOntology:** it represents the ontology object loaded from the base model contained in the GamiProM Ontology;

- **OWLIndividual:** it creates the instances of the ontology, identified as *individuals*. The type of individuals created are *GamifiedActivity*, *GamificationMEI* and *EngagementFactor*, provided from a gamified activity present in the gamified activities list of the application, the associated leaf node selected from the motivations tree, and the desired motivation associated to this leaf node, respectively;

- **OWLObjectProperty:** it represents object properties *implements* and *provides* of the ontology;

- **OWLDataProperty:** it represents data properties *gamificationMEITitle*, *gamificationMEIDescription*, *gamificationMEIGamifiedSingleValue*, *gamificationMEIGamifiedTotalValue*, and *gamificationMEIAdaptiveLevel* of the ontology;

- **OWLClassAssertionAxiom:** it defines the axiom that corresponds to the class type of the individual, associating this class type to an *OWLIndividual* object;

- **OWLObjectPropertyAssertionAxiom:** it defines the *Domain* and *Range* of the object properties, associating each *OWLObjectProperty* to its respective *OWLIndividual*;

- **OWLDataPropertyAssertionAxiom:** it defines the *Domain* and *Value* of the data properties, associating each *OWLDataProperty* to its respective *OWLIndividual* and data property value. The *Range* is automatically associated by the type of the data passed as an argument;

- **AddAxiom:** it creates objects representing every assertion axiom previously created that will be added to the *OWLOntology* object;

- **OWLOntologyManager:** it grants access to methods that apply the changes (*AddAxiom* objects) to the gamified model (*OWLOntology*).

4.5 Considerations about the chapter

This chapter presented the specifications of the GamiProM model. These specifications include the architecture of the model, illustrating the connections between each component, as well as detailed explanations of other components like the GamiProM Ontology and the GamiProM Application, approaching concepts such as the ontology composition, structure, functional requirements of the application, diagrams, modules etc.

5 IMPLEMENTATION

This chapter presents the implementation of the GamiProM model on a specific scenario. At first, the ontological model (gamified solution) was generated using the GamiProM Application. Subsequently, the relational database of the non-gamified software was prepared to match the object-oriented information present on the ontological model. At last, the UI was adjusted to make use of the updated database structure and exhibit the gamified software.

5.1 Ontological model

The application scenario selected to implement this model was a web application entitled *QrCafé* (WILLRICH; AZAMBUJA, 2017), created by an Information Systems student as its coursework. The web application uses credits (bonuses) given by teachers to students as a reward for the completion of specific tasks on different disciplines. These credits are stored in an account for each student registered in the web application, and every student with at least one credit available can exchange it for a cup of coffee. This coffee is given by a machine after its scanner reads the qrcode displayed when a student logs in the web application.

Following the specifications of the GamiProM model, the first step to gamify the *QrCafé* application was identify the non-gamified activities and register them in the GamiProM Application. Thus, two activities involving the *QrCafé* application were identified and registered: *ObterCafé* and *ConsumirCafé*. Once the *QrCafé* application uses the Brazilian Portuguese language, all of the data created during the gamification process was made in the same language. After that, the desired motivations were selected. Due to the evaluation method that is explained in details in the next chapter, only the motivations Autonomy, Mastery and Relatedness were chosen.

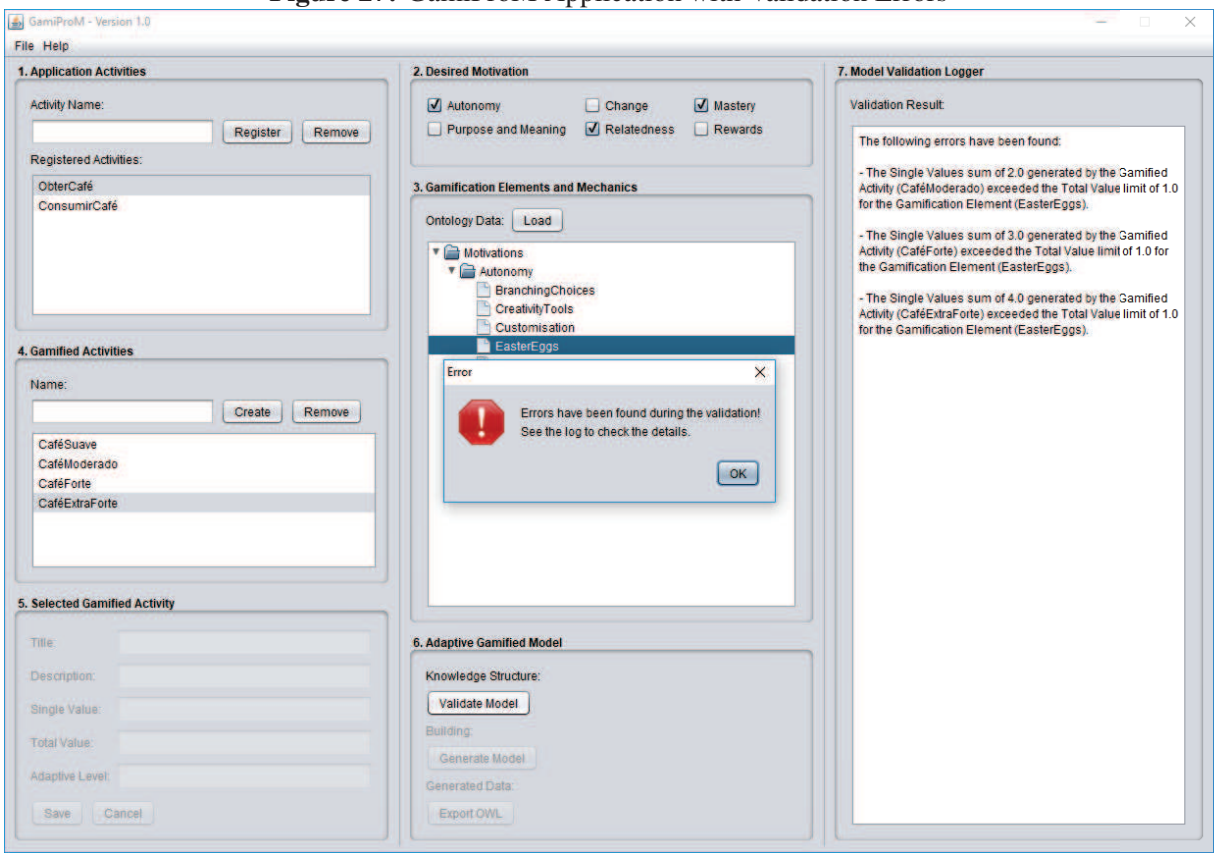
The next step in the model is to create the gamified activities. This is made by selecting a gamification element from the motivations tree displayed in the GamiProM Application and a non-gamified activity previously registered. After that, the properties of each gamified activity must be defined, such as *Title*, *Description*, *Single Value*, *Total Value* and *Adaptive Level*. The gamified values definition is subjective, depending on the effort amount planned by the developer for the user to complete that gamified activity, or by the amount of different gamified activities associated to the same gamification element that are being created.

In order to generate the built gamified model, it was necessary to validate it. To test this feature of the GamiProM Application, some single values were purposely modified to intentionally generate a validation error. The result is showed in Figure 27.

As can be seen in Figure 27, when the first gamified activity generates a validation error, every subsequent value that also exceeds the defined limits is added to a list of errors, properly displayed in module 7, along with a notification message informing a validation error.

After the validation test, the remaining gamified activities were properly created. The sin-

Figure 27: GamiProM Application with Validation Errors



Source: Elaborated by the author.

gle value of each gamified activity, the respective title and non-gamified activity associated is presented in Table 13.

A new validation was requested with all of the gamified activities containing valid gamified values (both single and total). Once only one gamification element was selected for each motivation, all total values were set to 1. As a result of the validation, the GamiProM Application displayed the message showed in Figure 28, also updating the log of module 7, and enabling the generation of the gamified model.

The next step was generate the gamified model, which means that the *OWLOntology* object was populated with all of the data stored in the GamiProM Application classes (including even the desired motivations selected), performed by a sequence of calls to the *OWL API*. When the process was completed, a notification message was displayed, as can be seen in Figure 29.

With the gamified model generated, the final step was export it as an OWL File to a selected location by the user. To do this, the GamiProM Application loaded a *JFileChooser* component, as can be seen in Figure 30.

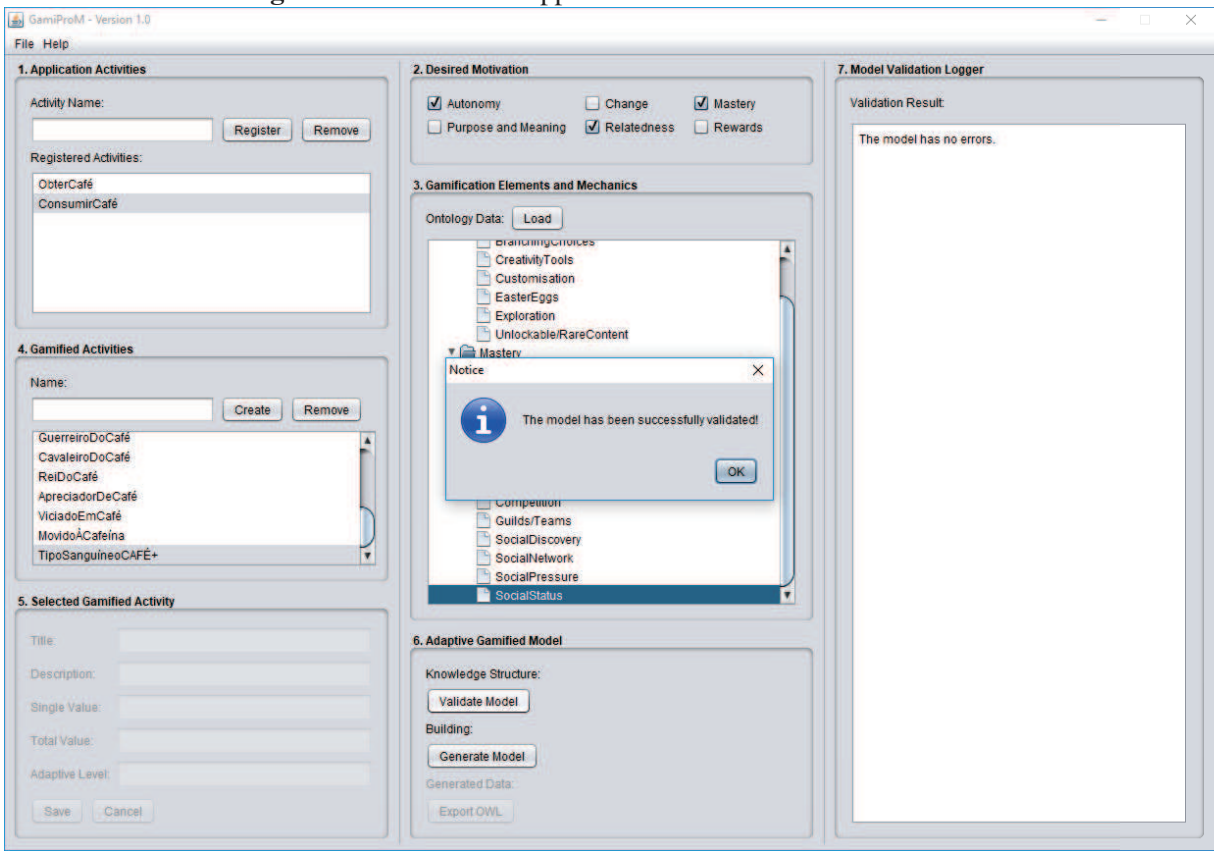
One of the many benefits of ontologies is its readability. Therefore, softwares like *Protégé* can be used to visualize the gamified model structure, enable a reasoner to fully navigate through all of the objects, generate graphs etc. As an example, Figure 31 displays the individuals tree loaded from the gamified model created for this implementation, when the exported OWL File

Table 13: Single Values of the Gamified Activities

Single Value	Gamified Activity Title	Activity Name
0.1	Medalha de Café Suave	Obter Café
0.2	Medalha de Café Moderado	Obter Café
0.3	Medalha de Café Forte	Obter Café
0.4	Medalha de Café Extra Forte	Obter Café
0.1	Nível 2	Consumir Café
0.2	Nível 3	Consumir Café
0.3	Nível 4	Consumir Café
0.4	Nível 5	Consumir Café
0.05	Aprendiz do Café	Obter Café
0.10	Guerreiro do Café	Obter Café
0.15	Cavaleiro do Café	Obter Café
0.20	Rei do Café	Obter Café
0.05	Apreciador de Café	Consumir Café
0.10	Viciado em Café	Consumir Café
0.15	Movido à Cafeína	Consumir Café
0.20	Tipo Sanguíneo CAFÉ+	Consumir Café

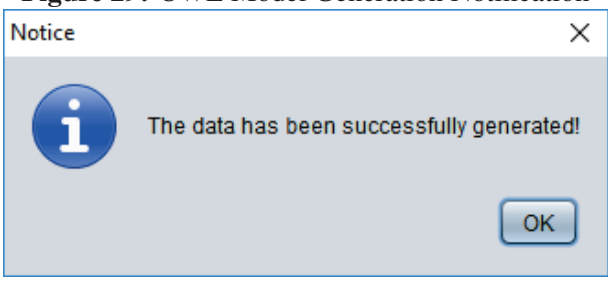
Source: Elaborated by the author.

Figure 28: GamiProM Application with Validation Succeeded



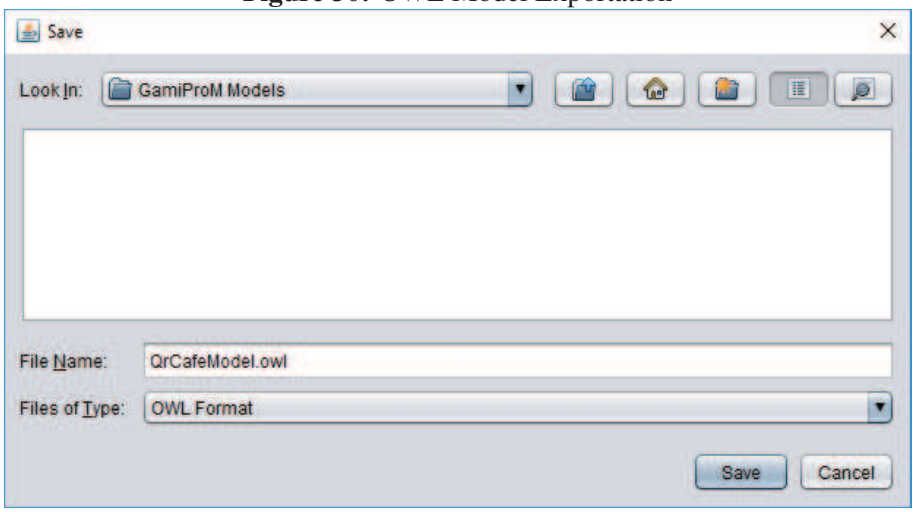
Source: Elaborated by the author.

Figure 29: OWL Model Generation Notification



Source: Elaborated by the author.

Figure 30: OWL Model Exportation



Source: Elaborated by the author.

is opened in *Protégé*.

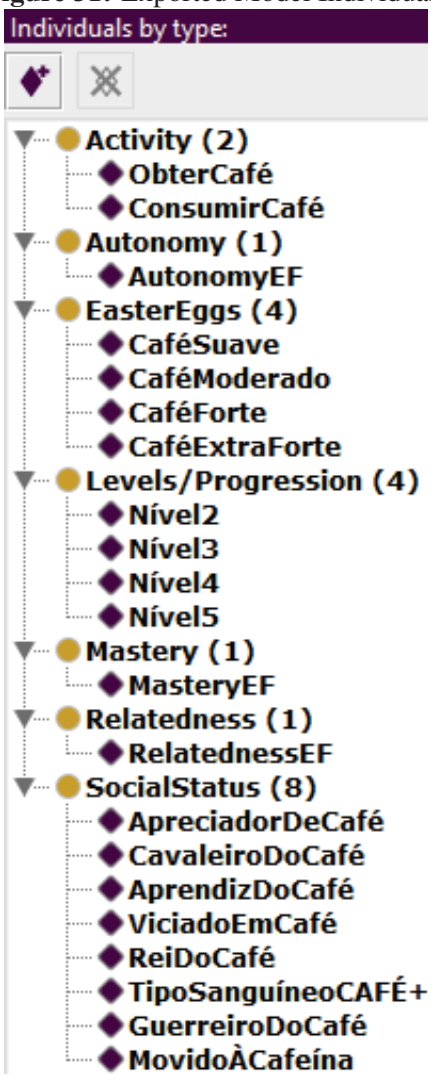
In order to have a standard format, the OWL File is saved using the RDF/XML Syntax. An example of an individual stored in the OWL File making use of this syntax is showed in Figure 32.

5.2 Database preparation

Following the specifications of the GamiProM Model, the next action taken was update the data storage of the non-gamified application with the data contained in the gamified model already created. The web application of this implementation scenario (*QrCafé*) stores its information on a relational database, and in order to store the required object-oriented information on this database, an object-relational mapping was performed. This mapping is presented in Table 14.

Considering that the *QrCafé* application was already fully developed when the gamification implementation started, as a convention practice, every table created for gamification purposes used the prefix "*gm_*", where *gm* is an abbreviation for the word gamification. After that, the

Figure 31: Exported Model Individuals



Source: Elaborated by the author.

Figure 32: RDF/XML Syntax Example of an individual

```
<!-- http://www.semanticweb.org/gamiprom/ontologies/QrCafeModel.owl#Nivel5 -->


<owl:NamedIndividual rdf:about="http://www.semanticweb.org/gamiprom/ontologies/QrCafeModel.owl#Nivel5">
    <rdf:type rdf:resource="http://www.semanticweb.org/gamiprom/ontologies/QrCafeModel.owl#Levels/Progression"/>
    <provides rdf:resource="http://www.semanticweb.org/gamiprom/ontologies/QrCafeModel.owl#MasteryEF"/>
    <gamificationMEIAdaptiveLevel rdf:datatype="http://www.w3.org/2001/XMLSchema#integer">1
    </gamificationMEIAdaptiveLevel>
    <gamificationMEIDescription rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Nível de Experiência 5
    </gamificationMEIDescription>
    <gamificationMEIGamifiedSingleValue rdf:datatype="http://www.w3.org/2001/XMLSchema#double">0.4
    </gamificationMEIGamifiedSingleValue>
    <gamificationMEIGamifiedTotalValue rdf:datatype="http://www.w3.org/2001/XMLSchema#double">1.0
    </gamificationMEIGamifiedTotalValue>
    <gamificationMEITitle rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Nível 5
    </gamificationMEITitle>
</owl:NamedIndividual>
```

Source: Elaborated by the author.

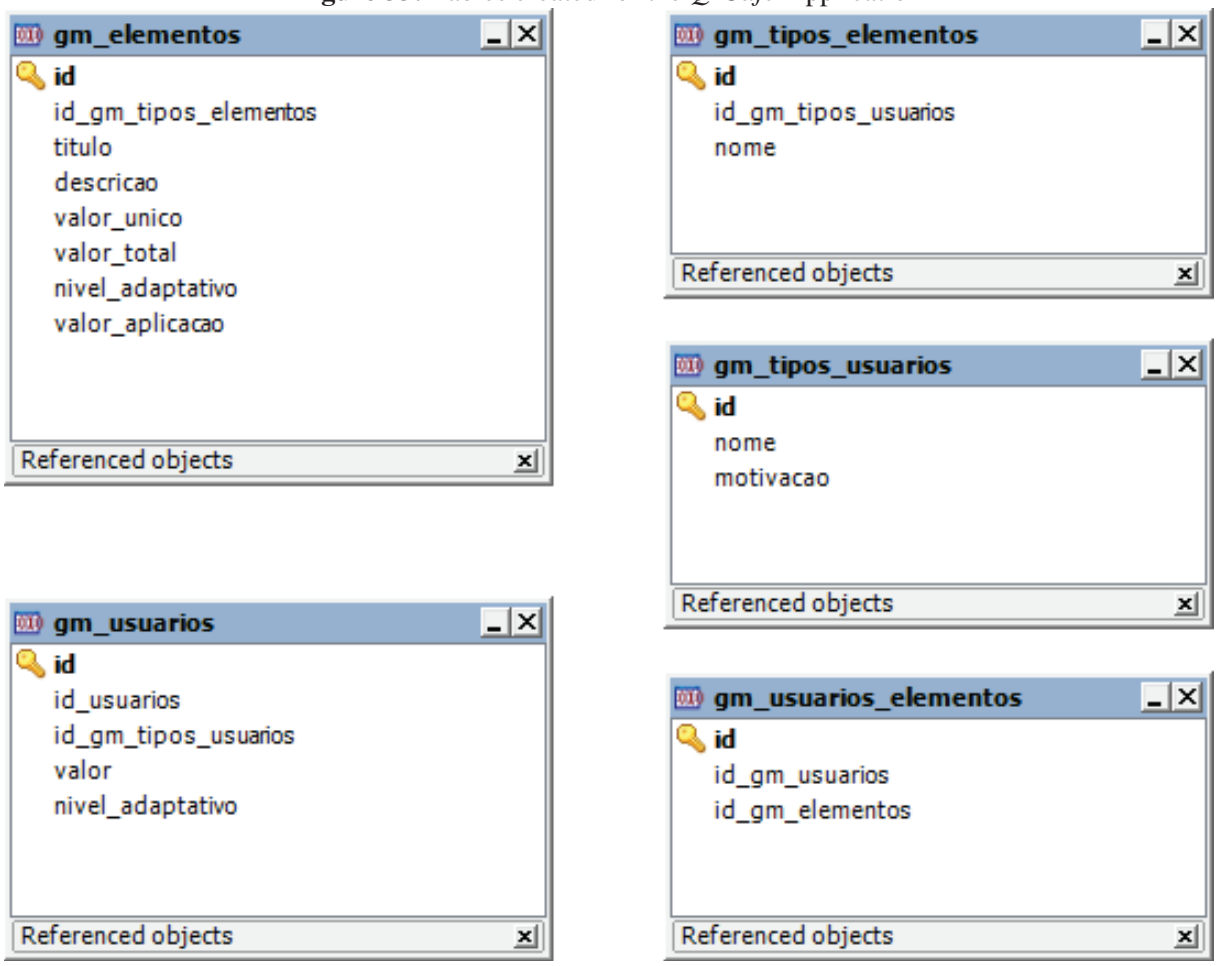
Table 14: Object-relational mapping for *QrCafé* Database

OWL Data	Table Name	N:N Cardinality Table Name
GamificationMEI Individual	*gm_elementos*	*gm_usuarios_elementos*
GamificationMEI Object	*gm_tipos_elementos*	-
UserType Individual	*gm_usuarios*	*gm_usuarios_elementos*
UserType Object	*gm_tipos_usuarios*	-

Source: Elaborated by the author.

data properties present in the ontological model were mapped as columns for their respective tables, as can be seen in Figure 33.

Figure 33: Tables created for the *QrCafé* Application



Source: Elaborated by the author.

Due to the cardinality of "*one to one*" between the objects *UserType* and *EngagementFactor* (motivation), instead of create an additional table to store the *EngagementFactor* of a *UserType*, it was opted to simplify the structure by storing this information as a column in the table *gm_tipos_usuarios*, named as "*motivacao*". The content of this table is presented in Figure 34.

The gamification elements (*GamificationMEI Objects*) associated to the gamified activities created for the *QrCafé* application were registered in table "*gm_tipos_elementos*". Their *User-*

Figure 34: Data stored in Table "*gm_tipos_usuarios*"

	id *	nome *	motivacao *
	1	FreeSpirit	Autonomy
	2	Achiever	Mastery
	3	Socialiser	Relatedness

Source: Elaborated by the author.

Types are associated by the object property *isSupportedBy*, present in the ontological model. The content of this table can be seen in Figure 35.

Figure 35: Data Stored in Table "*gm_tipos_elementos*"

id *	id_gm_tipos_usuarios *	nome *
1	1	EasterEggs
2	2	Levels/Progression
3	3	SocialStatus

Source: Elaborated by the author.

The last step needed for the database preparation of the *QrCafé* application was populate the table "*gm_elementos*" with the data stored in the gamified activities present in the gamified model. Considering that the gamified activities are individuals, every record inserted in this table needed to store not only the data properties *Title*, *Description*, *Single Value*, *Total Value* and *Adaptive Level* but also the object type of this individual (instance). Once the application value representing the goal of each gamified activity is different from its gamified value (which usually works as a proportional value), an additional column was also created to store this information, named as "*valor_aplicacao*". The content of this table is presented in Figure 36.

5.3 UI Development

With the data storage updated, the only change left to make in the *QrCafé* application was adjust the UI to reflect the modifications performed on the database. As mentioned before, this application was already fully developed when the gamification process started. Therefore, the gamification code written in the web application was the less intrusive possible, using the same programming language (*PHP*), the same template built, and the same toolkit for development of responsive applications (*Bootstrap*), using *HTML*, *CSS*, and *JavaScript*. Badge images were created using the pixel art editor *Aseprite*. A visual comparison of the UI changes applied in the Home Screen of the *QrCafé* application is presented in Figure 37, illustrating how the software was before and after the gamification process.

It is important to highlight that, despite of the gamification elements selected for this study

Figure 36: Data Stored in Table "*gm_elementos*"

id *	id_gm_tipos_elementos *	titulo *	descricao *	valor_unico *	valor_total *	nivel_adaptativo *	valor_aplicacao *
1	1	Café Suave	Medalha de Café Suave	0,1	1	1	10
2	1	Café Moderado	Medalha de Café Moderado	0,2	1	1	30
3	1	Café Forte	Medalha de Café Forte	0,3	1	1	60
4	1	Café Extra Forte	Medalha de Café Extra Forte	0,4	1	1	100
5	2	Nível 2	Nível de Experiência 2	0,1	1	1	40
6	2	Nível 3	Nível de Experiência 3	0,2	1	1	120
7	2	Nível 4	Nível de Experiência 4	0,3	1	1	240
8	2	Nível 5	Nível de Experiência 5	0,4	1	1	400
9	3	Aprendiz do Café	Aprendiz do Café	0,05	1	1	20
10	3	Guerreiro do Café	Guerreiro do Café	0,1	1	1	60
11	3	Cavaleiro do Café	Cavaleiro do Café	0,15	1	1	120
12	3	Rei do Café	Rei do Café	0,2	1	1	200
13	3	Apreciador de Café	Apreciador de Café	0,05	1	1	20
14	3	Viciado em Café	Viciado em Café	0,1	1	1	60
15	3	Movido à Cafeína	Movido à Cafeína	0,15	1	1	120
16	3	Tipo Sanguíneo CAFÉ+	Tipo Sanguíneo CAFÉ+	0,2	1	1	200

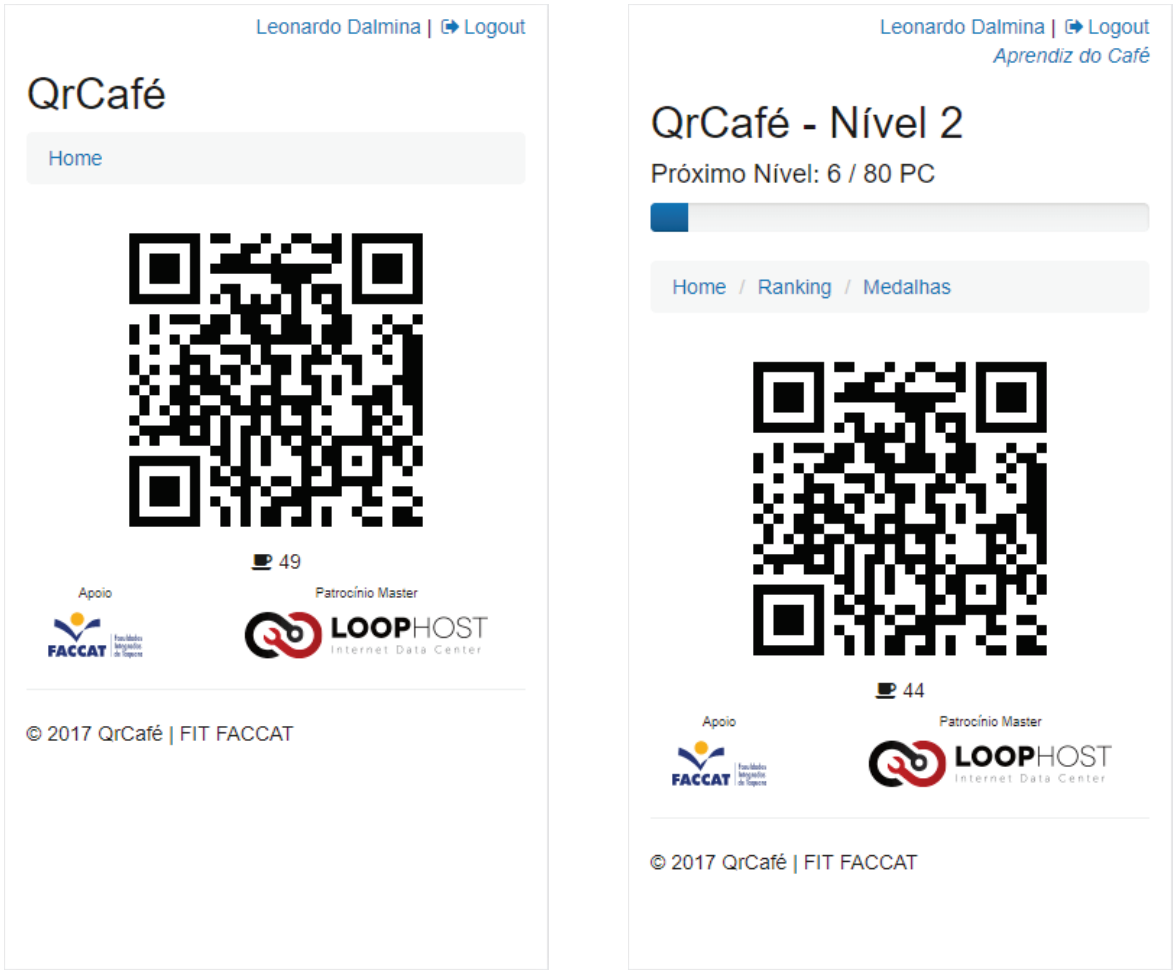
Source: Elaborated by the author.

be restricted due to the evaluation purposes explained in the next chapter, other elements were incorporated as a way to implement the selected ones. For example, Badges were utilized to reward the user when an Easter Egg is found, and Leaderboards were utilized to give to the users the ability to see the Social Status of other users. A visual representation of the Social Status visibility provided by the Leaderboards is presented in Figure 38, showing the Ranking Screen of the *QrCafé* application.

5.4 Considerations about the chapter

This chapter presented the implementation of the GamiProM model. The implementation was conducted by a sequence of steps present in the architecture of the model, starting from the building of the ontological model with the GamiProM Application, the database preparation to support the information structure contained in the ontological model, up to the final UI development to transform the software in a gamified application.

Figure 37: *QrCafé* UI Change Comparison

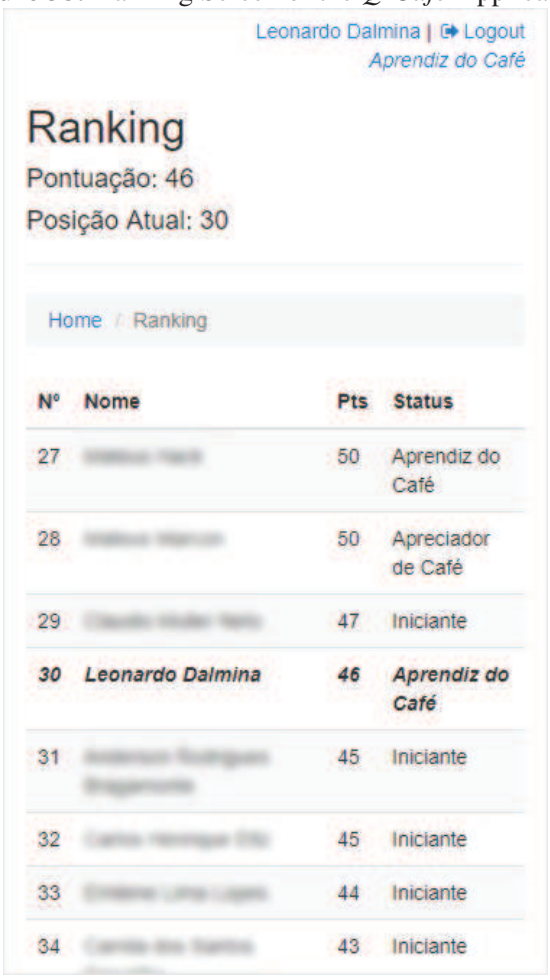


(a) Non-gamified *QrCafé*

(b) Gamified *QrCafé*

Source: Adapted from https://qrcafe.com.br

Figure 38: Ranking Screen of the *QrCafé* Application



Source: Adapted from https://qrcafe.com.br

6 EVALUATION

The evaluation of the GamiProM model was made using Pearson's product-moment correlation, analyzing the data collected after the implementation phase. In this chapter is described how the evaluation process was conducted and what are the goals of this evaluation, organized in four sections. The first section describes the satisfaction scale used to identify the basic psychological needs of the users. The second section presents the methodology utilized to collect the data needed to perform the evaluation. The information related to the correlation test applied is described in section three. At last, the section four presents and discusses the results of the evaluation.

6.1 Basic Psychological Need Satisfaction Scale

As mentioned before, the gamification elements and mechanics incorporated in the model of this research follow the gamification design of MARCZEWSKI (2015). Its design consolidates many other designs created throughout the years. Therefore, this consolidation resulted in the six motivations included in the GamiProM model. During the systematic mapping study conducted at the beginning of this research, it was found that many works connected their research involving gamification and motivations with varied concepts, like for example, the self-determination theory. After a wide association and comparison between the user types, motivations and elements, a similar terminology was identified among the motivations associated with gamification and the motivations contained in the basic psychological needs of the self-determination theory. According to the theory, these needs must be satisfied for people to develop and function in healthy or optimal ways (DECI; RYAN, 2000).

The basic psychological needs of the self-determination theory are *Autonomy*, *Competence* and *Relatedness*. Analyzing the motivations included in the GamiProM model and the gamification elements association found in works of the mapping study using the self-determination theory, it is possible to determine that the needs *Autonomy*, *Competence* and *Relatedness* are the motivations *Autonomy*, *Mastery* and *Relatedness*, respectively. Due to this motivation range, the other motivations (*Change*, *Purpose And Meaning*, *Rewards*) were not included in the gamified model during the implementation phase, once they are not present in the basic psychological needs of the self-determination theory.

To measure the basic psychological needs of a person, it was used the *Basic Psychological Need Satisfaction Scale* (DECI; RYAN, 2000; GAGNÉ, 2003), a 21-item scale that addresses need satisfaction in general in one's life. The 21-item scale is presented in the Appendix D. The replies must be done by selecting one single option that contains the appropriated scale for that question. The range goes from 1 to 7, where 1 means "not at all true", 4 means "somewhat true" and 7 means "very true". This scale generates three subscale scores, one for *Autonomy*, other for *Competence* (*Mastery*) and another for *Relatedness*. Some of the questions are reversed, and

for those, the scale value must be the reply value subtracted from 8. The final subscale value is defined by calculating the average of the reply values that belong to their associated need.

6.2 Data Collection Methodology

When the implementation of gamification in the *QrCafé* Application was finished, the scale was presented to the users of the application to take it. This was made electronically using a mailing list, where a message was delivered for each user (Information Systems students and teachers from the college FACCAT) providing a link to access the scale form and a release note briefly explaining that the *QrCafé* application was gamified.

As mentioned previously, the GamiProM model is elaborated to generate gamified profiles of the users when they execute specific gamified activities. Therefore, during a period of 30 days, every user that performed enough interactions with the gamified application (*QrCafé*) generated different gamified profiles. By the end of these 30 days, both the database of the gamified application and the scale forms stored the information required to perform the correlation test, explained in details in the next section. The only difference, however, is that the basic psychological needs of the users were provided extrinsically, by the answers fulfilled in the scale forms, whilst the motivations were provided intrinsically, by the gamified profiles generated in the gamified application throughout the usage of the system during the 30 days period.

After collecting the basic psychological needs of the *QrCafé* users, the next step consisted in collect from the relational database of the *QrCafé* application all of the gamified profiles (user types) generated during the usage of the gamified application. In order to obtain that information, a query was performed in the relational database.

6.2.1 Outliers

When the 30 days period ended and all of the needed information (basic psychological needs and motivations) was already collected, a data verification was performed to identify the existence of outliers in the scale forms. Initially, 18 scale forms were answered by the users. From these 18 scale forms, 7 were removed due to the users do not have utilized the gamified system during the 30 days period, meaning that no gamified profile was found in the database of *QrCafé* for those users, thus reducing the number to 11. From these 11 scale forms, 5 of them contained invalid data, due to the fact that in almost all of the replies (even the reversed ones) the same choice was selected, thus being removed from the collected data. Therefore, only 6 scale forms were able to be used in the correlation test. Once every scale form identified three different subscale scores (*Autonomy*, *Competence* and *Relatedness*), a total of 18 basic psychological needs were provided from these data.

6.3 Correlation Test

The main goal of this evaluation is verify the accuracy of the motivations stored in the gamified profiles of the users, identifying if exists any association between the basic psychological needs collected with the satisfaction scale and the motivations collected with the gamified application. To be more specific, if the motivations in the gamified application grow in the same direction of the basic psychological needs found in the satisfaction scale. To do this analysis, it was used the Pearson's product-moment correlation. The main reason to choose this correlation coefficient is because the data collected was distributed normally. In addition to that, it not only gives the direction of the correlation among the data analyzed but also indicates the strength of the correlation.

To perform the correlation, a small code was written in the R Language with the usage of functions like "*plot*", "*abline*" and "*cor.test*", in order to generate the dispersion graph and calculate the correlation data. The data analyzed consisted in a Dataset containing 18 entries. The content of the Dataset is presented in Figure 39.

Figure 39: Dataset containing the Evaluation Data

	Form	QrCafe
1	2.875000	1.0
2	3.000000	1.0
3	3.500000	1.6
4	3.500000	1.6
5	3.833333	1.6
6	4.000000	1.6
7	4.000000	2.8
8	4.000000	1.6
9	4.125000	1.6
10	4.142857	4.6
11	4.428571	2.8
12	5.000000	4.6
13	5.142857	2.8
14	5.375000	4.3
15	5.666667	2.8
16	5.714286	7.0
17	6.500000	4.0
18	6.714286	7.0

Source: Elaborated by the author.

As can be seen in Figure 39, every entry has two values, the first one (*Form*) representing a basic psychological need subscale found in the satisfaction scale of a specific user, and

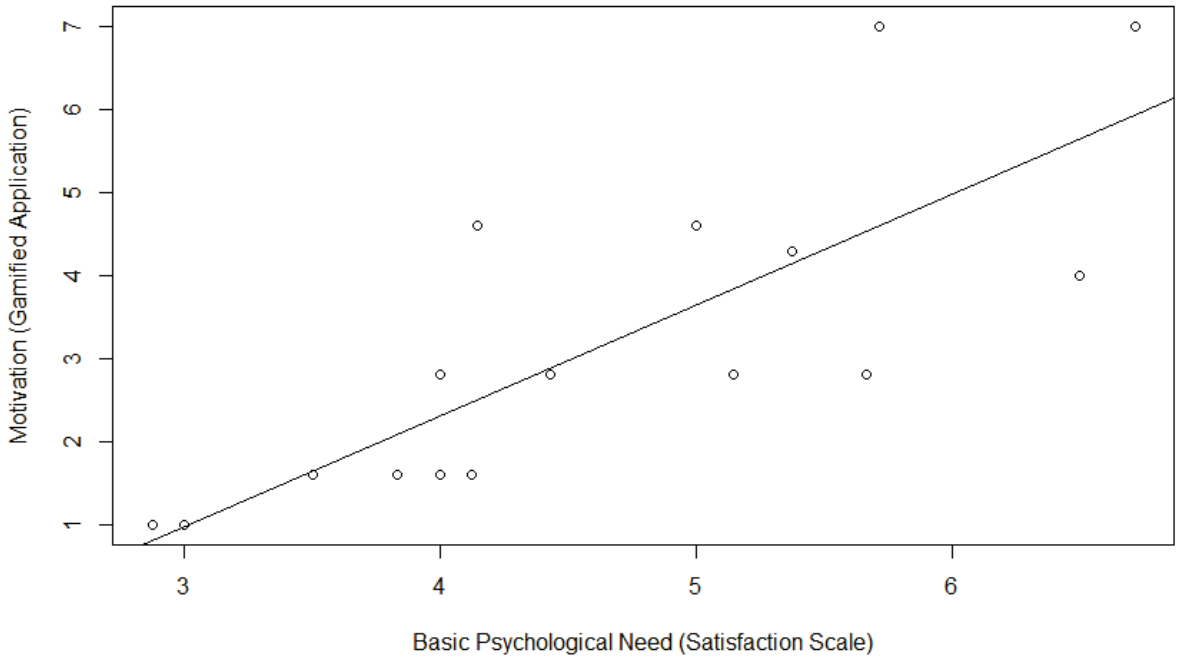
the second one (*QrCafe*) representing the equivalent motivation of the same user found in the relational database.

As mentioned before, the subscales of the basic psychological needs satisfaction scale generate values that range from 1 to 7, and the GamiProM model uses gamified values that range from 0 to 1. As a final step before executing the correlation test written in the R language, every entry representing the motivation found in the relational database was converted to match the same range of the basic psychological needs (1 to 7). Therefore, every gamified value was multiplied by 6 and incremented by 1 (column *QrCafe* presented in Figure 39).

6.4 Results

When using the Pearson's product-moment correlation it is important to define the dependent variable and the independent variable. In this evaluated scenario, the independent variable is the Basic Psychological Need of the users that answered the Satisfaction Scale, and the dependent variable is the Motivation (gamified value of a User Type) stored in the profile of the users that utilized the gamified application (*QrCafé*). With that information properly set, the correlation was performed and the dispersion graph displayed in Figure 40 was generated.

Figure 40: Dispersion Graph of Pearson's product-moment correlation



Source: Elaborated by the author.

By analyzing the R output generated (r = 0,8016, p = 6.338e-05) along with the dispersion graph, it is possible to state that the basic psychological needs of the users are strongly associated with their motivations (user type gamified values), due to the fact that the correlation is

higher than 0,8. It is also important to observe that this correlation has a significance level, once its p-value is smaller than 0,001.

Another valuable information obtained in this analysis is the direction of the correlation. As mentioned before, this evaluation aims to identify if the motivations in the gamified application grow in the same direction of the basic psychological needs found in the satisfaction scale, and this is only satisfactory with a positive correlation, which has been found. If, by any chance, the correlation was negative (despite of being strong), this would indicate that the motivations have an inverse relation with the basic psychological needs, leading this evaluation to inconclusive results based on its main objective.

From the results of this Pearson's product-moment correlation, it is possible to conclude that the motivations collected from the database of the gamified application were identified with a considerable accuracy, due to their strong correlation with the associated basic psychological need. The correlation result also indicates that the higher a basic psychological need of a user is, the bigger will be its respective motivation (gamified profile) in the *QrCafé* application.

6.5 Considerations about the chapter

This chapter presented the evaluation of the GamiProM model. The evaluation consisted in analyze the correlation between two data of each user of the gamified application, the first being the basic psychological needs collected from a satisfaction scale form and the second being the motivations of the user that were stored in a gamified profile. Details about the satisfaction scale are described as well as how the data collection and the correlation test were performed, finalizing with a discussion of the results obtained from the correlation test.

7 FINAL CONSIDERATIONS AND FUTURE WORKS

Gamification is being used on different areas to increase the motivation and engagement of users when they have to execute a task in a non-game environment, such as the workplace or a software application. This is often achieved by the addition of game design elements in these non-game environments.

In the preliminary stages of this research, a systematic mapping study was conducted to identify what is the state of art of Gamification Models oriented to motivational characteristics. One of the research gaps found during the study is the lack of user type analysis. Many of the models followed a trend of choosing the same gamification elements, thus supporting the same set of motivational factors. Aiming to fill this research gap, the model presented in this work was elaborated with a full support of every motivational characteristic available related to gamification. This support was achieved by the integration of the model with an ontology, not only adding semantic value to it but also representing all the knowledge involved among the gamification elements, user types and motivations, once it follows a gamification design. As seen in Figure 8, more than 40% of the researches available in this field do not follow a gamification design, and with the extensive amount of gamification concepts supported by this model, the knowledge be organized under the standards of a recognized design might encourage software developers to try a different set of gamification elements and mechanics, thus supporting different user types.

The GamiProM model was designed to help software developers to create gamified models of any system, which justifies its generic purpose, broad coverage and detailed description of steps, since the planning of gamified activities up to the implementation of the generated gamified model. As seen in Figure 4, many of the researches in this field focus on Education, leaving other areas less researched. Since GamiProM covers any available gamification mechanic, element or idea, be designed as a generic model might lead to a better coverage of these specific or even unexplored areas.

The evaluation of the model was focused on address the relation of the basic psychological needs of users with their motivations using the gamified application. Initially, a satisfaction scale was delivered to the users of the gamified application, in order to identify what are their basic psychological needs. Their motivations using the gamified application were dynamically collected as they were using the *QrCafé* application, due to the fact that the system was gamified using a model generated and validated by the GamiProM Application, thus making the correct use of the gamified values for the planned gamified activities. Finally, a Pearson's product-moment correlation was applied to identify the association between the basic psychological needs of the users and their motivations.

The result of the evaluation indicated a positive correlation between the basic psychological needs and the motivations of the users, resulting in a strong association of these data with a correlation above 0,8. This answers the main question of this research, that aims to identify the

motivation of users while using a gamified application, since the motivation levels of the users identified in the gamified application were more than 80% correlated to their respective basic psychological needs. It is important to highlight, however, that this result applies to a gamified model that was planned and generated to only track user types that are motivated by Autonomy, Competence (Mastery) and Relatedness.

In future works, other scenarios can be explored and evaluated, like for example, gamify applications that run on a different environment using a different amount of non-gamified activities and a different set of gamification elements, or even gamified activities with different adaptive levels. Additionally, the GamiProM Application can be expanded to support new modules like an SQL Script Generator to create the tables structure of a database that is going to receive gamification, also offering an option to inform the application value (if applicable) of a gamified activity, or even an Individuals Simulator that randomly populates the ontological gamified model simulating real users using the target application as if it were fully gamified and running.

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APPENDIX A COMPLETE LIST OF ALL PRIMARY STUDIES INCLUDED IN THE SYSTEMATIC MAPPING STUDY

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APPENDIX B COMPETENCE QUESTIONS TO THE GAMIPROM ONTOLOGY

- What are the existing activities of the non-gamified application?
- Which gamification elements, mechanics or ideas are being integrated to the activities?
- Which gamified activities are included?
- Which motivations are being provided by the gamified activities?
- What type of users are supported by the gamified activities?
- What is the adaptive level of the gamified activity?
- What is the adaptive level of the user type?
- What is the gamified value of the gamified activity?
- What is the gamified value of the user type?

APPENDIX C LIST OF RELEVANT TERMS TO GAMIPROM ONTOLOGY

- **Activity:** activity performed by a non-gamified application;
- **Engagement Factor:** factor that motivates / engages an user;
- **Gamification MEI:** gamification mechanic, element or idea;
- **Gamified Activity:** activity generated by the integration of a non-gamified Activity with a Gamification MEI;
- **Profile:** unique record of an user;
- **User:** the person that is going to use the gamified application;
- **User Type:** the type of user that is motivated by a specific engagement factor.

APPENDIX D 21-ITEM SATISFACTION SCALE (BASIC PSYCHOLOGICAL NEED)

1. I feel like I am free to decide for myself how to live my life.
2. I really like the people I interact with.
3. Often, I do not feel very competent.
4. I feel pressured in my life.
5. People I know tell me I am good at what I do.
6. I get along with people I come into contact with.
7. I pretty much keep to myself and don't have a lot of social contacts.
8. I generally feel free to express my ideas and opinions.
9. I consider the people I regularly interact with to be my friends.
10. I have been able to learn interesting new skills recently.
11. In my daily life, I frequently have to do what I am told.
12. People in my life care about me.
13. Most days I feel a sense of accomplishment from what I do.
14. People I interact with on a daily basis tend to take my feelings into consideration.
15. In my life I do not get much of a chance to show how capable I am.
16. There are not many people that I am close to.
17. I feel like I can pretty much be myself in my daily situations.
18. The people I interact with regularly do not seem to like me much.
19. I often do not feel very capable.
20. There is not much opportunity for me to decide for myself how to do things in my daily life.
21. People are generally pretty friendly towards me.