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Applying Gamification to Education:
A Case Study in an E-learning Environment

Master Thesis

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Abstract

Gamification is defined as the application of game-design elements (a.k.a. mechanics) – such as challenges, badges, ranking and leader boards, and storylines– in non-game contexts with the intention of modifying behaviours, increasing fidelity or engaging people, by leveraging human motivations present in games

Since each person has her own personality and tastes, certain game elements that motivate her may be irrelevant or non-engaging for others. It is thus needed to consider different types of players, which suit each person according to how she interacts and reacts when playing a game, and to the personal motivations that drive to take certain actions.

Previous work has shown the success of gamification approaches in different domains. However, the effectiveness of particular game-design elements and their correspondences with assigned player types are often ignored and are not empirically validated. Moreover, the player type and its associated mechanics assumed for a certain user may not be appropriate due to the actions that have to be performed in the domain of interest, which is something that, to the best of our knowledge, is not taken into account in general.

In this thesis we address the above issues, focusing on the educational domain. Specifically, we conduct a user study in an e-learning environment aimed to increase the motivation and engagement of students attending assignment solving lectures in the "Programming II" subject, which belongs to the first course of the Degree in Computer Science and Engineering at Universidad Autónoma de Madrid.

In the study, we assess a personality-based questionnaire to infer the students' player types, propose particular implementations of gamification mechanics for the context of interest, and evaluate the effectiveness of the considered player types and gamification mechanics.

Based on the results and conclusions achieved in the study, we present a number of design proposals for the future implementation of an intelligent gamified e-learning framework, in which the students' player types are inferred and adapted automatically, and gamification mechanics are presented to the students in a personalized way according to their player types and learning profiles.

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Contents

Chapter 1. Introduction

1.1 Motivation

Gamification is defined as the application of game-design elements (a.k.a. mechanics) – such as challenges, storylines, badges, ranking and leader boards, and statues– in non-game contexts with the intention of modifying behaviours, increasing fidelity or motivating and engaging people, by leveraging human motivations present in games [1]. For instance, the e-learning systems Duolingo[1] –which unlocks syllabus of higher difficulty as level achievements– and ClassDojo[2] –which provides personal scores and awards– motivate students in their learning process. The Foursquare[3] platform has achieved notoriety for being a geolocation-based service where users can win multiple badges by checking at certain places. The Starbucks[4] mobile application encourages new visitors through the accumulation of stars, which results in free drinks. In the Language Quality Game [2], Microsoft employees correct translation errors, competing in a worldwide leader board. Similarly, Codecademy[5] uses points, levels, and challenges of increasing difficulty to motivate employees to learn new programming languages. Fostering good habits, in 2010 the Swedish National Society for Road Safety implemented the Speed Camera Lottery[6], where all drivers who did not exceed the speed limit automatically entered into a lottery whose prize came from claimed fines.

In the literature, several frameworks (e.g. [3], [4]) have been proposed to better understand how particular game-design elements arouse emotions, moods, concerns, and needs in people. Since each person has her own personality and tastes, certain game elements that motivate her, may be irrelevant or non-engaging for other people. It is thus needed to consider different **player types** [5], [6], which suit each person according to how she interacts and reacts when playing a game. Hence, for example, particular elements such as working in teams and managing social relationships could promote *relatedness*, by generating feelings of camaraderie in "socializer" users. Elements such as unlockable content and creativity tools may promote *autonomy*, by creating sensations of freedom and self-expression in "free spirit" users who like to act and progress freely. Elements like certificates and difficulty levels could indorse *mastery*, by stimulating needs of progression and reputation in "achiever" users. Finally, elements such as gifting and sharing may promote *purpose*, by providing a superior meaning or value to the actions conducted by "philanthropist" users.

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[1] "Duolingo | Learn Spanish, French, German, Portuguese, Italian and English for free." [Online]. Available: https://www.duolingo.com/. [Accessed: 13-Jul-2015].

[2] "ClassDojo," ClassDojo. [Online]. Available: https://www.classdojo.com/. [Accessed: 13-Jul-2015].

[3] "Foursquare." [Online]. Available: https://foursquare.com/. [Accessed: 02-Aug-2015].

[4] "My Starbucks RewardsTM," Starbucks Coffee Company. [Online]. Available: http://www.starbucks.com/card/rewards. [Accessed: 10-Jul-2015].

[5] "Codecademy," learn to code. [Online]. Available: https://www.codecademy.com/. [Accessed: 11-Aug-2015].

[6] "The Fun Theory award winner - The Speed Camera Lottery | The Fun Theory." [Online]. Available: http://www.thefuntheory.com/2009/11/12/fun-theory-award-winner-speed-camera-lottery. [Accessed: 14-Jul-2015].

In general, players are categorized into different types according to the motivations that drive them to take certain actions. The most common motivations are those related to the social nature of human beings, which allows users to express creativity, to maintain the autonomy achieved in adulthood, reach a certain degree of reputation, or hope that their acts will have a positive impact on other individuals or groups. In this context, although **gamification mechanics** have successfully been used to encourage good behaviours, and psychologists have extensively studied theories of motivation [7]–[9], to the best of our knowledge, still there are no single and verified formalizations of such elements for given domains, and of the particular correspondences between game elements and personal motivations. There are several works such as [10], [11] have attempted to figure out what might be the archetypes of players based on demographic factors (e.g., age, gender, education, occupation, and social status), psychographics (e.g., attitudes, interests, values, and life styles), and behaviour patterns towards or with a product. Reviews on the similarities and differences between the proposed player types provide the fundamental concepts for profiling a user, where achievement, exploration, sociability, and domination are the most recurrent ones [10]–[13].

Other studies have also shown the success of gamification approaches in different domains [14]–[21]. However, the effectiveness of particular game-design elements and their **correspondences** with assigned player types are often ignored. In fact, in some cases, a limited number of motivations are taken into consideration [22]. Moreover, the player type assumed for a certain user may not be appropriate due to the actions that have to be performed in the domain of interest. For example, in an educational context, the player types whose motivations are exploring, creating, and modifying the environment, may not be effective for students who are learning to solve initial assignments in a subject, regardless their personality and behavioural patterns. Finally, the attributed belonging of game elements to certain player types may be wrong. For example, an element of competition may be intuitively attributed to a player who is looking for accomplishments and desires the victory, but could also be attributed to a more sociable player who wants to be compared with her peers in a leader board.

In general, thus, in the literature one can find that every game-design mechanic has intuitively attributed to one or more player type by the belief that it produces the right motivations to the users whose characteristics have been artificially credited to such player types. In contrast, for a given domain, a well-designed gamification framework would require:

- Having as many player types and game-design mechanics as needed to meet the existing user personalities, tastes and needs, as well as the available activities and tasks.
- Validating the actual correspondence between each player type and each game-design mechanic, and the implementation of the latter as certain domain-related action.

1.2 Goals and research questions

In this thesis we focus on the application of gamification in the **educational domain**. As a primary goal, the study conducted in the thesis was aimed to increase the motivation of the students attending the "Programming II" subject, which belongs to the first course of the Degree in Computer Science and Engineering[7] at Universidad Autónoma de Madrid[8].

Specifically, we designed gamified assignment solving lectures addressing fundaments of Abstract Data Types in computer programming, such stacks, queues, and linked lists. The students had to first fill a personality questionnaire with which their player types were inferred [23]. Afterwards, in the classroom, during a testing session and two evaluation sessions of two hours each, the students solved assignments while performing actions that corresponded to gamification mechanics, such as competing, working in teams, achieving challenges, increasing personal scores, and winning awards. The actions were freely chosen and recorded in an online system by the students. Some of these actions were: being the first to solve a particular problem, helping classmates to solve an assignment, and evaluating the contributions made by classmates in a work team.

The study relied on the following research questions:

RQ1. Were all the items of the initial personality questionnaire useful to infer the students' player types?
The used questionnaire was proposed in [23], but the effectiveness of its items to inference player types had not been evaluated yet.

RQ2. Did the considered gamification mechanics and their implementations as learning-based actions really correspond to the students' inferred player types?
Conceptually each gamification mechanic is related to a player type, but such correspondences have to be empirically validated for a particular domain.

RQ3. Which player types and gamification mechanics were effective in the tested e-learning environment?
For a specific domain, there may be gamification mechanics or even player types which are not effective to motivate users to perform certain actions.

RQ4. How the students assessed the proposed gamified activities?
To evaluate a gamification approach, in addition to analyzing the users' activity records, we also need to take into account the users' opinions and perceptions about the considered player types, gamification mechanics, and domain-related activities.

Based on the results and conclusions achieved in the study, our ultimate goal is to design and build an intelligent gamified e-learning framework, in which the students' player types are inferred and adapted automatically, and gamification mechanics and actions are presented to the students in a personalized way according to their player types and learning

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[7] "Escuela Politécnica Superior - Grado en Ingeniería Informática." [Online]. Available: http://www.eps.uam.es. [Accessed: 09-Jul-2015].

[8] "Universidad Autónoma de Madrid." [Online]. Available: http://www.uam.es/. [Accessed: 09-Jul-2015].

profile. In this thesis we propose preliminary insights about how such e-learning system would be, and which research issues may be taken into consideration.

1.3   Contributions

In this thesis we claim the following contributions:

- Evaluating the effectiveness of well-known player types in an educational domain.
- Implementing gamification mechanics as generic activities of the educational domain.
- Evaluating the effectiveness of gamification mechanics in an e-learning environment.
- Analysing the actual correspondences between gamification mechanics and their intuitively assigned player types.
- Proposing a number of design issues for building a gamified e-learning framework.

Part of the work presented in the thesis has been published in the following research paper:

- Borja Gil, Iván Cantador, and Andrzej Marczewski. 2015. **Validating Gamification Mechanics and Player Types in an E-learning Environment**. In: *Proceedings of the 10th European Conference on Technology Enhanced Learning (EC-TEL'15)*, pp. 568-572. Lecture Notes in Computer Science 9307, Springer, ISBN 978-3-319-24257-6.

1.4   Structure of the document

In Chapter 2 we present the foundations of gamification. We define gamification, present non-game contexts and real examples in which it has been applied, describe existing approaches to model games, their elements, and the players' behavior and emotional responses, and depict benefits and difficulties of using gamification.

In Chapter 3 we present our approach and user study aimed to apply and evaluate gamification in an e-learning environment for a High Education context. We detail the activities conducted by students in the classroom, present how we designed player types and implemented gamification mechanics, and analyze and discuss the obtained results.

In Chapter 4 we outline previous work in gamified education, learning styles, and user engagement that is related to our approach, and may be valuable for the future implementation of a personalized gamified e-learning framework.

In Chapter 5 we introduce design proposals for such a framework, based on the conclusions achieved in the conducted user study and literature review.

Finally, in Chapter 6 we summarize the key lessons learnt and conclusions compiled in the thesis, and depict research areas and work lines we will have to take into account in our next steps to develop the above mentioned framework.

Chapter 2. Gamification: definition and elements

In this chapter we present the fundaments of gamification. In Section 2.1, we provide a definition of gamification, describing non-gaming contexts in which it has been successfully applied, and reviewing approaches proposed to understand games, their elements, and the players' behavior and emotional responses. Next, in Section 2.2, we present the player types proposed in the literature to characterize players according to the motivations that lead performing certain actions, and in Section 2.3, we describe the gamification mechanics that correspond to each player type. Finally, in Section 2.4 we present some benefits and implementation difficulties of gamification through several examples.

2.1 Defining gamification

Gamification is defined as the application of game-design elements in non-game contexts with the intention of modifying behaviours, increasing fidelity or motivating and engaging people, by leveraging human motivations present in games [1]. For example, there are employees for whom a competition motivates them to be the best in a leader board, customers who like getting discounts and rewards for their fidelity with a certain brand, students who are encouraged not to abandon a subject when it starts to get complicated by working in teams, and people for whom helping others provides the satisfaction to participate in an activity.

Examples of **non-game contexts** where gamification has been applied are teaching, marketing, business, and habit motivation for social good. In the educational domain, the Duolingo system allows learning languages by unlocking syllabus through the achievement of increasing difficulty levels, and the ClassDojo platform helps teachers to improve the students' behavior and performance by creating and customizing points and prizes for good behavior and homework completion. In e-commerce, gamification modules create a link between consumers and sellers by promoting customer loyalty and engagement toward products. Although now Foursquare is evolving to a recommender system, its success comes for being a geolocation-based system in which users can register check-ins at places of interest, sharing them with friends and winning multiple badges such as "Mayorship" for recording a large number of check-ins or finding new places of interest. These collectable badges, among other things, allowed the company to go from having fifty thousand users in 2009 to more than fifty million in 2014. The loyalty mobile app of the international coffee chain Starbucks encourages new visitors through the accumulation of stars, which results in free drinks. Gamification has also been applied within companies, making employees feel active and important part of a company, feeling a motivation that leads them to perform certain tasks not only because of the salary but also because of the fact that they really believe in what they are doing. An example is the Language Quality Game [2] in which Microsoft employees around the world competed by countries to have the highest number of translation errors corrected, a task which may not be an explicit part of their work. Codecademy is a website in which anyone can learn different programming languages, including a company's employees during working hours. This website contains game-design elements such as points, levels and challenges to motivate the leaners. Finally,

gamification has also been used to change social habits for good purposes through the promotion of healthy habits, environmental respect, and careful driving. In 2010 the Swedish National Society for Road Safety implemented the Speed Camera Lottery, where all drivers who did not exceed the speed limit had the chance of winning monetary prizes coming from claimed fines.

To better understand what gamification is, it is first necessary to distinguish between **play** and **game** [24]. *Play* comes from the Greek word *Paidia* which means "child", and can be seen as a carefree, spontaneous act, which have no or a few rules. *Game*, on the other hand, comes from the Latin word *ludus*, which means playing attending standards and objectives. In addition, we also have to distinguish between **serious games** and **gameful design** [25]. The serious games are intended to be more than entertainment, having a purpose, e.g., the digital game-based learning and the simulation games. The gameful design, in contrast, does not create a game, but uses parts of games to incorporate them into other contexts in order to encourage certain actions or behaviors. Hence, the concept of *gamification* refers to the *gameful design* of tasks in non-game contexts.

A formal approach to understanding the games, their elements, and the players' behavior and emotional responses is the **MDA framework** [3], shown in *Figure 1*, and composed of three aspects, namely Mechanics, Dynamics, and Aesthetics:

- ▪ "*Mechanics* describe the particular components of the game, at the level of data representation and algorithms. Mechanics are the various actions, behaviours and control mechanisms afforded to the player within a game context. Together with a *game content* (levels, assets and so on) the mechanics support overall gameplay dynamics. For example, the mechanics of shooters include weapons, ammunition and spawn points, which sometimes produce dynamics like camping and spinning. Adjusting the mechanics of a game helps us fine-tune the game's overall dynamics."

- ▪ "*Dynamics* work to create aesthetic experiences, and describe the run-time behaviour of the mechanics acting on one player's inputs and each other's outputs over time." For example:
  - o "*Challenge* is created by things like time pressure and opponent play."
  - o "*Fellowship* can be encouraged by sharing information among certain members of a session, or by supplying winning conditions that are more difficult to achieve."
  - o "*Expression* comes from dynamics that encourage individual users to leave their marks: purchasing, building or earning game items, designing, constructing and changing levels or worlds, and creating personalized, unique characters."
  - o "*Dramatic tension* comes from actions that encourage rising tension, a release, and a denouement."

- ▪ "*Aesthetics* describes the desirable emotional responses evoked in a player, when she interacts with the game system. Each game pursues multiple aesthetic goals, in varying degrees", e.g.:
  - o "*Sensation*. Game as sense-pleasure."
  - o "*Fantasy*. Game as make-believe."

- o *"Narrative.* Game as drama."
- o *"Challenge.* Game obstacle course."
- o *"Fellowship.* Game as social framework."
- o *"Discovery.* Game as uncharted territory."
- o *"Expression.* Game as self-discovery."
- o *"Submission.* Game as pastime."

Although the prospect of a game designer is to create mechanics to develop dynamics and foster aesthetics, the user perceives the game in the opposite direction so the designer must consider both ways since any change in any of three levels of abstraction impacts on the other, and may change the end user experience.
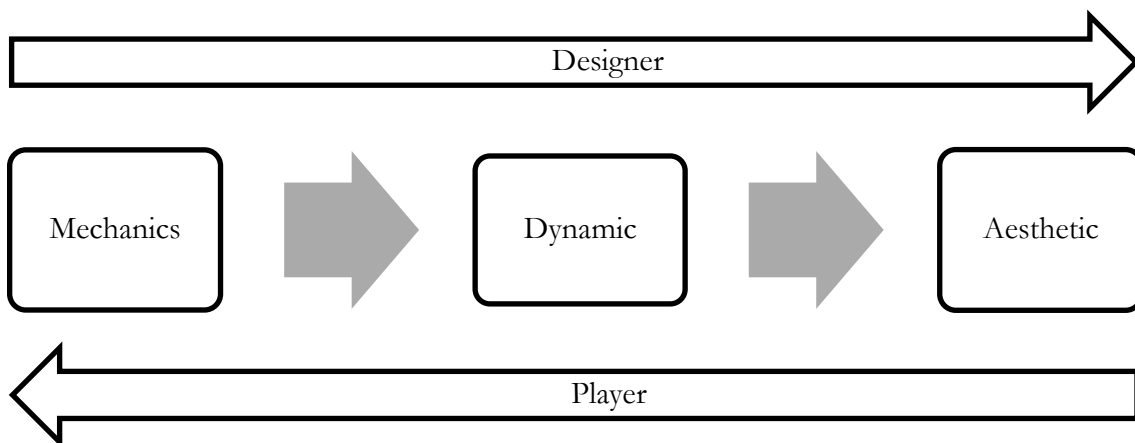
Figure 1. The MDA framework.

Another formal approach is the **Game Element Hierarchy** [4], shown in *Figure 2*. This approach is not so general, and focuses specifically on three relevant categories in gamification: components, mechanics, and dynamics, which are arranged in descending order of abstraction. In this case, mechanics evoke one or more dynamics, and each component form several mechanics and/or evokes one or more dynamics.

- ▪ *"Components* are the most-specific forms that mechanics or dynamics can take. Each component ties to one or more higher-level elements. The fifteen important game components are achievements, avatars, badges, boss fights, collections, combat, content unlocking, gifting, leader boards, levels, points, quests, social graphs, teams, or virtual goods"
- ▪ *"Mechanics* are the basic processes that drive the action forward and generate player engagement. Each mechanic is a way of achieving one or more of the dynamics described. Ten important game mechanics are challenges, chance, competition, cooperation, feedback, resource acquisition, rewards, trading, turns, or win states"
- ▪ *"Dynamics* are the big-picture aspects of the gamified system that you have to consider and manage but which you can never directly enter into the game." For example:
  - o *"Constraints.* Limitations or forced trade-offs."
  - o *"Emotions.* Curiosity, competitiveness, frustration, happiness."
  - o *"Narrative.* A consistent, ongoing storyline."
  - o *"Progression.* The player's growth and development."

o *"Relationships*. Social interactions generating feelings of camaraderie, status, altruism."

"A critical part of that experience is the *aesthetics* of the game. The visual experience of the game and the sound. The other aspects that tie the game together and make it feel somehow real to the players. All of that is above and beyond the elements, all of that is certainly extremely important in games and often important in gamification. Putting all these things together is the central task of gamification design. It is necessary to use a design process to apply these elements that constitute games."
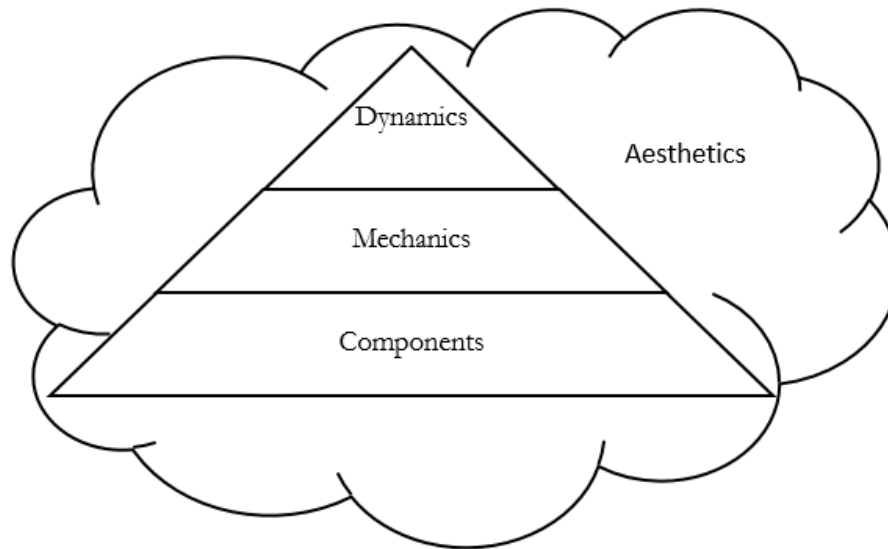
Figure 2. The Game Element Hierarchy.

Despite the different view of this approach and the names assigned to each level of abstraction, the Game Element Hierarchy can be considered equivalent to the MDA as follows:

- The *Components* correspond to the mechanics of MDA framework.
- The *Mechanics* correspond to the dynamics of MDA framework.
- The *Dynamics* correspond to the aesthetics of MDA framework.

From now on, when dealing with the game-design elements we will refer to the MDA framework for its acceptance in the scientific field [26], [27], considering all the examples provided by the Game Element Hierarchy by applying the above described correspondences. For instance, Doom 3[9], a science fiction survival horror first-person shooter video game, is composed by mechanics like boss fights against demons, combats with multiple weapons and quests completing missions in the maps. It creates dynamics like challenge to wrestle with multiple demons more difficult and aesthetics like the emotion of fear. In the multiplayer mode, with the mechanic of teams a player gets a dynamic of competition with other gamers and the competitiveness emotion and relationships are created as aesthetics.

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[9] "Doom 3," Wikipedia, the free encyclopedia. 02-Jul-2015.

Given that each user has different motivations it is necessary to define *user or player types* to enclose their needs, desires and concerns. The player types have allowed the games to reach a larger number of people by adapting the preferences of each player. Players who like to create social relations will be more motivated by mechanics like teams and social networks, dynamics like cooperation, and aesthetics like relationships. Players who like to feel free, and explore and create new contents will be motivated by mechanics like avatars, or content unlocking, dynamics like chance or resource acquisition, and aesthetics like the emotion of curiosity, or a consistent narrative. Players who like to compete and achieve goals will be motivated by mechanics like badges, leader boards, levels, points, or quests, dynamics like challenges, competition, or rewards, and aesthetics like the emotion of competitiveness, or progression. Finally, players who like to take actions for a meaning, such as helping others, will be motivated by mechanics like collections or gifting, dynamics like trading, and aesthetics like the emotion of happiness for helping. The challenge is to ascertain whether mechanics, dynamics and aesthetics that are assumed for each player type are correct and if they are well implemented in a particular domain, an issue that is investigated in Chapter 3 for the education domain.

In Section 2.2, we will present the proposed player types to correspond with the motivations that lead users to take actions, and in Section 2.3 we describe the gamification mechanics that have been intuitively attributed to the above player types.

2.2 Player types

Researchers have categorized players in different ways. One of the most widely accepted categorization is that proposed by **Richard Bartle** [5], one of the first who studied the multiplayer online video games, which are capable of supporting large numbers of players simultaneously. In the Bartle's model four main player types are defined in terms of two dimensions, expressed in two coordinate axes as shown in *Figure 3*. The first dimension – the horizontal axis– indicates whether a player is more interested in other players (left) or in the virtual world around her (right), while the second dimension –the vertical axis– indicates if the interest is focused on acting (up) or interacting (below). More specifically, the player types are defined as follows:

- The *achievers* are interested in acting on the environment in which they dominate the features it provides. "Achievers are proud of their formal status in the game built-in level hierarchy, and of how short a time they took to reach it."
- The *explorers* are interested in interacting with the environment, exploring all the existing targets, and experiment with them later on. "Explorers are proud of their knowledge of the game's finer points, especially if new players treat them as founts of all knowledge."
- The *socializers* are interested in interacting with other players, encouraging their social relationships. "Socializers are proud of their friendships, their contacts and their influence."
- The *killers* are interested in strengthening its superiority over other players acting with their consent or without it, regardless they harm the later. "Killers are proud of their reputation and of their oft-practiced fighting skills."
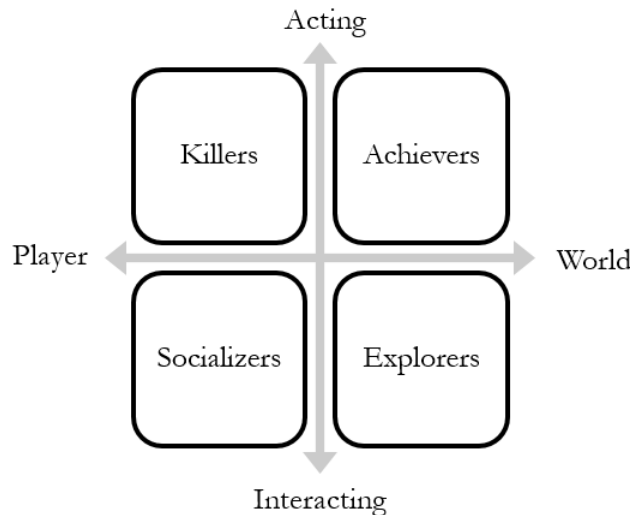
Figure 3. Bartle's player types.

In the Bartle's model, a killer may hurt any other in order to get what she intends, for fun or for being superior A second player type design, proposed by **Andrzej Marczewski** [28], addresses that problematic. According to Marczewski, the killer player type is a "misunderstood group of people" being understood as players who "only are interested in what they can gain from the system or other users." To understand the Marczewski's player types, let first describe the motivations that make each player type feels interest in things they can do in a system and how player interactions provoke emotions.

The psychology of motivation is related with the aesthetics of the MDA framework seen in Section 2.1, which represent human needs and concerns that motivate people. According to the **Self-Determination Theory (SDT)** [9], we can distinguish between extrinsic and intrinsic motivations based on the different reasons or goals that give rise to an action. An extrinsic motivation comes from an activity aimed to achieve a result derived from completing a task, e.g., studying a subject to pass a course or to gain some knowledge, but not for the fact of finding it interesting. An intrinsic motivation, in contrast, comes from an activity performed for the satisfaction of doing it. The SDT states that intrinsic motivations can be divided into three categories:

- *Relatedness.* Meeting the human social needs; feeling part of a group with which one is identified and belongs to.
- *Autonomy.* Satisfying the desire of each individual to be independent, innovating and creating, encouraging the sense of freedom and personal development.
- *Mastery/Competence.* Satisfying the desire to surpass oneself and others up to the maximum level of perfection, increasing one or more skills as the challenges become more complicated.

When employee motivations were investigated in business environments [29], *purpose* was considered as an intrinsic motivation to satisfy the need to know that personal actions have an importance, an impact on what one does. Unifying the above types of motivations, Marczewski proposed the so-called **intrinsic motivations RAMP model** [30], which means *Relatedness, Autonomy, Mastery and Purpose.*

Hence, the model based on the psychology of motivation and the Bartle's player types were considered together and proposed in the **User Types Hexad** by Andrzej Marczewski [6], [31]. Marczewski proposed a particular player type for each intrinsic motivation. In his model, *achievers* players are competitive, but have not destructive spirits to other players or to the system, and the *killers* players become part of the *disruptors* players, who distort the system or other users for different motivations.

More specifically, the intrinsically motivated player types proposed in Marczewski's model are:

- The *socializers*, who are motivated by *relatedness*, want to interact with others and create social connections. They interact with users for intrinsic reasons, e.g., they just like to talk to others and enjoy being connected to people.
- The *free spirits*, who are motivated by *autonomy*, want to create and explore. They spirits interact with system for intrinsic reasons, e.g., they enjoy the self-expression a system may afford them, or by getting the most from a system.
- The *achievers*, who are motivated by *mastery*, aim to learn new things and improve themselves, and want challenges to overcome. They act on the system for intrinsic reasons, e.g., they enjoy by learning from the system, or by doing tasks perfectly. They also may be motivated by status as a representation of their personal achievement."
- The *philanthropists*, who are motivated by *purpose and meaning*, are altruistic, wanting to give and share with others, enriching the lives of the latter somehow with no expectation of reward. They act on users for intrinsic reasons, e.g., they answer questions on forums or edit entries on wikis.

Moreover, the model proposes the *disruptors* and *players* types, who are extrinsically motivated:

- The *disruptors*, who are motivated by *change*, in general want to disrupt the system, either directly or through other users to force positive or negative changes. They want to change or corrupt things around them. The reasons for that are manifold, e.g., they feel that disrupting the system has a greater meaning, since it may show the creators' faults or prove that there is somehow wrong.
- The *players*, who are motivated by *rewards*, do what is needed to collect recompenses from a system for themselves. For example, they like to get achievements in a system, and see their names on leader boards. For such purpose, they may make use of loopholes to gain advantages.

The Bartle's killer type is "only interested in what they can gain from the system or other users". The Marczewski's types take into account the psychology of motivation so the Bartle's killer type becomes *player* since its motivations are extrinsic.

The Marczewski's User Types Hexad [6] is shown in *Figure 4*. The player types are arranged in two centric hexagons. The outer hexagon contains the player type names, and the inner hexagon has the player types main motivations. Each player type is intuitively associated with several gamification mechanics, and each group of mechanics provides some kind of fun.
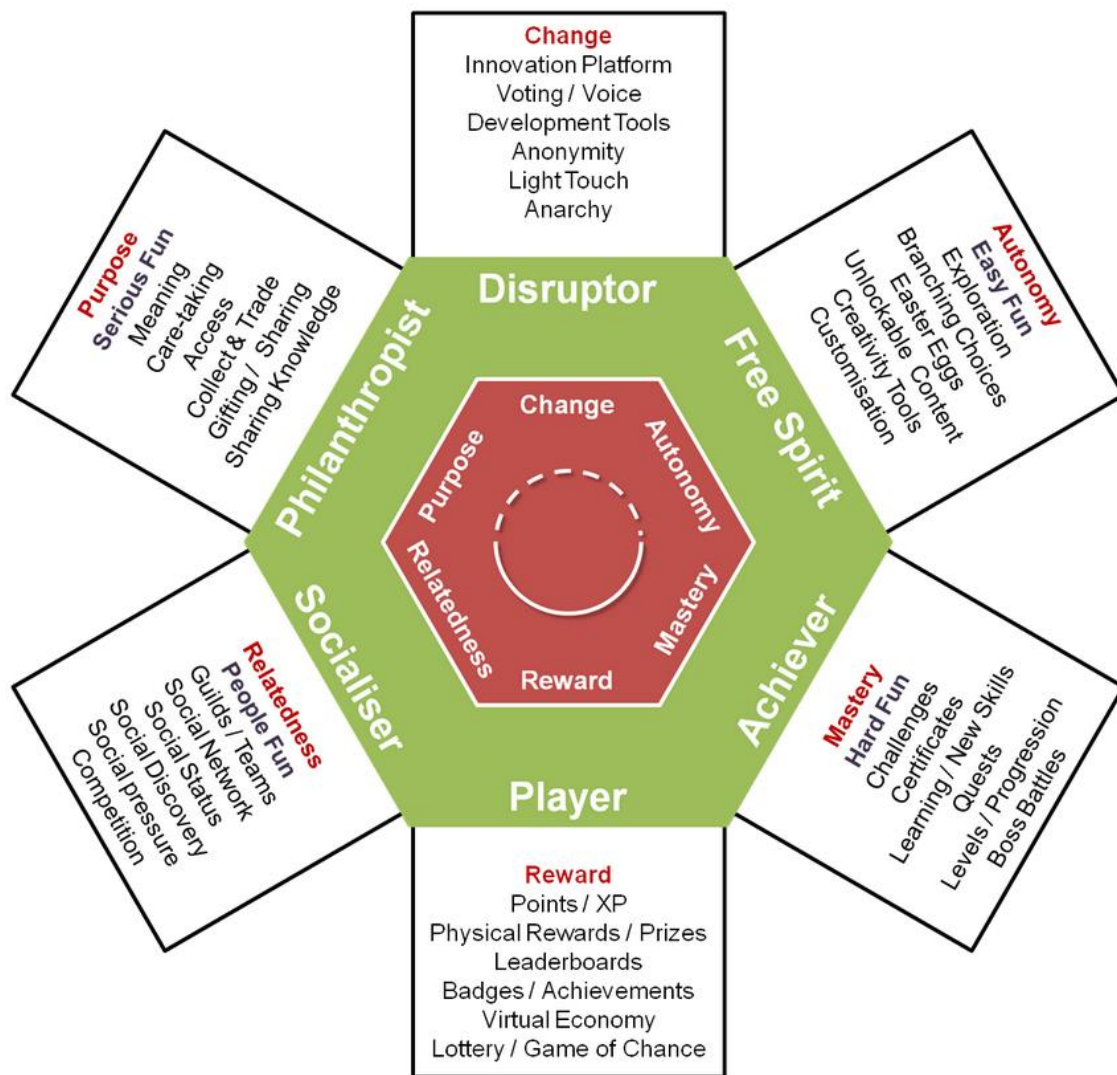
Figure 4. Marczewski's User Types Hexad, extracted from [6].

In order to intuitively assign each set of mechanics to a main motivation, it is necessary to know the study of human emotions, and how player interactions create emotions. The **4 Keys 2 Fun** model designed by Nicole Lazzaro [32], [33], describes four types of fun:

- *People Fun.* "Provides the excuse to hang out with friends." Actions like communicate, cooperate or compete, arouse emotions like amusement, admiration, social bounding, or friendship.
- *Easy Fun.* "Inspires exploration and role play." Actions like exploration, fantasy, or creativity, arouse emotions like curiosity, surprise, wonder, or awe.
- *Hard Fun.* "Provides the opportunity for challenge, mastery, and feelings of accomplishment." Actions like goals, obstacles, or strategy, arouse emotions like frustration, pried, or relief.
- *Serious Fun.* "Purposeful play changes how players think, feel, behave, or make a difference in the real world." Actions like repetition, rhythm, or collection, arouse emotions like excitement, zen focus, or relaxation.

Hence, in *Figure 4* the player types are associated with a different kind of fun. It is assumed that socializers are associated with mechanics that encourage *people fun*, free spirits with *easy fun*, achievers with *hard fun*, and philanthropists with *serious fun*.

The mechanics for the intrinsic player types (i.e., socializer, achiever, free spirit, and philanthropist) are described in more detail in Section 2.3. The mechanics for the extrinsic player types are not detailed because the purpose of our study, explained in Chapter 3, is intended to intrinsically motivate students in higher education.

2.3 Mechanics

The purpose of our study, presented in Chapter 3, is to intrinsically motivate university students in its learning process, when they have to put in practice some of the topics and concepts of a given subject syllabus. Thus, from now on we will not consider neither the *player* type nor the *disruptor* type, which do have extrinsic motivations. Our study was conducted in a limited e-learning environment and during a relatively short period of time. These issues did not allow potentially player students to get a significant amount of points, rewards, or badges, and did allow potentially disruptor students to perform destructive behaviors, to the system or to other colleagues.

In the literature, many game mechanics have been identified. One of the most complete collections is the one given by Andrzej Marczewski, which considers 47 gamification elements [34]. Next, we summarize the mechanics assigned to each of the intrinsically motivated player types.

For the **socializer** player type:

- *Guild/Team.* "Let people build close-knit guilds or teams. Small groups can be much more effective than large sprawling ones. Create platforms for collaboration but also pave the way for team based competitions."
- *Social Networking.* "Allow people to connect and be social with an easy to use and accessible social network. It is can be more fun to play with other people than to play on your own."
- *Social Status.* "Status can lead to greater visibility for people, creating opportunities to create new relationships. It can also feel good. You can make use of feedback mechanics such as leader boards and certificates."
- *Social Discovery.* "A way to find people and be found is an essential to building new relationships. Matching people based on interests and status can all help get people started."
- *Social Pressure.* "People often do not like feeling they are the odd one out. In a social environment this can be used to encourage people to be like their friends. Can demotivate if expectations are unrealistic."
- *Competition.* "Competition gives people a chance to prove themselves against others. It can be a way to win rewards, but can also be a place where new friendships and relationships are born."

For the **free spirit** player type:

- *Exploration.* "Give your Free Spirits room to move and explore. If you are creating virtual worlds, consider that they will want to find the boundaries and give them something to find."
- *Branching Choices.* "Let the user choose their path and destiny. From multiple learning paths to responsive narratives. Remember, choice has to be or at least feel meaningful to be most effective and appreciated."
- *Easter Eggs.* "Easter eggs are a fun way to reward and surprise people for just having a look around."
- *Unlockable/Rare Content.* "Add to the feeling of self-expression and value, by offering unlockable or rare content for free spirits to make use of. Link to Easter eggs and exploration as well as achievement."
- *Creativity Tool.* "Allow people to create their own content and express themselves. This may be for personal gain, for pleasure or to help other people (teaching materials, levels, gear, FAQ, etc)."
- *Customization.* "Give people the tools to customize their experience. From avatars to the environment, let them express themselves and choose how they will present themselves to others."

For the **achiever** player type:

- *Challenge.* "Challenges help keep people interested, testing their knowledge and allowing them to apply it. Overcoming challenges will make people feel they have earned their achievement.
- *Certificate.* "Different from general rewards and trophies, certificates are a physical symbol of mastery and achievement. They carry meaning, status and are useful."
- *Learning/New Skill.* "Give your users the opportunity to learn and expand."
- *Quest.* "Quests give users a fixed goal to achieve. Often made up from a series of linked challenges, multiplying the feeling of achievement."
- *Level/Progression.* "Levels and goals help to map a user's progression through a system. It can be as important to see where you can go next as it is to see where you have been."
- *Boss Battle.* "Boss battles are a chance to consolidate everything you have learned and mastered in one epic challenge."

For the **philanthropist** player type:

- *Meaning/Purpose.* "Some just need to understand the meaning or the purpose of what they are doing (epic or otherwise). For others they need to feel they are part of something greater than themselves."
- *Care-taking.* "Looking after other people can be very fulfilling. Create roles for administrators, moderators, curators etc. Allow users to take a parental role."
- *Access.* "Access to more features and abilities in a system can give people more ways to help others and to contribute. It also helps make them feel valued. More meaningful if earned."

- *Collect & Trade.* "Many people love to collect things. Give them a way to collect and trade items in your system. Helps build relationships and feelings of purpose and value."
- *Gifting/Sharing.* "Allow gifting or sharing of items to other people to help them achieve their goals. Whilst a form of altruism, the potential for reciprocity can a strong motivator."
- *Sharing Knowledge.* "For some, helping other people by sharing knowledge with them is its own reward. Build the in the ability for people to answer questions and teach others."

2.4   Benefits and difficulties caused by the use of gamification

Before presenting some of the benefits and difficulties of gamified activities, we have to first emphasize what gamification is not. As discussed by Kapp [35]:

- Gamification is not only using game mechanics as badges, points, or rewards. The gamification is not simply applying these game-design elements in any system. These elements may lose interest quickly for users if their use does not really pursuit the achievement of certain dynamics and aesthetics. Hence, for example, gamification has to be a serious approach to accelerate the experience and knowledge curve of students in an e-learning tool, and the engagement and loyalty curve of customers in an e-commerce site.
- Gamification is not perfect for every situation and domain. One has to first consider or assess whether the game-design elements to be incorporated into a system are needed, and if they provide desired results. If such items do not contribute to the user experience, by increasing their motivation and fun, they will quickly become trivialized and non-relevant.

Although the term "gamification" is relatively new [36], the application of some of its elements in the educational domain is something that has been done long time ago. In education, gamification aims to join game-design elements to accelerate the learning curve of students, increasing their motivation and reinforcing the concepts learned through traditional educational techniques. Moreover, teachers, educators, and social workers have been using gaming techniques not only to teach educative content, but also to change the students' misbehaviors. For such purposes, a major problem that has to be faced is to avoid the over justification effect, that is to say, performing a task to achieve a collateral result from completing it and not for the knowledge and satisfaction that could be obtained. As an illustrative example conducted at Asociación Tobogán de Luz[10], Tobotermo is a game element that motivates the expression of emotions; it is a cardboard thermometer composed of several temperature faces that represent different emotions. The thermometer motivate children to place and explain their moods, allowing to detect worrying states of anxiety and sadness [37]. The experiment conducted by Lepper & Nisbett [7] indicated that the children interest for drawing activity decreased in those that expected awards, who devoted less time and effort to complete the tasks. The study

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[10] "Asociación Tobogán de Luz - Web de las Asociaciones." [Online]. Available: http://www.injucam.org/asociaciones/asociaciones/asociacion-tobogan-de-luz/. [Accessed: 14-Sep-2015].

conducted by Cantador [38] aimed to establish how competition-based learning activities should be designed to be not harmful, even beneficial, to the students' learning process.

In the commercial and business domains, a problem that often occurs is the over emphasis on mechanics as points and badges. A representative gamified application is Foursquare, a geolocation-based service in which users can record check-ins of places where they have been, sharing them with friends, and winning badges for it, such as "mayorships" as more check-ins or new place findings are done. These collectibles badges, among other things, allowed the company to increase its fifty thousand users in 2009 to more than fifty million in 2014. Nowadays, the services is evolving towards a recommender system with a more mature design. The company not only removed the overemphasis on points and badges, but also all gamification elements of the original application. In August 2014, Foursquare separated the gamified social part, as the check-ins, in a second application called Swarm[11], and eliminated game-design elements that made them so famous like the "Mayorship" element. Until October 2014 Foursquare lost users dramatically[12]. The recent Swarm application could not maintain users at that time. Hence, only one third of the users of the platform used both applications. In May 2015 Dennis Crowley, Foursquare co-founder and CEO, announced[13] that Swarm would be updated recovering old badges obtained in the past, and that new game-design elements related with social interaction would appear. In March 2013[14] Cortizo-Pérez, BrainSINS[15] co-founder, opined that "what FourSquare should do is to analyse what their users expect from the system, and create and adapt the gaming mechanics that may allow re-engaging users who were tired of the current mechanics." He also expressed that "he would focus on helping users to discover new challenges in the platform". Combining the existing gamification with new discovery (and gamified) features, he claimed that "Foursquare would become something pretty interesting not only for newcomers, but also for the registered users who had not used Foursquare in months".

Ian Bogost is a game designer and theorist, and a leading criticist of gamification. In his position statement at the Wharton Gamification Symposium, he defended the view that "gamification is bullshit"[16], understanding *bullshit* as a synonym for something used to conceal, impress or coerce. "Unlike liars, bullshitters have no use for the truth. All that matters to them is hiding their ignorance or bringing about their own benefit." "More specifically, gamification is marketing bullshit, invented by consultants as a means to capture the wild, coveted beast that is videogames and to domesticate it for use in the grey, hopeless wasteland of big business, where bullshit already reigns anyway." He suggested the term *exploitationware* as a more accurate name for gamification's real intentions.

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[11] "Swarm is the app that turns your life into a game." [Online]. Available: https://www.swarmapp.com/. [Accessed: 08-Aug-2015].

[12] "Will the check-in survive? Foursquare's controversial relaunch, by the numbers," VentureBeat. [Online]. Available: http://venturebeat.com/2014/10/23/will-the-check-in-survive-foursquares-controversial-relaunch-by-the-numbers/. [Accessed: 08-Aug-2015].

[13] J. Crook, "Swarm 2.3 Feels Like The Old Foursquare, Looks Way Better," TechCrunch.

[14] "Why FourSquare's Decision of Phasing Out Gamification is a Great Mistake," JoSeK.

[15] "BrainSINS - Smart eCommerce - 360o E-Commerce Personalization Suite," BrainSINS - Smart ECommerce. [Online]. Available: http://www.brainsins.com/en/. [Accessed: 08-Aug-2015].

[16] I. Bogost, "'Gamification Is Bullshit,'" The Atlantic, 09-Aug-2011.

Gabe Zichermann, a gamification expert, responded saying that "gamification is here to stay (and it is not bullshit)."[17] "Some say that gamification is a 'perversion' of games, their mechanics twisted into a magical marketing pill for big, evil corporations. This overlooks all the good that gamification does, and has the potential to do more." "We must recognize that the fundamental purpose of all organizations is to create as much value as possible. This value may be measured in assets or lives saved, children made healthier or kilos of trash diverted from landfill." For example, "in Nike+[18], players are provided with clearly disclosed encouragement to improve their physical fitness using a gamified system. And while Nike would like for you to buy more shoes, they do not trick you into doing so by any other method than wearing them out from exercise." "The question is really more subtle – hinging on issues of truth, disclosure and self-determination rather than who designed the product and what it is advocating." "Gamification is helping real people with real issues – promoting fitness, reducing waste and helping improve education are only the start."

[17] G. Zichermann, "Gamification Is Here to Stay," The Atlantic, 29-Aug-2011.

[18] "Join me on Nike+." [Online]. Available: https://secure-nikeplus.nike.com/plus/. [Accessed: 09-Aug-2015].

Chapter 3. Validating player types and mechanics in an e-learning environment

In this chapter we present the experiment conducted in an e-learning environment, aimed to validate on the Higher Education domain generic player types and mechanics proposed in the gamification literature. In Section 3.1 we describe the study in general. In Section 3.2 we present how we designed the player types and how we implement the considered mechanics. Next, in Section 3.3 we explain the data analysis we performed to address the research questions of this thesis, and finally in Section 3.4 we discuss main results and conclusions.

3.1   User study

In Chapter 2 we presented four player types –socializer, free spirit, achiever and philanthropist– commonly accepted in the Gamification field, and their associated mechanics, proposed independently of the application domain. In this context, it becomes mandatory 1) to decide how to implement the mechanics for a particular domain, and 2) to validate empirically whether these mechanics and implementations really correspond to their assumed player types. Specifically, in this thesis, we focus on Higher Education, and investigate gamified activities during practical assignments lectures of a particular subject.

The selected subject was Programming II, which belongs to the first course of the Degree in Computer Science and Engineering at Universidad Autónoma de Madrid. The course addresses the fundamental aspects of Abstract Data Types (e.g., stacks, queues, and linked lists) used in computer programming, and uses the C programming language for practical explanations. Examples of the subject assignments are writing pseudocodes and C code functions for given prototypes, explaining and writing in detail the pseudocode of certain function that is and adaptation or extension of other, providing the C implementation of a stack be means of calls to functions that are provided as interface, determining the correction of expressions composed of paired symbols through the evolution of a stack, evaluating postfix, suffix and infix expressions, and developing the code of primitive functions of the Abstract Data Types. Statements of available actions for every player type can be found in *Appendix A*, and one example worksheet given in class can be found in *Appendix B*.

A week before the study, students were asked to complete an adaptation of the **player type questionnaire** proposed by Marczewski [23] to infer the player type of a person. The proposed questions are shown in Table 2. Specifically, 16 questions in the test were intended to infer percentages of correspondence between each student and socializer, free spirit, achiever, and philanthropist player types. Since the original test consists of questions focused on user interaction with the web, social networks, and videogames, the test presented to the students adapted the original questions to make them generic and domain-independent. The allowed answers to the questions could be "I strongly disagree", "I disagree", "I neither agree nor disagree", "I agree" and "I strongly agree".

Before the study, we conducted a **gamified testing session** with a duration of two hours, addressing general issues about Abstract Data Types. This session served for

familiarize students to the kind of assignments and gamification mechanics that were going to take place in the study, as well as to help us to refine the implementation of some mechanics. The data recorded in the two subsequent sessions were those we analyzed and from which we obtained the results and conclusions of the study.

At the beginning of each of the **two study sessions**, taken a total of four hours, the students were presented with a large number of assignments, each of them marked with certain degree of difficulty. The students were asked to freely choosing the assignments to solve, as well as performing a number of gamified actions (i.e., specific implementations of well-known gamification mechanics), which they had to record in an online e-learning platform through their laptops and mobile devices.

In order to encourage the assimilation and performing of the mechanics by the students, the names of the player types were replaced by the names of well-known "Middle-Earth" races appearing in the J. R. R. Tolkien's "The Lord of the Rings" novel[19]. Hence, during the two sessions, the students were free to choose at any time the race (i.e., the player type) they wanted to play. Specifically, *socializers* were called *humans/men*[20], *philanthropists* were called *hobbits*[21], *achievers* were called *dwarves*[22] and *free spirits* were called *elves*[23]. From the beginning, the students showed interest in learning about each race and its mechanics, in order to discover which ones were best suited to their preferred way to address problems and solve assignments. The **player types** are briefly described as follows:

- *Socializers (Humans/Men)* have dynamics to work in communities. They are characterized by their sociability, and like to interact with others.
- *Free Spirits (Elves)* have dynamics to work alone. They are characterized by their autonomy, and like to create and explore.
- *Achievers (Dwarves)* have dynamics to work alone. They are characterized by their mastery, and like to address challenges and achieve victories.
- *Philanthropists (Hobbits)* have dynamics to work in pairs. They are characterized by their altruism, and like to help and share with others.

The students belonging to each race were sit and grouped around one of the four corners of the classroom to easily identify who belonged to each race, being the philanthropists the only ones who could move around the room to help others.

The students could record actions such as granting positive awards to classmates who asked for help or to students who were helped, negative awards to those who did not helped, granting positive or negative awards to classmates based on how they worked in group, and to giving/exchanging collectibles, to name a few. Other actions were recorded by the lecturer in charge of supervising the activity by requests from the students, who want to validate certain actions, such as changing their current race, receiving an award for writing an assignment solution on the blackboard, for being the first one to correctly solve an assignment, for asking for assignment solutions to the lecturer, for completing all the

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[19] "The Lord of the Rings," Wikipedia, the free encyclopedia. 08-Jul-2015.
[20] "Man (Middle-earth)," Wikipedia, the free encyclopedia. 02-Jul-2015.
[21] "Hobbit," Wikipedia, the free encyclopedia. 25-Jun-2015.
[22] "Dwarf (Middle-earth)," Wikipedia, the free encyclopedia. 09-Jul-2015.
[23] "Elf (Middle-earth)," Wikipedia, the free encyclopedia. 05-May-2015.

assignment with certain difficulty degree, for asking for the statements of assignments of high difficulty or belonging to an unexplained subject topic, and proposing or modifying an assignment in an interesting way. In Section 3.2 we will explain in detail the implemented mechanics and actions of each player type. We note here that every action was assigned to certain player type, but this does not mean that only could be recorded by students of such types. For example, any player could have explained an assignment solution on the blackboard, regardless the fact that this action is in principle assumed for a philanthropist.

Once the two study sessions were finished, the students were requested to fill **opinion questionnaires** evaluating several issues of the proposed gamified activity and e-learning system. The analysis of the recorded actions, together with the students' opinions will be discussed in Section 3.3.

3.2   Implementing player types and gamification mechanics

In *Figure 5* we show our understanding of the main stages that have to be followed for applying gamification in a particular domain. First, we have to define the player types that will be considered, e.g., based on consumers' habits and purchases in an e-commerce site or based on students' learning styles and goals in an e-learning platform. Next, for each player type, we have to choose the corresponding gamification mechanics that make sense in the target domain. Finally, we have to design and implement specific domain-dependent actions for each of the selected mechanics.
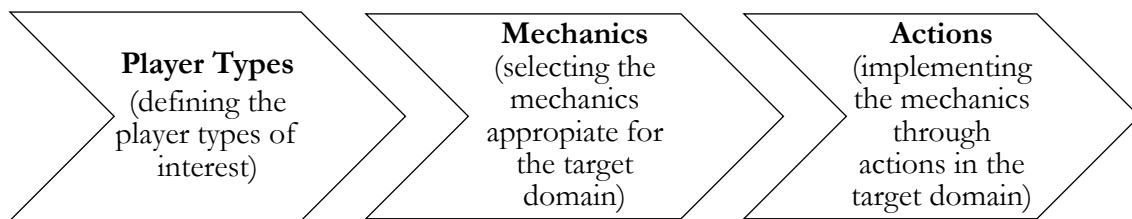
Figure 5. Stages in the application of gamification in specific domains.

In our study on the educational domain, to determine what would be the relevant player types to consider, we start with the player types of Marczewski's User Type Hexad, shown above in *Figure 4*, since it clearly separates the player types whose motivations are intrinsic or extrinsic (*player* and *disruptor* player types). Hence, we decided to segment the students among the four player types with intrinsic motivations, namely *socializers*, *achievers*, *free spirits*, and *philanthropists*. This decision was made because our goal was to encourage intrinsic motivations in students to study the subject topics addressed in the study sessions. The description of the player types presented to the students, and the mechanics selected/discarded for each player type are described next.

Achievers (dwarves) work individually, and are characterized by their mastery, overcoming new challenges and winning achievements. They perform assignments attempting to rise above themselves and their classmates, by reaching certain goals stated in the statements. They have the ability to ask philanthropists for help. The gamification mechanics selected/discarded for achievers are:

✓   Challenge: a student has to be the first in solving an assignment, like a sprint.

✓ Quest: a student has to face a number of challenges for a prolonged period of time, like a long distance race.

✓ Level/Progression: the student is motivated by checking that her knowledge increases as she solves assignments.

✓ Certificate: a student is awarded for certain achievements.

✗ Learning/New Skills: this mechanic was not selected because the reminder mechanics are aimed to motivate the students' learning.

✗ Boss Battles: this mechanic was not selected because it would require a larger number of gamified sessions.

Free spirits (elves) work individually, and are characterized by their autonomy, thinking, creating and exploring contents. They have more freedom than the rest of students, to wonder how an assignment could be changed, or how new assignments could be. They have the ability to ask philanthropists for help. The gamification mechanics selected/discarded for free spirits are:

✓ Exploration: the student has free and so does not feel pressured, arranging study at their own pace and interest.

✓ Unlockable/Rare Content: this type of content arouses the student researcher curiosity.

✓ Customization: the student asks himself how he would perform certain tasks having introduced variants in the statement.

✓ Creativity: the student can devise new tasks that can be solved by the knowledge acquired.

✗ Branching Choices: this mechanic is not selected because during the gamified sessions all students should study or practice the whole set of planned agenda.

✗ Easter Eggs: this mechanic is not selected because we do not find an implementation that will bring a significant motivation.

Socializers (humans/men) work in teams of four to six people, and are characterized by their sociability, interacting, coordinating and communicating with others, and thus working collaboratively in a productive way. Since they work in group, they do not have the ability to ask philanthropists for help unless the latter take an interest in helping. The gamification mechanics selected/discarded for socializers are:

✓ Team/Guild: the students have to work together productively.

✓ Competition: the student teams check their levels of productivity and efficiency achieved by ranking comparison with others.

✓ Social Status: a student can received a positive recognition from her classmates.

✓ Social Networking: it promotes the collaboration between a team members.

✓ Social Discovery: encourages peer interaction of students who do not belong the same team.

✗ Social Pressure: this mechanic was not selected to avoid potential conflicts among a team members.

Philanthropists (hobbits) work in pairs, and are characterized by their altruism, helping and sharing with others. The students belonging to other races can ask a pair of

philanthropists for help, and the pair decides whether or not to help. Philanthropists have also the chance of moving around the classroom to offer their help to the rest of the students. The gamification mechanics selected/discarded for philanthropists are:

- ✓ Meaning/Purpose: a student makes an action that not only has an impact on her learning but on the others'.
- ✓ Care Taking: a student shows interest not only in her learning process, but also in her personal satisfaction for helping others.
- ✓ Sharing Knowledge: a student shares her knowledge with others, not keeping it for him.
- ✓ Access: a student has access to assignments solutions in order to help others.
- ✓ Collecting & Trading: a student can gather and exchange collectibles with others, gaining points.
- ✓ Gifting: a student can give own points to others.

Table 1 summarizes the selected mechanics and implemented actions for each player type through concrete actions in a typical assignment lecture.

The *achievers'* actions were designed as one-person tasks in which the students are motivated by challenges: getting the maximum number of personal points on a leader board solving a number of assignments (the *quest badge* mechanic), performing all the assignments of a particular difficulty degree (the *level-X expertise badge* mechanic), and standing out by accumulating the largest number of possible merits (the *mastery certificate* mechanic). The students of all the player types have the chance to be the first performing a task (the *victory badge* mechanic), although it is intuitively associated to the achievers.

The *free spirits'* actions were designed as flexible and open one-person tasks in which the students have more freedom and are motivated by encouraging their curiosity for other more difficult tasks (the *exploration badge* mechanic), going beyond the issues addressed in the theory material available for solving the assignments (the *adventurer badge* mechanic), and thinking about assignment adaptations (the *customizer badge* mechanic), or even the proposal of new assignments (the *creator badge* mechanic).

The *socializers'* actions were designed for work teams of four to six members, and were aimed to motivate students by means of achieving effective coordination and communication to solve tasks collaboratively (the *team/guild* mechanic), and comparing results with those of other teams (the *competition* mechanic). They were also designed to motivate students by easing interaction with classmates (the *social networking* mechanic), encouraging them to gain and maintain a social status/recognition within their teams according to their work attitude and contributions (the *social status* mechanic), and allowing them to meet unknown classmates to work with (the *social discovery* mechanic).

The *philanthropists'* actions were designed for motivating students by given them the opportunity to help their classmates, either by their own initiative (the *care-taking* mechanic) or by others' request (the *meaning/purpose* mechanic). Since the knowledge of a philanthropist may be similar to the rest of the students, in order to help others she should have access to assignments solutions, so she could first understand and then explain the tasks resolution (the *access* mechanic).

Table 1. Considered student actions, gamification mechanics, and assumed player types.

Student action	Mechanic	Player type
A1 Choosing to work alone for solving the assignments	Challenge	Achiever
A2 Receiving a "victory badge" for being the first student who solved certain assignment		
A3 Receiving a "quest badge" for solving certain number of assignments	Quest	
A4 Receiving a "level-X expertise badge" for solving certain number of assignments with difficulty level X	Level / Progression	
A5 Receiving a "mastery certificate" for obtaining certain number of victory, quest and/or expertise badges	Certificate	
F1 Choosing to work alone for solving the assignments	Exploration	Free Spirit
F2 Receiving an "explorer badge" for asking (the teacher/system) and solving hidden assignments of high difficulty		
F3 Receiving an "adventurer badge" for asking (the teacher/system) and solving assignments out of the study topics	Unlockable / Rare Content	
F4 Receiving a "customizer badge" for proposing and solving adaptations or modifications of an assignment	Customization	
F5 Receiving a "creator badge" for proposing and solving new assignments	Creativity	
S1 Choosing to work in a team for solving the assignments	Team / Guild	Socializer
S2 Receiving points for the competition ranking by solving assignments	Competition	
S3 Receiving a "colleague badge" (from a member of my team) for being very participative and cooperative	Social status	
S4 Creating a "twinning link" with a student I enjoyed working with	Social networking	
S5 Giving a "gentleman badge" to a student to whom I asked for help on solving an assignment	Social discovery	
P1 Receiving a "gentleman badge" from a student I helped on solving an assignment	Meaning / Purpose	Philanthropist
P2 Helping a student to solve an assignment	Care taking	
P3 Presenting an assignment solution on the blackboard	Sharing knowledge	
P4 Ask (the teacher/system) for an assignment solution	Access	
P5 Interchanging a "ring" with other student	Collecting & Trading	
P6 Giving one of my rings to a student	Gifting	

In addition to the above actions, the students belonging to any player types could gather collectable objects. In particular, they had the chance to collect fictional "rings", each of them belonging to one of the four Middle-Earth races, and having assigned points to be added to the students' ranking sores. Exchanging (the *collecting & trading* mechanic) or giving away (the *gifting* mechanic) rings were thus equivalent to exchange or give away points, actions that may be assumed as intrinsic motivations of philanthropists. Also, all the students had the possibility of solving and explaining assignment solutions on the blackboard (the *sharing knowledge* mechanic), which again may be assumed as intrinsic motivations of philanthropists.

3.3   Validating the implemented player types and mechanics

As mentioned in previous sections, before the activity, the students filled a personality questionnaire aimed to infer their assumed player types, which were not reported to the students. During the activity, the students were presented with all the alternative races (player types) and actions (mechanics), and were asked to choose and change the race to play or the action to perform at any time.

In this context, we remind that the study was aimed to address the following four **research questions**:

RQ1.   Were all the items of the initial personality questionnaire useful to infer the students' player types?

RQ2.   Did the considered gamification mechanics and their implementations as learning-based actions really correspond to the students' inferred player types?

RQ3.   Which player types and gamification mechanics were effective in the tested e-learning environment?

RQ4.   How the students assessed the proposed gamified activities?

These four research questions are addressed in the subsequent subsections. In Section 3.3.1 we analyse the effectiveness of the questionnaire to infer the students' player types (RQ1). In Section 3.3.2 we validate the proposed mechanic implementations and their correspondences with the considered player types (RQ2). In Section 3.3 we evaluated the effectiveness of the mechanics in the e-learning environment (RQ3). Finally in Section 3.3.4 we analyse the students' opinion about the gamified activity (RQ4).

3.3.1   Effectiveness of the player type inference

RQ1. Were all the items of the initial personality questionnaire useful to infer the students' player types?

Table 2 shows the 16 items of the personality questionnaire proposed to infer the students' player types. The questions are adaptations of Marczewski's player types questionnaire [23], which focuses its items on the games and video games domains. There are 4 questions aimed to estimate the closeness of a target student to each player type. Questions 1-4 were intended to infer the *philanthropist* closeness, 5-8, the *achiever* closeness, 9-12, the *socializer* closeness, and 13-16, the *free spirit* closeness. The allowed answers for each question were "I strongly disagree", "I disagree", "I neither agree nor disagree", "I agree", and "I strongly disagree."

Table 2. Proposed personality questionnaire to infer player types.

Questionnaire item	Player type
1 I usually help people (even if they are unknown to me) and enjoy doing it.	Philanthropist
2 I usually book and dedicate part of my time to help people (even if they are unknown to me) and enjoy doing it. For example, I work in a support centre, contribute on internet forums, etc.	
3 I usually provide information to people (even if they are unknown to me) and enjoy doing it. For example, I write posts in blogs or wikis, provide class notes in college, etc.	
4 I do not usually share my knowledge with others.	
5 I tend to attend a course for the sake of learning, not for getting a degree or certificate.	Achiever
6 I tend to repeat tasks until I do them perfectly.	
7 For me, the way to achieve something is as important as the goal itself.	
8 I tend to give up if something gets too difficult or hard.	
9 I participate in social networks (Facebook, Twitter, etc.) regularly.	Socializer
10 I prefer to relate/interact with people in social networks rather than follow them and just watch what content they upload.	
11 For me, the number of friends/followers is one of the most important measure of success in social networks, blogs, etc.	
12 Usually I share content with my friends/followers in social networks, blogs, etc., and enjoy doing it.	
13 Self-expression is very important to me. Self-expression: expressing own originality and autonomy, emphasizing yourself as a person who has a unique personality and is distinct from those around you.	Free Spirit
14 I enjoy more a game/videogame/book with a guided story and a fixed route, than other that lets me explore and have a more open story.	
15 I do not usually like being confined by too many rules in a game/videogame.	
16 I usually try find hidden objects or 'Easter eggs' in movies, videogames, etc.	

As done by Marczewski, and shown in *Figure 6*, each possible answer for each question was intuitively set a weight. The greater the weight of the answer, the higher its influence for assigning the corresponding player type to the student. Specifically, the closeness score $clo(s,p) \in [0,1]$ of student s to player type p is computed as the average value of the weights $w(p_i)$ set to the answers of the four questions $p_i, i \in [1,4]$, corresponding to p, i.e.:

$$clo(s,p) = \frac{\sum_{i=1}^{4} w(p_i)}{4}$$

Note that for questions 1-3, 5-7, 9-10, 12-13 and 15-16, the "I strongly disagree" answer means having a null closeness with the corresponding player type, and that for questions 4, 8, 11 and 14, the "I strongly disagree" answer means having a total closeness with the corresponding player type.

Player Type	Question	Weight				
		Strongly Disagree	**Disagree**	**Neither**	**Agree**	**Strongly Agree**
Philanthropist	1	0	0,25	0,5	0,75	1
Philanthropist	2	0	0,25	0,5	0,75	1
Philanthropist	3	0	0,25	0,5	0,75	1
Philanthropist	4	1	0,75	0,5	0,25	0
Achiever	5	0	0,25	0,5	0,75	1
Achiever	6	0	0,25	0,5	0,75	1
Achiever	7	0	0,25	0,5	0,75	1
Achiever	8	1	0,75	0,5	0,25	0
Socializer	9	0	0,25	0,5	0,75	1
Socializer	10	0	0,25	0,5	0,75	1
Socializer	11	1	0,75	0,5	0,25	0
Socializer	12	0	0,25	0,5	0,75	1
Free Spirit	13	0	0,25	0,5	0,75	1
Free Spirit	14	1	0,75	0,5	0,25	0
Free Spirit	15	0	0,25	0,5	0,75	1
Free Spirit	16	0	0,25	0,5	0,75	1

Figure 6. Weights assigned to the question answer pairs of each player type.

Once a student filled the questionnaire on-line, the closeness score $clo(s,p)$ for each player type was computed as below. The player type with the highest score was considered as the student's primary player type. In case of having two player types with the highest score for a particular student (this occurred in 12 cases), the further analysis was conducted by considering two different student profiles. It this happened with the secondary player type, we proceed in the same way.

A total of 32 students participated in the study, filling the player type questionnaire and also recording some actions into the online system during the gamified activity. More specifically, 21 students recorded actions in the two study sessions; they were 6 philanthropists, 6 achievers, 7 socializers, and 2 free spirits, according to their inferred primary player type. Since only two students were associated to *free spirits*, the results for this player type may not be significant, so we cannot obtain reliable conclusions from their actions.

Player Type	Question	Students Associated with 1st Player Type (Mean)					Students Associated with 1st Player Type (Std. dev.)			
		Philanthropist (6)	Achiever (6)	Socializer (7)	Free Spirit (2)		Philanthropist (6)	Achiever (6)	Socializer (7)	Free Spirit (2)
Philanthropist	1	4,83	3,83	3,57	4,00	1	0,41	0,75	0,53	0,00
Philanthropist	2	4,33	3,67	3,43	2,50	2	0,52	1,03	0,98	0,71
Philanthropist	3	4,00	3,83	3,86	4,00	3	0,63	0,75	0,69	0,00
Philanthropist	4*	4,33	4,17	4,00	4,00	4	0,52	0,41	0,58	0,00
Achiever	5	3,67	4,50	3,57	4,00	5	0,52	0,55	0,53	0,00
Achiever	6	3,67	4,50	2,71	3,00	6	0,82	0,55	0,76	1,41
Achiever	7	4,17	4,33	3,86	3,00	7	0,41	0,82	0,69	0,00
Achiever	8*	4,00	3,67	3,71	4,00	8	0,89	1,03	0,95	0,00
Socializer	9	4,00	3,33	4,14	3,50	9	1,10	1,21	1,21	2,12
Socializer	10	3,67	2,50	3,86	3,50	10	0,52	1,05	1,07	0,71
Socializer	11*	3,67	4,00	4,00	3,50	11	0,82	0,89	0,82	2,12
Socializer	12	3,50	2,67	3,71	3,50	12	0,84	1,21	0,49	0,71
Free Spirit	13	3,83	3,50	3,86	4,50	13	0,41	0,84	0,69	0,71
Free Spirit	14*	3,50	3,67	2,86	4,00	14	0,55	1,03	1,07	0,00
Free Spirit	15	3,00	3,67	3,57	3,00	15	0,63	0,82	0,53	0,00
Free Spirit	16	3,67	2,67	3,43	5,00	16	1,03	1,03	1,13	0,00

(*) Score invested regarding to initial test to match the rest, 1 = Strongly Disagree and 5 = Strongly Agree

Figure 7. Mean (left) and standard deviation (right) values obtained from the responses to each question, grouped by inferred primary player types.

Assigning [1,5] values to the possible answers in terms of increasing closeness of the questions to their player types (i.e., 1 to "I strongly disagree", 2 to "I disagree", 3 to "I neither agree nor disagree", 4 to "I agree", and 5 to "I strongly agree"), *Figure 7* shows the mean and standard deviation values of the answers received in the player type questionnaire.

From the figure, we see that questions 8 (*achiever*) and 15 (*free spirit*) did not correspond with the player types to which they were intended, because of their low mean values with respect to other types. We also observe that questions 7 (*achiever*), 10 (*socializer*) and 13 (*free spirit*) did not clearly correspond with their player types due to high standard deviation values.

Hence, the questions that properly discriminated primary player types were 1-6, 9, 11-12, 14 and 16, although 14 and 16 may be unreliable because of their low number of responses. These questions were related to whether a student usually helps people sporadically, reserves and spends part of her time to explicitly help people, shares information and knowledge, does not usually share knowledge, attends a course for the sake of learning and not only to obtain a degree or certificate, works to achieve the perfection on her tasks, regularly and actively participates in social networks, thinks the number of friends/followers is a measure of success in social networks/blogs/etc., shares content with his friends/followers, prefers more a game with a guided story and a fixed route instead of another that lets her to explore and to have a more open story, and tends to look for uncommon and wrong issues in movies or games.

Questions 7-8, 10, 13 and 15 did not properly inferred their intended primary player type. That is, those questions that ask whether a student thinks the way to a goal is as important as the goal itself, tends to give up if something gets too difficult or hard, prefers to relate/interact with people in social networks rather than follow them and just watch

what content they upload, thinks that self-expression is very important for her, and does not usually like being confined by too many rules in a game.

From these results, we could claim the following **conclusions:**

- The questions that properly inferred a primary player type were: the four corresponding to *philanthropists* (1-4), two corresponding to *achievers* (5-6), and three corresponding to *socializers* (9 and 11-12). The remainder questions may be removed or adapted in a future implementation of the questionnaire.

- We could not validate the effectiveness the questions aimed to infer the *free spirit* player type (13-16). Nonetheless, as we will see later on, the actions associated to this player type were not chosen by the students during the activity. We thus believe that this player type is not appropriate for the e-learning environment we propose.

In addition to consider the inferred primary player types, we also analyze the secondary ones. In this case, we only inferred player types for 12 students who recorded actions in the two study sessions: 4 *philanthropists*, 1 *achiever*, 4 *socializers*, and 3 *free spirits*. *Figure 8* shows the mean and standard deviation values of their responses, as explained above.

Player Type	Question	Students Associated with 2nd Player Type					Students Associated with 2nd Player Type			
		⇑ 4	⇓ 1	⇑ 4	⤢ 3		⇑ 4	⇓ 1	⇑ 4	⤢ 3
		Philanthropist	Achiever	Socializer	Free Spirit		Philanthropist	Achiever	Socializer	Free Spirit
Philanthropist	1	⇨ 4,25	⇓ 4,00	⇑ 4,50	⇓ 4,00	1	⇑ 0,96	⇓ 0,00	⇑ 1,00	⇑ 1,00
Philanthropist	2	⇘ 3,25	⇓ 3,00	⇑ 4,00	⇘ 3,33	2	⇑ 0,96	⇓ 0,00	⇑ 0,82	⤢ 0,58
Philanthropist	3	⇓ 4,00	⇓ 4,00	⇑ 4,25	⇓ 4,00	3	⇑ 0,82	⇓ 0,00	⇑ 0,96	⇑ 1,00
Philanthropist	4*	⇓ 4,00	⇓ 4,00	⇑ 4,50	⤢ 4,33	4	⇑ 0,82	⇓ 0,00	⤢ 0,58	⤢ 0,58
Achiever	5	⤢ 3,75	⇑ 4,00	⤢ 3,75	⇓ 3,00	5	⇘ 0,50	⇓ 0,00	⇨ 0,96	⇑ 1,73
Achiever	6	⇘ 3,50	⇑ 4,00	⇓ 3,25	⇑ 4,00	6	⤢ 1,29	⇓ 0,00	⇨ 0,96	⇑ 1,73
Achiever	7	⇑ 4,25	⇓ 3,00	⇑ 4,25	⇑ 4,33	7	⇑ 0,96	⇓ 0,00	⇨ 0,50	⇑ 1,15
Achiever	8*	⇑ 4,50	⇨ 4,00	⇘ 3,75	⇓ 3,33	8	⇘ 0,58	⇓ 0,00	⇨ 0,96	⇑ 2,08
Socializer	9	⇑ 4,50	⇓ 2,00	⇑ 4,50	⇓ 2,00	9	⇘ 0,58	⇓ 0,00	⇘ 0,58	⇑ 1,73
Socializer	10	⇑ 3,25	⇑ 3,00	⇑ 3,25	⇓ 2,00	10	⇑ 0,96	⇓ 0,00	⇑ 0,96	⇑ 1,00
Socializer	11*	⇓ 3,25	⇑ 5,00	⇓ 3,50	⤢ 4,33	11	⇨ 0,50	⇓ 0,00	⇑ 1,00	⇑ 1,15
Socializer	12	⇨ 3,50	⇓ 3,00	⇑ 4,25	⇓ 3,00	12	⇘ 0,58	⇓ 0,00	⇘ 0,50	⇑ 1,73
Free Spirit	13	⇓ 3,75	⇨ 4,00	⇑ 4,25	⇨ 4,00	13	⇑ 0,96	⇓ 0,00	⇨ 0,50	⇑ 1,00
Free Spirit	14*	⇓ 3,25	⤢ 4,00	⇨ 3,75	⇑ 4,33	14	⇑ 1,26	⇓ 0,00	⤢ 0,96	⇨ 0,58
Free Spirit	15	⤢ 3,25	⇓ 3,00	⤢ 3,25	⇑ 3,33	15	⇨ 0,50	⇓ 0,00	⇑ 0,96	⤢ 0,58
Free Spirit	16	⇨ 4,00	⇑ 5,00	⇘ 3,75	⇓ 3,33	16	⇑ 0,82	⇓ 0,00	⇑ 0,96	⤢ 0,58
	(*) Score invested regarding to initial test to match the rest, 1 = Strongly Disagree and 5 = Strongly Agree									

Figure 8. Mean (left) and standard deviation (right) values obtained from the responses to each question, grouped by inferred secondary player types.

Only one student inferred as *achiever* performed actions playing with this type, so the results are not reliable for this type. The questions seem to not correspond to their secondary player type except questions 9, 10, 12 (*socializer*), 14 and 15 (*free spirit*). In the figure, we observe that the responses to questions 9 and 10 aimed to *socializers* serve equally for *philanthropists* because their mean and standard deviation values are the same. The mean value of question 15 is lower than 3.5 out of 5 so we do not consider it high enough.

We thus conclude that the questionnaire items do not properly infer secondary player types, so from now on we discard these types for the performed analysis.

3.3.2   Correspondence between mechanics and player types

RQ2. Did the considered gamification mechanics and their implementations as learning-based actions really correspond to the students' inferred player types?

At the beginning of the test session and the two study sessions, the students were presented with all assignment statements and difficulty degrees, short introductions of the races, and descriptions of the gamified actions. At any time, they were free to choose which race (player type) to play and which action (gamification mechanic) to perform. The only requirement was that all performed actions had to be recorded in the online system. Some of these actions were recorded by the students themselves through their mobile devices or laptops, and others were recorded by the teacher from the students' requests, such as recording the awards achieved. In a final implementation of the system, all the actions will be recorded by the students, some of them in an automatic, implicit way.

Figure 9 shows the number of students who recorded each action at least once. They are grouped by inferred player types in order to better see if performed actions were really chosen by the students belonging to the assumed player type. In a perfect correspondence between player types and actions/mechanics, the cells within the black-border squares would have the highest values per row (action/mechanic). We can observe that this happens in a relatively large percentage of the proposed mechanic implementations for all player types. Those cases in which this does not occur represent mechanics that may be discarded or implemented in a different way on a future gamified e-learning platform. To complement these results, *Figure 10 top* shows the number of students who performed each mechanic by player type. According to the proposed radial visual representation, the curve of each player type should be predominant in a particular quadrant.

Player Type	Mechanic	#Total	Achiever	Free Spirit	Socializer	Philanthropist
			Students Associated with 1st Player Type			
			⬆ 6 ⬇ 2	⬆ 7	⬆ 6	
Achiever	A1, A2 - Challenge	⬆ 14	⬆ 6	⬆ 2	➡ 4	➡ 2
Achiever	A3 - Quest	⬈ 10	➡ 3	⬆ 2	➡ 3	➡ 2
Achiever	A4 - Level / Progression	⬇ 2	⬊ 2	⬇ 0	⬇ 0	⬇ 0
Achiever	A5 - Certificate	⬈ 11	➡ 3	⬆ 2	➡ 4	➡ 2
Free Spirit	F1, F2 - Exploration	➡ 8	⬆ 6	⬆ 2	⬇ 0	⬇ 0
Free Spirit	F3 - Unlockable / Rare Content	⬇ 2	⬊ 2	⬇ 0	⬇ 0	⬇ 0
Free Spirit	F4 - Customization	⬇ 0	⬇ 0	⬇ 0	⬇ 0	⬇ 0
Free Spirit	F5 - Creativity	⬇ 0	⬇ 0	⬇ 0	⬇ 0	⬇ 0
Socializer	S1 - Team / Guild	⬆ 13	⬇ 1	⬇ 0	⬆ 7	⬆ 5
Socializer	S2 - Competition	⬊ 5	⬇ 1	⬇ 0	➡ 3	⬊ 1
Socializer	S3 - Social Status	➡ 7	⬇ 0	⬇ 0	⬆ 7	⬇ 0
Socializer	S4 - Social Networking	⬊ 4	⬇ 0	⬇ 0	➡ 4	⬇ 0
Socializer	S5 - Social Discovery	➡ 6	➡ 3	➡ 1	⬊ 2	⬇ 0
Philanthropist	P1 - Meaning / Purpose	⬊ 5	⬇ 0	⬇ 0	⬇ 0	⬆ 5
Philanthropist	P2 - Care Taking	⬇ 1	⬇ 0	⬇ 0	⬇ 0	⬊ 1
Philanthropist	P3 - Sharing Knowledge	➡ 7	⬇ 0	⬆ 2	➡ 3	➡ 2
Philanthropist	P4 - Access	⬊ 4	⬇ 0	⬇ 0	⬇ 0	⬆ 4
Philanthropist	P5 - Collecting & Trading	⬇ 2	⬇ 1	⬇ 0	⬇ 1	⬇ 0
Philanthropist	P6 - Gifting	⬊ 4	⬇ 1	⬇ 0	⬇ 1	➡ 2

Figure 9. Number of students associated with their inferred player type in the combination of the two study sessions.
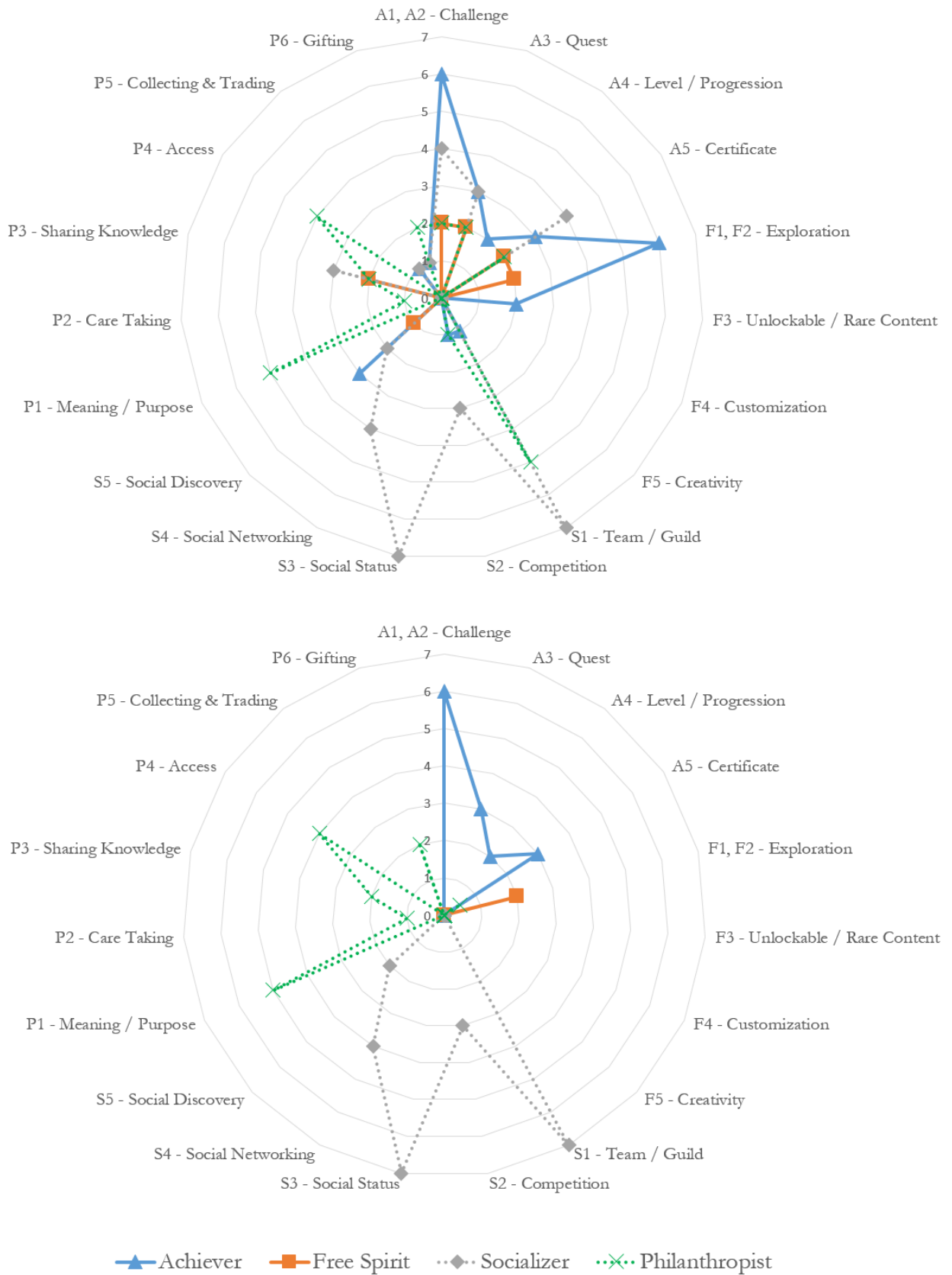
Figure 10. Number of students who recorded each action associated to their principal player type inferred, averaging (top) and not averaging (bottom) the numbers by the weights proposed by Marczewski for the player type questionnaire items.

In descending order of number of actions recorded by students inferred as *achievers*, the most frequently used mechanics were:

1. Challenge (A1, A2), Exploration (F1, F2).
2. Quest (A3), Certificate (A5), Social Discovery (S5).
3. Level/Progression (A4), Unlockable/Rare Content (F3), Team/Guild (S1), Competition (S2), Collecting & Trading (P5), Gifting (P6).
4. Customization (F4), Creativity (F5), Social Status (S3), Social Networking (S4), Meaning/Purpose (P1), Care Taking (P2), Sharing Knowledge (P3), Access (P4).

In descending order of number of actions recorded by students inferred as *free spirits*, the most frequently used mechanics were:

1. Challenge (A1, A2), Quest (A3), Certificate (A5), Exploration (F1, F2), Sharing Knowledge (P3).
2. Level/Progression (A4), Unlockable/Rare Content (F3), Customization (F4), Creativity (F5), Team/Guild (S1), Competition (S2), Social Status (S3), Social Networking (S4), Social Discovery (S5), Meaning/Purpose (P1), Care Taking (P2), Access (P4), Collecting & Trading (P5), Gifting (P6).

In descending order of number of actions recorded by students inferred as *socializers*, the most frequently used mechanics were:

1. Team/Guild (S1), Social Status (S3).
2. Challenge (A1, A2), Certificate (A5), Social Networking (S4).
3. Quest (A3), Competition (S2), Social Discovery (S5), Sharing Knowledge (P3).
4. Level/Progression (A4), Exploration (F1, F2), Unlockable/Rare Content (F3), Customization (F4), Creativity (F5), Meaning/Purpose (P1), Care Taking (P2), Access (P4), Collecting & Trading (P5), Gifting (P6).

In descending order of number of actions recorded by students inferred as *philanthropists*, the most frequently used mechanics were:

1. Team/Guild (S1), Meaning/Purpose (P1).
2. Access (P4).
3. Challenge (A1, A2), Quest (A3), Certificate (A5), Sharing Knowledge (P3), Gifting (P6).
4. Level/Progression (A4), Exploration (F1, F2), Unlockable/Rare Content (F3), Customization (F4), Creativity (F5), Competition (S2), Social Status (S3), Social Networking (S4), Social Discovery (S5), Care Taking (P2), Collecting & Trading (P5).

From these results, we could claim the following **conclusions:**

▪ Achievers and socializers recorded all the mechanics that were assumed for them. Philanthropists recorded all the mechanics assumed for them except *Collecting & Trading* (P5), which had a few records and none from philanthropists, so its correspondence is doubtful. Free spirits only recorded a mechanic assumed for them, *Exploration* (F1, F2). Members of all player types did not show interest in mechanics associated to free spirits.

- Without taken the *free spirits* into account, *Level/Progression* (A4) for achievers; *Social Status* (S3), *Social Networking* (S4), and *Competition* (S2) for socializers; and *Meaning/Purpose* (P1), and *Access* (P4) for philanthropists, were the most representative and discriminative gamification mechanics.
- *Challenge* (A1, A2), *Quest* (A3) and *Certificate* (A5), assumed for achievers, were recorded by all player types, showing to be the most versatile gamification mechanics.

In order to infer the predominant player types for selected mechanics, Marczewski intuitively assigned weights to each of the items in his player type questionnaire. These weights are given in *Figure 11*, where 1 means that an action is assumed to certain player type, and 0 otherwise.

Player Type	Mechanic	Achiever	Free Spirit	Socializer	Philanthropist
Achiever	A1, A2 - Challenge	1	0	0	0
Achiever	A3 - Quest	1	0	0	0
Achiever	A4 - Level / Progression	1	0	0	0
Achiever	A5 - Certificate	1	0	0	0,25
Free Spirit	F1, F2 - Exploration	0	1	0	0
Free Spirit	F3 - Unlockable / Rare Content	0	1	0	0
Free Spirit	F4 - Customization	0	1	0	0
Free Spirit	F5 - Creativity	0	1	0	0
Socializer	S1 - Team / Guild	0	0	1	0
Socializer	S2 - Competition	0	0	1	0
Socializer	S3 - Social Status	0	0	1	0,25
Socializer	S4 - Social Networking	0	0	1	0
Socializer	S5 - Social Discovery	0	0	1	0,25
Philanthropist	P1 - Meaning / Purpose	0	0	0	1
Philanthropist	P2 - Care Taking	0	0	0,25	1
Philanthropist	P3 - Sharing Knowledge	0	0	0	1
Philanthropist	P4 - Access	0	0	0	1
Philanthropist	P5 - Collecting & Trading	0	0	0	1
Philanthropist	P6 - Gifting	0	0	0	1

Figure 11. Weights manually assigned to each mechanic for each player type.

Figure 10 bottom shows the number of students performing each action group by inferred player type, averaged with the questionnaire item weights proposed by Marczewski. Comparing the differences between the two graphs of the figure, we could claim the following **conclusion**:

- *Exploration* (F1, F2) and *Social Discovery* (S5) performed by achievers, *Challenge* (A1, A2) and *Certificate* (A5) performed by socializers, and *Team/Guild* (S1) performed by philanthropists, are mechanics that were not assumed for such player types, but they were recorded by them. In a future implementation of the gamified e-learning system, they could be discarded or defined in a different way.

Nonetheless, we have to notice that this conclusion has to be carefully taken into account since the weights intuitively assigned without any previous empirical evidence.

Finally, *Figure 12* split the number of students performing each action for each of the two study sessions, in order to check whether there was a bias on the results due to the increasing students' experience and activity during the study. Note that the number of students who performed an action in the whole study *(Figure 9)* is not the sum of the number of students who performed the action in each session. This is due to the race changes done by the students from one session to the other.

| Player Type | Mech. | #Total | Students Associated with 1st Player Type | | | | Mech. | #Total | Students Associated with 1st Player Type | | | |
			Achiever (6)	Free Spirit (2)	Socializer (7)	Philanthropist (6)			Achiever (6)	Free Spirit (2)	Socializer (7)	Philanthropist (6)
Achiever	A1, A2	7	4	1	0	2	A1, A2	8	3	1	4	0
Achiever	A3	5	1	2	1	1	A3	9	3	1	3	2
Achiever	A4	1	1	0	0	0	A4	2	2	0	0	0
Achiever	A5	4	0	2	0	2	A5	8	3	1	4	0
Free Spirit	F1, F2	5	4	1	0	0	F1, F2	4	3	1	0	0
Free Spirit	F3	0	0	0	0	0	F3	2	2	0	0	0
Free Spirit	F4	0	0	0	0	0	F4	0	0	0	0	0
Free Spirit	F5	0	0	0	0	0	F5	0	0	0	0	0
Socializer	S1	6	1	0	2	3	S1	7	0	0	5	2
Socializer	S2	2	1	0	0	1	S2	4	1	0	3	0
Socializer	S3	2	0	0	2	0	S3	5	0	0	5	0
Socializer	S4	1	0	0	1	0	S4	3	0	0	3	0
Socializer	S5	3	1	1	1	0	S5	3	2	0	1	0
Philanthropist	P1	3	0	0	0	3	P1	2	0	0	0	2
Philanthropist	P2	1	0	0	0	1	P2	0	0	0	0	0
Philanthropist	P3	4	0	2	0	2	P3	4	0	1	3	0
Philanthropist	P4	2	0	0	0	2	P4	2	0	0	0	2
Philanthropist	P5	2	1	0	1	0	P5	0	0	0	0	0
Philanthropist	P6	3	1	0	0	2	P6	1	0	0	1	0

Figure 12. Number of students associated with their inferred player type in the first (left) and second (right) session.

From these results, we could claim the following **conclusions:**

- In the second session, achievers and socializers recorded more mechanics assumed for their player types, free spirits recorded the same mechanics in a low quantity, and philanthropists recorded less mechanics and in a lower quantity. The *achiever* and *socializer* player types seem to be the better designed and implemented ones.
- Free spirits and philanthropists were the two player types who tend to lose interest from students faster. In a future implementation of the gamified e-learning system, the motivation and outcomes of the *philanthropists'* mechanics should be reinforced.

3.3.3 Effectiveness of the mechanics

RQ3. Which player types and gamification mechanics were effective in the tested e-learning environment?

After completing the two sessions of gamified assignments, the students were asked to freely fill an online questionnaire aimed to gather their opinion about the proposed activity. 22 students responded to the questionnaire. In the questionnaire they were asked to mark their favorite mechanics. Based on their preferences, we identified their primary player types; they were 5 achievers, 3 free spirits, 7 socializers, and 7 philanthropists.

To find out which were the most effective mechanics, *Figure 13* shows a comparison between the numbers of students who performed each action, grouped by <u>inferred</u> player type, and the numbers of students who marked each action in the questionnaire, grouped by <u>preferred</u> player type.

Player Type	Mechanic	#Total	Stds. 1st PT inferred (Total / Achi / FS / Soci / Phil)					Stds. 1st PT preferred (Total / Achi / FS / Soci / Phil)				
		#Dif. Stds. = 38	↑6	↓2	↑7	↑6		➡5	↓3	↑7	↑7	
Achiever	A1, A2 - Challenge	↑ 28	↑14 ↑6	↑2	➡4	➡2		↗9 ↗2	↑2	↗3	↘2	
Achiever	A3 - Quest	↗ 19	↗10 ➡3	↑2	➡3	➡2		↗9 ↘1	↑1	➡2	↗5	
Achiever	A4 - Level / Progression	↓ 3	↓2 ↘2	↓0	↓0	↓0		↑11 ↑3	➡1	↑4	➡3	
Achiever	A5 - Certificate	↗ 21	↗11 ➡3	↑2	➡4	➡2		↓3 ↘1	➡1	↘1	↓0	
Free Spirit	F1, F2 - Exploration	↗ 20	➡8 ↑6	↑2	↓0	↓0		↓3 ↗2	↓0	↘1	↓0	
Free Spirit	F3 - Unlockable / Rare Content	↓ 3	↓2 ↘2	↓0	↓0	↓0		➡6 ↘1	↓0	↘1	➡4	
Free Spirit	F4 - Customization	↓ 0	↓0 ↓0	↓0	↓0	↓0		↓1 ↓0	↓0	↓0	↓1	
Free Spirit	F5 - Creativity	↓ 0	↓0 ↓0	↓0	↓0	↓0		↘5 ↘1	↑2	↘1	↓1	
Socializer	S1 - Team / Guild	↑ 28	↑13 ↓1	↓0	↑7	↑5		↑13 ↘1	↓0	↑5	↑7	
Socializer	S2 - Competition	↘ 9	↘5 ↓1	↓0	➡3	↘1		↘5 ↗2	↓0	↘1	↘2	
Socializer	S3 - Social Status	➡ 15	➡7 ↓0	↓0	↑7	↓0		↘5 ↘1	↑2	↘1	↓1	
Socializer	S4 - Social Networking	➡ 13	↘4 ↓0	↓0	➡4	↓0		↓2 ↓0	↓0	↘1	↓1	
Socializer	S5 - Social Discovery	↘ 10	➡6 ➡3	➡1	↘2	↓0		↘4 ↘1	↓0	➡2	↓1	
Philanthropist	P1 - Meaning / Purpose	↘ 10	↘5 ↓0	↓0	↓0	↑5		↓1 ↓0	↓0	↓0	↓1	
Philanthropist	P2 - Care Taking	↓ 4	↓1 ↓0	↓0	↓0	↘1		➡7 ↓0	➡1	↑4	↘2	
Philanthropist	P3 - Sharing Knowledge	➡ 16	➡7 ↓0	↑2	➡3	➡2		➡7 ↘1	➡1	➡2	➡3	
Philanthropist	P4 - Access	↘ 9	↘4 ↓0	↓0	↓0	↑4		↓3 ↓0	➡1	➡2	↓0	
Philanthropist	P5 - Collecting & Trading	↘ 10	↓2 ↓1	↓0	↓1	↓0		➡6 ↘1	➡1	➡2	↘2	
Philanthropist	P6 - Gifting	↘ 6	↘4 ↓1	↓0	↓1	➡2		↘4 ↓0	↓0	↘1	➡3	

Figure 13. Total number of students who recorded each action at least once (left), number of students who performed each action in the 2 sessions, grouped by <u>inferred</u> player type (centre), and number of students who marked each action in the questionnaire, grouped by <u>preferred</u> player type.

We can see that *Level/Progression* (A4), and *Competition* (S2) in less degree, were not engaging mechanics. This may be due to the facts that i) the publication of the students' scores and ranking was not done in real time, and ii) two sessions did not represent an enough period of time in which stimulating ranking changes and confrontations arose.

As noticed previously, we can also observe that the mechanics associated to *free spirits* were not performed by the students. Definitely, they were not engaging in the proposed gamified e-learning environment, in which students were focused on solving (individually, in pairs, or in teams) the assignments, and not on thinking about the adaptation and creation of assignments, and the exploration of new lecture contents.

Care taking (P2) and *Access* (P4) did not have a great success. We believe that they were not implemented properly: for P2, the students were not aware of those classmates with doubts and difficulties, unless the latter stood up and looked for help; for P4, the students had to ask the teacher for the assignment solutions. We believe that in both cases, if the needed information was available online, the students would perform the two actions more times.

Finally, we also notice that *Gifting* (P6) was not very effective: the symbolic value of the "rings" was not engaging for the students. We believe this mechanic, which is not related to the assignments and lecture contents, has to be discarded in the future.

Mechanics in descending order according to the number of students who recorded them:

1. Challenge (A1, A2), Quest (A3), Certificate (A5), Exploration (F1, F2), Team/Guild (S1).
2. Social Status (S3), Social Networking (S4), Social Discovery (S5), Meaning/Purpose (P1), Sharing Knowledge (P3), Collecting & Trading (P5).
3. Level/Progression (A4), Unlockable/Rare Content (F3), Competition (S2), Care Taking (P2), Access (P4), Gifting (P6).
4. Customization (F4), Creativity (F5).

Mechanics in descending order according to the number of students who recorded them, and had as <u>inferred</u> player type that of the corresponding mechanic:

1. Challenge (A1, A2), Quest (A3), Certificate (A5), Exploration (F1, F2), Team/Guild (S1).
2. Social Status (S3), Social Discovery (S5), Sharing Knowledge (P3).
3. Competition (S2), Social Networking (S4), Meaning/Purpose (P1), Access (P4), Gifting (P6).
4. Level/Progression (A4), Unlockable/Rare Content (F3), Customization (F4), Creativity (F5), Care Taking (P2), Collecting & Trading (P5).

Mechanics in descending order according to the number of students who marked them in the questionnaire, grouped by <u>preferred</u> player type:

1. Challenge (A1, A2), Quest (A3), Level/Progression (A4), Team/Guild (S1).
2. Unlockable/Rare Content (F3), Care Taking (P2), Sharing Knowledge (P3), Collecting & Trading (P5).
3. Creativity (F5), Competition (S2), Social Status (S3), Social Discovery (S5), Gifting (P6).
4. Certificate (A5), Exploration (F1, F2), Customization (F4), Social Networking (S4), Meaning/Purpose (P1), Access (P4).

From these results, we could claim the following **conclusions:**

- The students' preferences for mechanics associated to achievers and socializers match with the most performed mechanics inferred for such player types.
- The previous match also applies to philanthropists' mechanics, but in this case, some of such mechanics, i.e., *Care taking* (P2) and *Access* (P4), did not were effective. We believe they can be effective in a complete e-learning system.
- The *free spirit* player type was not effective at all. We would be in favour of not considering it the proposed e-learning environment.
- *Level/Progression* (A4), and *Competition* (S2) were not very effective, but could be successful in a complete e-learning system used for a long period of time. We notice that a large percentage of the students indicated their preference for such mechanics.
- Despite the students showed preferences for *Unlockable/Rare Content* (F3), they did not perform this mechanic. This may be due to the fact that the students had

already access to the assignment solutions (P4), so we see here a redundancy that should be avoided in the future.

▪ *Collecting & Trading* (P5) and *Gifting* (P6) were not positively appreciated by the students. In our opinion, these mechanics could be effective in a context more oriented to games and fun, but not in an e-learning environment where the main goal is (and has to be) the students' learning process and goals.

3.3.4 Students' opinion

RQ4. How the students assessed the proposed gamified activities?

To complement the effectiveness analysis of the studied player types and gamification mechanics, after finishing the gamified assignment solving lectures, we asked the students to fill an online questionnaire to known about their opinions about the activity. The questionnaire can be found in *Appendix C*.

Specifically, *Figure 14* shows the students' average opinions about several aspects of the activity, namely general acceptance (like), enjoy (fun), effectiveness for the learning process and goals, its preference than conventional lectures, and engagement. The discrete values of the opinion responses were grouped by preferred player types, averaged and converted into a [0,1] scale, 1 meaning totally agreement, 0 meaning totally disagreement, 0.5 meaning neither agreement nor disagreement, and so on.
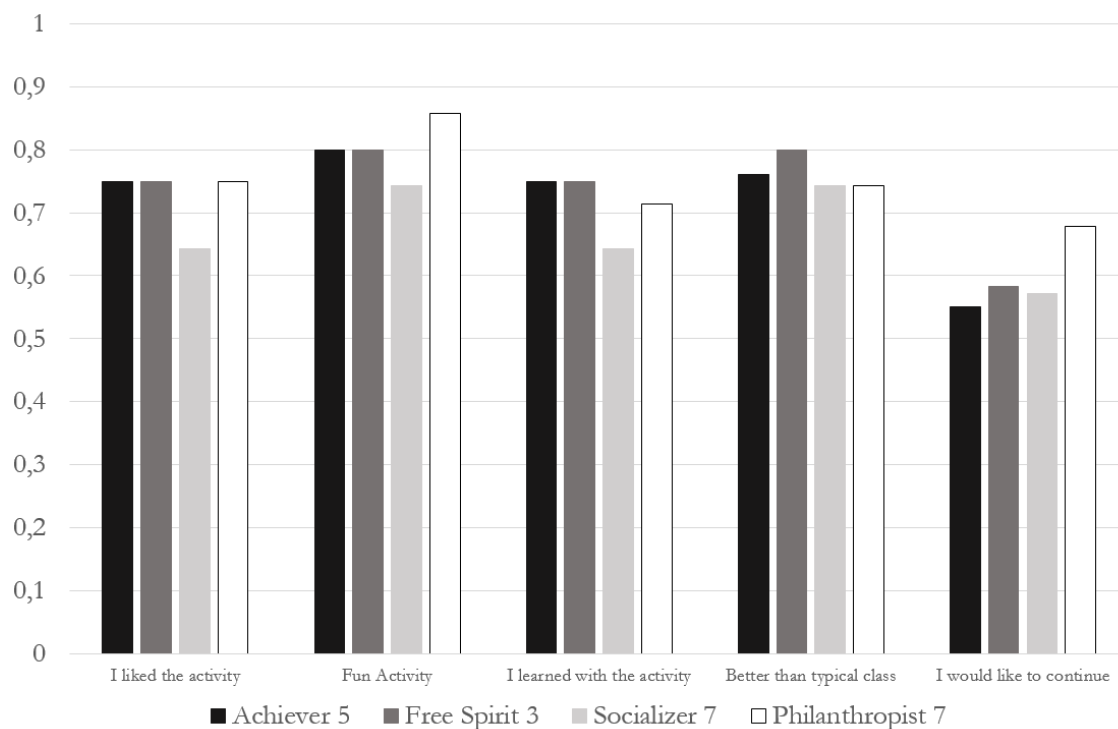

Figure 14. The students' average opinion about several aspects of the activity, grouped by their favourite player type.

From these results, we could claim the following **conclusions:**

- In general, the level of appreciation for the activity was positive (average values greater than 0.5) in terms of acceptance and enjoy, and was considered as effective for the students' learning process and goals, and preferred to a conventional lecture.
- The success of the engagement aspect was not so clear, except for the *philanthropists*, who expressed they really enjoyed the activity and declared they were in favour of continuing it. The explanation for this may be the fact that *philanthropists* work in pairs, instead of individually, as *achievers* and *free spirits* do.
- The students who preferred the *socializer* player type were the ones than less accept, enjoy, and find effective the gamified activity. We believe that this may be due to the fact that the teams were too big (with 4-6 people), which could make a student feeling she did not contribute enough. Note that the *philanthropist* player type, which was based on working in pairs, had the highest values for the above issues.

Figure 15 shows the students' average opinions about feelings they had when they performed their favourite player type. They were asked about how easy was to understand and take into practice the corresponding mechanics (easy mechanic), the level of stress (easy-going mechanic), and the level of fun (fun mechanic). For all aspects, 0 means being totally disagreement, and 4 being totally agreement.
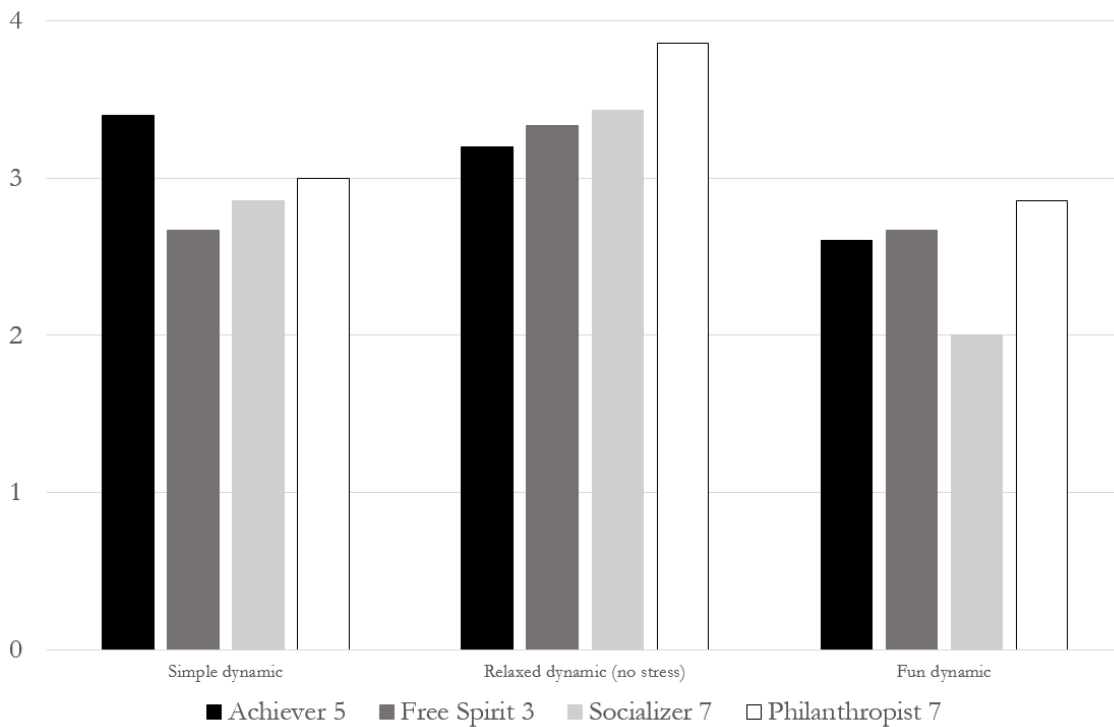

Figure 15. The students' opinion about some feeling aspects related to the activity, grouped by their favourite player type.

From these results, we could claim the following **conclusions:**

- In general, despite the fact that the system was not entirely implemented, the students found the activity and its mechanics easy to understand and perform.
- The students who preferred the *achiever* player type were the ones that found the activity easier to understand, but suffered a higher level of stress. They worked alone and were motivated by the achievement of challenges, certificates and quests.

▪ The students who preferred the *free spirity* player type found less easy the activity and suffered certain level of stress. The difficulty of modifying and creating assignments, and exploring new lecture contents, may be the reason.

▪ The students who preferred the *socializer* and *philanthropist* player types did not find the activity difficult despite the fact that they had to work in pairs or groups. This issue seems to be the reason for the lowest levels of stress.

3.4 Summary of results and conclusions

RQ1. Were all the items of the initial personality questionnaire useful to infer the students' player types?

The questionnaire items that properly inferred the students' primary player types were the four corresponding to *philanthropists* (1-4), two corresponding to *achievers* (5-6), and three corresponding to *socializers* (9 and 11-12). The remainder questions may be removed or adapted in a future implementation of the questionnaire. The questions were related to whether a student usually helps people sporadically (1), reserves and spends part of her time to explicitly help people (2), shares information and knowledge (3), does not share knowledge (4), attends a course for the sake of learning and not only to obtain a degree or certificate (5), works to achieve the perfection on her tasks (6), regularly and actively participates in social networks (9), thinks the number of friends/followers is a measure of success in social networks/blogs/etc. (11), and online shares content with his friends/followers (12).

The effectiveness of the questions aimed to infer the *free spirit* player type (13-16) were not validated. The actions (mechanics) associated to this player type were not chosen and performed by the students during the activity. We believe this player type is not appropriate for the e-learning environment we propose.

We also conclude that the questionnaire items do not properly infer secondary player types, so from now on we would discard them in future work.

RQ2. Did the considered gamification mechanics and their implementations as learning-based actions really correspond to the students' inferred player types?

Achievers and socializers recorded all the mechanics that were assumed for them. Philanthropists recorded all the mechanics assumed for them except *Collecting & Trading* (P5), which had a few records and none from philanthropists, so its correspondence is doubtful. Free spirits only recorded a mechanic assumed for them, *Exploration* (F1, F2). Members of all player types did not show interest in mechanics associated to free spirits.

Without taken the *free spirits* into account, *Level/Progression* (A4) for achievers; *Social Status* (S3), *Social Networking* (S4), and *Competition* (S2) for socializers; and *Meaning/Purpose* (P1), and *Access* (P4) for philanthropists, were the most representative and discriminative gamification mechanics. *Challenge* (A1, A2), *Quest* (A3) and *Certificate* (A5), assumed for achievers, were recorded by all player types, showing to be the most versatile gamification mechanics.

In order to infer the predominant player types for selected mechanics, Marczewski intuitively assigned weights to each of the items in his player type questionnaire. *Exploration*

(F1, F2) and *Social Discovery* (S5) performed by achievers, *Challenge* (A1, A2) and *Certificate* (A5) performed by socializers, and *Team/Guild* (S1) performed by philanthropists, are mechanics that were not assumed for such player types, but were recorded by them in our study. In a future implementation of the gamified e-learning system, they could be discarded or implemented in a different way.

RQ3. Which player types and gamification mechanics were effective in the tested e-learning environment?

The students' preferences for mechanics associated to achievers and socializers match with the most performed mechanics inferred for such player types. The previous match also applies to the philanthropists' mechanics, but in this case, some of such mechanics, i.e., *Care taking* (P2) and *Access* (P4), did not were effective. We believe, nonetheless, they could be effective in a complete e-learning system with social networking functionalities. *Level/Progression* (A4), and *Competition* (S2) were not very effective, but could be successful in a complete e-learning system used for a long period of time. We notice that a large percentage of the students indicated their preference for such mechanics.

The *free spirit* player type was not effective at all. We would be in favour of not considering it the proposed e-learning environment. Despite the students showed preferences for *Unlockable/Rare Content* (F3), they did not perform this mechanic. This may be due to the fact that the students had already access to the assignment solutions (P4), so we see here a redundancy that should be avoided in the future. *Collecting & Trading* (P5) and *Gifting* (P6) were not positively appreciated by the students. In our opinion, these mechanics could be effective in a context more oriented to games and fun, but not in an e-learning environment where the main goal is (and has to be) the students' learning process and goals.

RQ4. How the students assessed the proposed gamified activities?

In general, the students' level of appreciation for the activity was positive in terms of acceptance and enjoy, and was considered as effective for the students' learning process and goals, being preferred to conventional lectures. The success of the engagement aspect was not so clear, except for the *philanthropists*, who expressed they really enjoyed the activity and declared they were in favour of continuing it. The explanation for this may be the fact that *philanthropists* work in pairs, instead of individually, as *achievers* and *free spirits* do.

The students who preferred the *socializer* player type were the ones with less acceptance, and enjoy levels, and did not find the gamified activity effective enough. We believe that this may be due to the fact that their teams were too big (with 4-6 people), which could make a student feeling she did not contribute as much as she could. We notice that the *philanthropist* player type, which was based on working in pairs, had the highest values for the above issues.

In general, despite the fact that the system was not entirely implemented, the students found the activity and its mechanics easy to understand and perform. The students who preferred the *achiever* player type were the ones that found the activity easier to understand, but suffered a higher level of stress. They worked alone and were motivated by the achievement of challenges, certificates and quests. The students who preferred the *free spirit*

player type found less easy the activity and suffered certain level of stress. The difficulty of modifying and creating assignments, and exploring new lecture contents, may be the reason. The students who preferred the *socializer* and *philanthropist* player types did not find the activity difficult despite the fact that they had to work in pairs or groups. This issue seems to be the reason for the lowest levels of stress.

Chapter 4. Related work

Gamification is based on the application of game-design elements in non-game contexts, so it can be related to multiple domains and research disciplines depending on the target context. In particular, in this thesis we have conducted a user study in an e-learning context for the High Education domain.

Since in Chapter 2 we reviewed generic literature on Gamification, we decided to include this chapter to briefly discuss some works related to our context of interest, namely the application of gamification in education. Some of the ideas presented in the next sections will be cited in Chapter 5, where we propose a number of design issues for the implementation of a complete gamified e-learning system. This is the reason of not including this chapter at the beginning/end of the dissertation, as it is usually done in scientific manuscripts.

We note that our aim is not to give an extensive review of the state of the art, but to describe a few works that present some ideas that may guide us in the future for the improvement of our study and the implementation of the complete gamified e-learning system. Section 4.1 addresses observed effects of gamification in learning activities. Section 4.2 outlines well-known models of learning styles, which should be taking into account in combination with the performed gamification mechanics. Finally, Section 4.3 briefly describes works on user engagement – its foundations and how to measure it.

4.1   Effects of gamified learning

In the educational domain, the effect of several gamification mechanics on the learning process has already been investigated. One of such mechanics has been the *social networking* mechanic. Defining an online social network as a "web-based service that allows individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system" [39], an empirical study comparing gamification and social networking on e-learning was made by De Marcos et al. [40]. This study used elements of gamification as challenges, quests, levels/progression, competition, social status, and knowledge sharing using badges, hidden badges, rewards, and leader boards. One conclusion of the study was that gamification could emphasize the competition above collaboration reducing the students' participation, and that it is not necessary to choose between one of these two approaches, but *take the long-term motivation of gamification together with the cooperation and participation provided by social networks*. Regarding our study, the competitive emphasis provided by gamification depends on how it is implemented, that is to say, the kind of mechanics one wants to utilize while a student interacts with the system, and the aesthetics or feelings one aims to generate. Some game-design elements aimed at creating social connections, those which are associated with a socializer player type, can be implemented within a social networking site so they are not incompatible, and avoid the need of choosing between one of the two approaches.

In [41], assessing the effects of gamification in the classroom, studying the intrinsic motivation, social comparison, satisfaction, effort, and academic performance, Hanus & Fox used the next measures:

- Adaptation of the 30-item lifetime television exposure scale [42], with questions for video games use. The scale assessed how often one played video games currently, as an adolescent and as a child. Items were measured on a 7-point scale from 1 (never) to 7 (almost always) and included items such as "As a child, how often do you play video games when you first wake up in the morning?"

- Intrinsic motivation inventory [8], which contains 22 items, which were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree) and included items such as "I felt like I was doing what I wanted to do while I was working on the task".

- Class satisfaction measured with a 5-item scale that included items such as "In the last month, I have been happy taking this class." Class effort measured with a 4-item scale that included items such as "In the last month, I feel I have put forth a lot of effort in this class." Both inventories were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- An 18-item learner empowerment scale. Items were measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) and included items such as "This course will help me achieve my future goals"

- A 6-item social orientation scale. Students rated how often they compared with other students in the class. Items were measured on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) and included items such as "In the last month, I have looked to others' performance to feel better about my performance".

- Two exam scores. The first exam was given midway through the semester, and the second exam was given as the course's final exam.

Some of the measures used in this study could be applied in our system. The combination of leader boards, badges, and competition mechanics did not improve educational outcomes; the authors comment that "future gamification research should investigate specific elements of gamification rather than as an overarching concept so that the effectiveness of different mechanics can be parsed out", suggestion that we applied in our study to investigate the correlation between mechanics and player types, as well as the effectiveness of mechanics in learning taking into account the students' assessments.

4.2 Learning styles

In education and psychology, learning styles and their respective tests have been widely studied. As defined by Felder [43], learning styles are "characteristic strengths and preferences in the ways they take in and process information." In [44], Konert, Göbel, & Steinmetz attempted to find *correlations* among models to *predict Bartle's player types and Kolb's learning styles* [45] *from personality traits of a person of NEO Five-Factor Inventory (NEO-FFI)* [46]:

Openness to Experiences[24], Conscientiousness[25], Extraversion[26], Agreeableness[27] and Neuroticism[28].

The **Kolb's model** is designed from learning theory, formed by a four-stage learning cycle composed by (1) Concrete Experience, (2) Reflective Observation, (3) Abstract Conceptualization, and (4) Active Experimentation.

Depending on the skills of each person, her learning style or styles will be found in any of the quadrants formed by the learning cycle, shown in *Figure 16*. A brief description provided by Businessballs[29] is indicated next:

- *Diverging.* "People with Diverging learning are able to look at things from different perspectives. They are sensitive. They prefer to watch rather than do, tending to gather information and use imagination to solve problems. They are best at viewing concrete situations several different viewpoints."
- *Assimilating.* "The Assimilating learning preference is for a concise, logical approach. Ideas and concepts are more important than people. These people require good clear explanation rather than practical opportunity. They excel at understanding wide-ranging information and organizing it a clear logical format."
- *Converging.* "People with a Converging learning style can solve problems and will use their learning to find solutions to practical issues." "People with a Converging learning style are best at finding practical uses for ideas and theories. They can solve problems and make decisions by finding solutions to questions and problems."
- *Accommodating.* "The Accommodating learning style is 'hands-on', and relies on intuition rather than logic. These people use others' analysis, and prefer to take a practical, experiential approach." "They commonly act on 'gut' instinct rather than logical analysis. People with an Accommodating learning style will tend to rely on others for information than carry out their own analysis. This learning style is prevalent and useful in roles requiring action and initiative."

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24 "Openness to experience," Wikipedia, the free encyclopedia. 04-Apr-2015.
25 "Conscientiousness," Wikipedia, the free encyclopedia. 01-May-2015.
26 "Extraversion and introversion," Wikipedia, the free encyclopedia. 23-Jul-2015.
27 "Agreeableness," Wikipedia, the free encyclopedia. 29-Apr-2015.
28 "Neuroticism," Wikipedia, the free encyclopedia. 19-Jul-2015.
29 "Kolb's learning styles, experiential learning theory, kolb's learning styles inventory and diagram." [Online]. Available: http://www.businessballs.com/kolblearningstyles.htm. [Accessed: 23-Jul-2015].
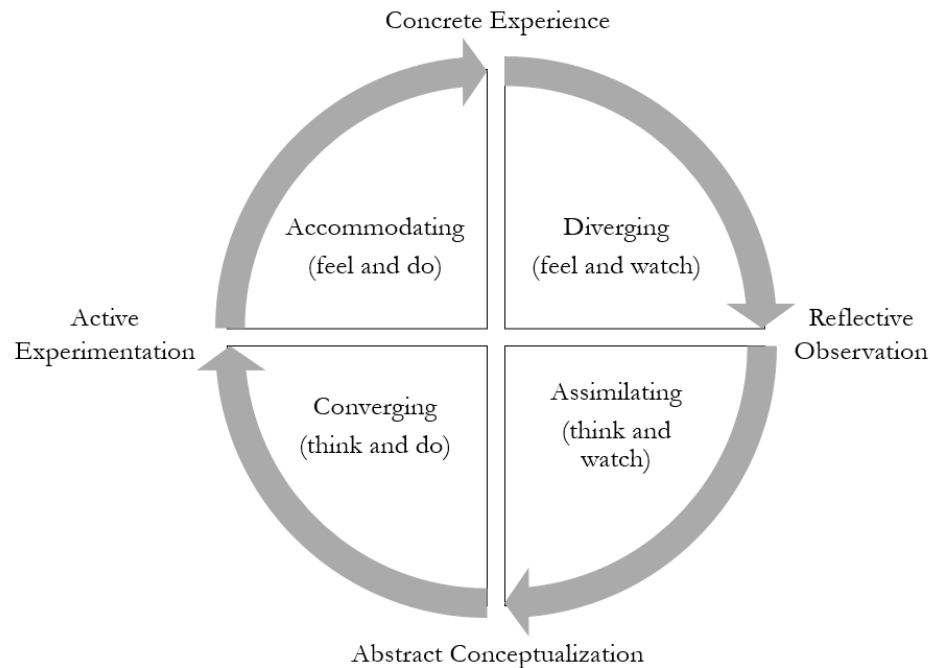
Figure 16. Kolb's learning cycle and learning styles.

Another of the most used models of learning styles that could be used in studies like the one seen above is the **Felder-Silverman model** [47]. It consists of five separate dimensions that classify students:

- *Perception*: sensory/intuitive.
    - Sensory students rely on information perceived by the external senses. They prefer to pay attention to detail, observable facts and problems with well-defined patterns solutions.
    - Intuitive students rely on your memory, conjecture and interpretations. They manipulate easily abstractions so they do not tend to pay attention on details, this helps them grasp new concepts.
- *Input*: visual/auditory.
    - Visual students retain information better through images so they may have trouble remembering heard information.
    - Auditory students retain better heard and written information.
- *Organization*: inductive/deductive.
    - Inductive students start their apprenticeship with particularities up to generalities with which they can more easily infer principles.
    - Deductive students start their apprenticeship with generalities to reach particularities with which to deduce consequences more easily.
- *Processing*: active/reflective.
    - Active students need to experiment with the information that has been provided as soon as they are available. They like to work in groups to design and carry out experiments.
    - Reflective students need to think about the information provided before use it. They often work alone or in small groups defining the problems that need to be resolved.

- *Understanding*: sequential/global.
    - Sequential students learn more easily with a sequential and incremental progression of concepts, solving problems with a convergent analytical thinking.
    - Global students prefer to start learning new concepts watching them first broadly, forming connections between concepts although they may be far apart.

The study concluded "that the prediction of Bartle's playing style preferences or Kolb's Learning Style Inventory preferences is not sophisticated possible on basis of the NEO-FFI personality values conducted from the BFI-K questionnaire." So the authors comment that "researchers are encouraged to further investigate how the established models can be combined and used most effectively together to keep players in the state of flow in both models' worlds: playing and learning."

Regardless the potential relationships between learning styles and personality- or player type-based student profiles, we envision the possibility of using both as valuable sources of information to drive the learning process and student engagement in our future gamified e-learning system.

4.3   Student engagement

As shown in Chapter 3, our preliminary e-learning environment showed to be successful. However, part of its success may be caused by its 'novelty'. Due to the (time) limitations of our study, we do not have any clue about whether it really was engaging for the students. In fact, as discussed in the analysis sections, we observed that philanthropists and free spirits showed certain tendency to lose interest if their motivations were not satisfied enough. To prevent this in the future, we have to effectively engage the students, keeping their interest during a long period of time, such an entire course.

In game theory, as Csikszentmihalyi defines in [48], "flow is a subjective state that people report when they are completely involved in something to the point of forgetting time, fatigue, and everything else but the activity itself." *Figure 17* shows the Csikszentmihalyi's model of the flow state. "Flow is experienced when perceived challenges and skills are above the actor's average levels; when they are below, apathy is experienced. Intensity of experience increases with distance from the actor's average levels of challenge and skill, as shown by the concentric rings."
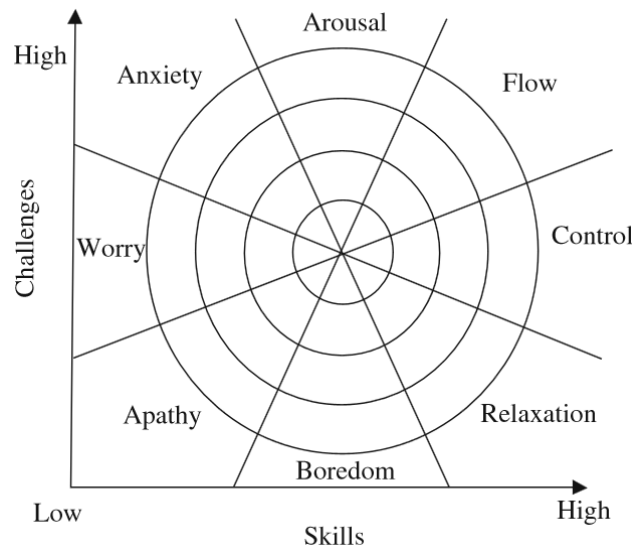
Figure 17. Csikszentmihalyi's flow state, extracted from **[48]**.

To maintain a game in this flow state, it is necessary to follow a number of states like those designed by Amy Jo Kim in The Player's Journey[30], composed of three key stages of the player's experience. The descriptions of the three states by Kevin Werbach in his MOOC[31] (Massive Open Online Course) about Gamification[32] are the following:

1. *Onboarding.* "How to get the player into the game as quickly and easily as possible."
2. *Scaffolding/Habit-building.* "Places where the game makes it easier and overcomes some of the complexity that otherwise would get a user stuck. That otherwise would have the player not realize what they need to do next."
3. *Pathways to mastery/Mastery.* "To get to the point where the player has conquered and achieved some real skill. Some real accomplishment within the framework of the game."

Gamifying learning experiences, Domínguez et al. [22] used only players who foster competition, leaving aside other motivations aimed to other player types, and therefore there were students for whom *the system was not motivating enough to participate along the course.* In addition, students who followed traditional assignments performed similarly in overall score than those who followed gamified assignments. From their point of view, in the educational environment they failed to export the cognitive characteristics of gaming experiences that result in *flow experiences.* Because our study has only been conducted in a test session and two study sessions of two hours each, the spent time was not enough to analyse which is the progress of each student along the three states, but the fact of having sets of mechanics grouped by motivations benefits the adaptability of a gamified depending on the user type who uses it.

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30   A. J. Kim, "The Player's Journey," Amy Jo Kim. [Online]. Available:
     http://amyjokim.com/2014/04/08/the-players-journey/. [Accessed: 27-Jan-2015].
31   "Massive open online course," Wikipedia, the free encyclopedia. 04-Aug-2015.
32   "Gamification - University of Pennsylvania," Coursera. [Online]. Available:
     https://www.coursera.org/course/gamification. [Accessed: 25-Jul-2015].

O'Brien & Toms [49] describe the development and evaluation of a survey to measure user engagement in online shopping environments. The result of their research is a survey instrument that may be used to test the engagement of software applications. The study identifies six attributes of engagement:

- Aesthetics: "This set of items pertained to specific features of the interface, such as the screen layout and graphics/images, and to respondents' overall aesthetic impressions of the Website's attractiveness and sensory appeal."
- Novelty: "Each of these spoke to the curiosity evoked by the participants' interest in the shopping task."
- Felt Involvement: "These items pertained to respondents feeling of being drawn into and involved in the shopping task and their overall assessment of the experience as 'fun.'"
- Focused Attention: "These items related to users' perceptions of time passing and their degree of awareness about what was taking place outside of their interaction with the shopping Website."
- Perceived Usability: "This factor's items pertained to the emotions experienced by respondents when completing their shopping task, i.e., 'annoyed', 'frustrated', 'stimulated' and 'discouraged.'"
- Endurability: "Items assessed respondents' likelihood to recommend the shopping Website to others, as well as to perceive shopping experience as 'successful', 'rewarding', 'worthwhile', and working out as planned."

The resulting path model contained more relationships than predicted in the proposed model, adding:

- Aesthetics predicted Focused Attention, Felt Involvement, and Perceived Usability.
- Novelty predicted Focused Attention and Felt Involvement.
- Focused Attention predicted Felt Involvement.
- Felt Involvement predicted Perceived Usability and Endurability.
- Perceived Usability predicted Endurability.

Perceived Usability and Felt Involvement were integral components that mediated the relationships between Aesthetics, Novelty, and Focused Attention with the outcome variable, Endurability.

Later, O'Brien & Cairns [50] examined the six-factor structure proposed before, the User Engagement Scale (UES), for its robustness as a measure in the online news domain. They found evidence to support the reliability and construct validity of the UES across three studies conducted in the online news domain. They believe that the UES reliability captures the dimensions of user engagement in a range of context. Aesthetics, usability, and focused attention appear to be "stable" dimensions of an engaged experienced across various types of digital media, whereas felt involvement, novelty, and endurability are more variable in terms of whether they are "stand alone" factors.

More recently, Attfield et al. [51] identified other characteristics for user engagement like emotions experienced during interaction, richness and control that are shaped by the

features of a product and the user's expertise, global trust users have on a given entity, and the user's motivation, incentives and benefits.

The user engagement is a research field related with user-centred technologies, like the case study of this thesis. Since gamification aims to generate user engagement, it is necessary to measure each and every one of its effects in a rigorous manner.

Chapter 5. Design proposal of a gamified e-learning framework

In the classroom, students are requested to solve a number of assignments related to different topics of a subject. For such task, they could work in different ways (e.g., alone, in pairs, or in teams) and perform different actions, which were related to certain gamification mechanics and player types while the system adapts the assignments according to their learning styles. All the actions could be supported and recorded by an e-learning system, accessible online though the students' mobile devices and laptops.

Figure 18 shows a simplified view of the architecture of such a system. In the figure we can distinguish between four main modules, namely the *assignment manager*, the *action recorder*, the *player type learner*, and the *learning styles learner*. The assignment manager is accessed by both the teacher (stage 1 in the figure) and the students (stage 2). The former uploads the assignments statements and solutions, while the latter download the assignments statements and solutions when needed. The action recorder stores all the actions performed by the students during the assignment solving process (stage 4). These action records can be used in analysis as those conducted in this thesis. The player type learner infers the students' types of player from an on-line questionnaire (stage 3) and the recorded student actions. Finally, the learning styles learner infers the students' learning styles from on-line questionnaires (stage 5), and recorded student actions as the chosen preferences about how the assignments must be presented. The students' profiles –composed by the students' assignment and learning history, player type, and actions, learning styles with information like which assignment types they have chosen over time, and among other data– would be used by a assignment manager and gamification adapter to personalize the presentation of the most appropriate assignments and gamification mechanics for a student at certain point.

The system interface allows students to access the assignment statements and solutions, fill the player type and learning styles questionnaires, record actions, view user profiles and study results (such as personal achievements and global rankings), and evaluate the conducted study and system functionalities.
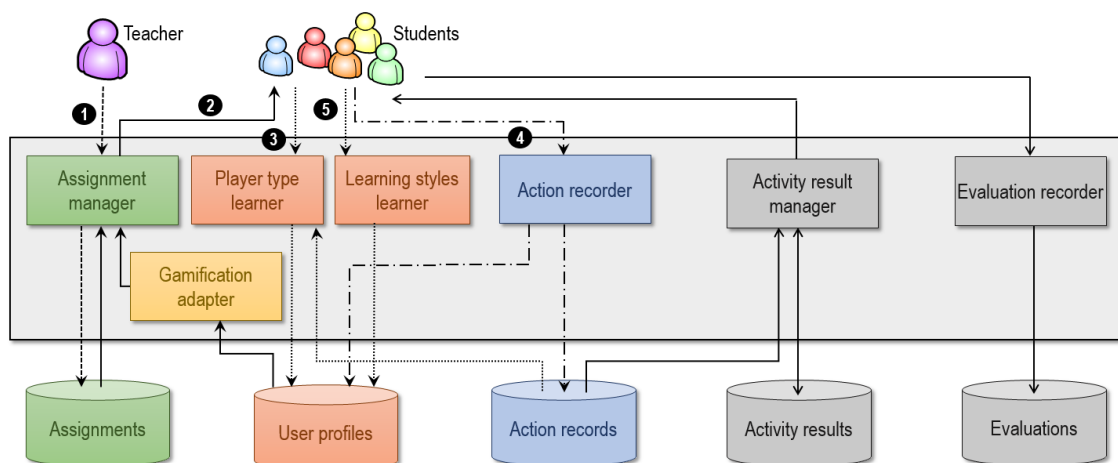

Figure 18. Simplified architecture of the gamified e-learning system.

The system will select the most appropriate assignments, and apply the most appropriate gamification mechanics for each user profile based on her learning objectives. *Figure 19* shows the data flow for the selection of gamification mechanics. The process involves the following stages:

1. Selecting the most appropriate gamification mechanic for the active learning objectives (and their associated assignments).
2. Selecting the game mechanics best adapted to the target student's profile (player type, learning style, engagement stage, etc.).
3. From the selected mechanics, determining those to apply by a decision-making algorithm based on past results.
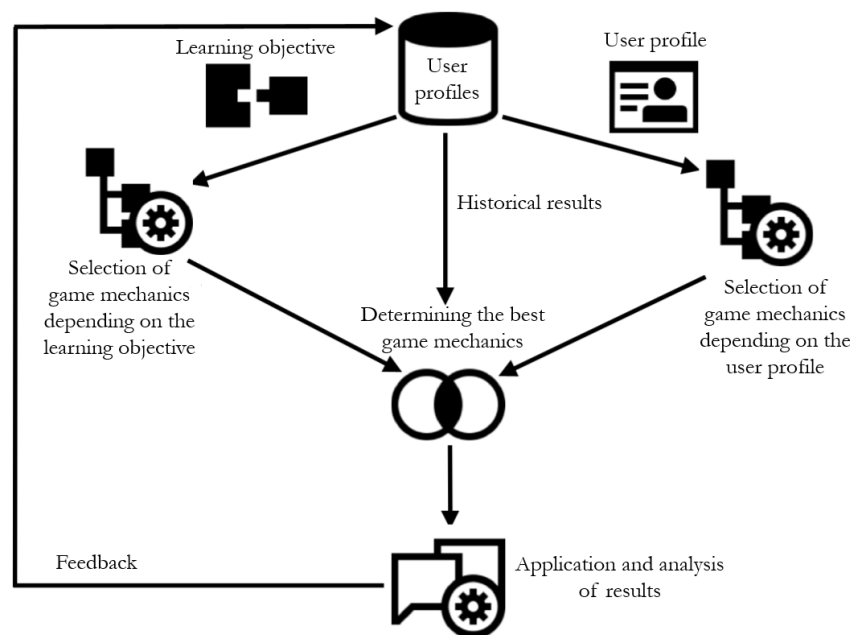

Figure 19. Schematic representation of the method to determine the gamification mechanics to apply according to the active learning objectives, and target student's profile.

From a technological point of view, the main challenges of the project would be:

- Storing large volumes of information that are updated continuously, and be able to analyze these information in real time to apply best gamification mechanics at any time.
- Developing an algorithm able to learn the users' behaviour based on their response to the presented game mechanics, adjusting and improving results.

The main objectives in the development of an intelligent gamification mechanics engine are:

- Designing the necessary algorithms for the automated decision making of which gamification mechanics to apply in each case.
- Implementing these algorithms in an efficient way.

5.1   Representation of knowledge and learning contents

In [52] Gaeta et al. investigate how ontologies can be exploited in order to customize e-learning experiences. Modeling educational domain ontologies, learning contents could be represented by means of semantic entities, such as topics, subtopics, and concepts. Their approach focuses on three types of relationships between entities: HasPart (in brief HP), which represents an inclusion relation, IsRequiredBy (in brief IRB), which represents an order relation, and SuggestedOrder (in brief SO), which represents a weak order relation. With these relationships, graphs can be built in which the whole semantic space is made up of entities which may, or may not, have dependency relationships between them. Learning certain entities would allow the achievement of given learning objectives.

For example, in Programming II subject, where we conducted our study, examples of related entities could be:

- Programming II – *HasPart* => Abstract Data Types, Stacks, Queues, Linked lists.
- Abstract Data Types – *IsRequiredBy* => Stacks, Queues, Linked lists.
- Stacks – *SuggestedOrder* => Queues.
- Queues – *IsRequiredBy* => Linked lists.

The subject teacher, as an expert in the domain of interest, would be the responsible for dividing a subject into topics, subtopics and concepts. From these entities, she would define the relationships, as described above.

The learning contents (e.g., assignments) may have additional semantic information, such as the degree of difficulty and the estimated time to learn or do them. Note that both the degree of difficulty and the estimated time, do not only serve to present the students with extra information about particular assignments, but also to trace paths in the semantic graph depending on the level of skill possessed by the student, and the time available from the moment she logged in.

5.2   Representation and acquisition of learning profiles

The semantic graph described in the previous section indicates default relationships between learning entities regardless of the students' learning styles. In the doctoral thesis of Paredes-Barragán [53], graphs are adapted to the learning styles by the Felder-Silverman's model. Joining this study with the issues discussed in the previous section, a student with a style of moderate-extreme global learning may access to all the concepts so that the isRequiredBy relations become SuggestedOrder for her. If she has a moderate-extreme sequential learning style she could only navigate between learning entities and contents once she had unlocked all the required entities established by the teacher; then, all SuggestedOrder relations become IsRequiredBy relations. The second adjustment performed by Paredes Barragan is to consider whether a student's learning style is sensory or intuitive. At first, theoretical tasks are presented for moderate-extreme intuitive students, and tasks example are presented firstly for moderate-extreme sensory students. The third adaptation, active/reflective, is used for the formation of work groups. For each learning entity, the teacher has the ability to indicate how presenting a task by default. The teacher

has also the option to indicate if the way to present a task is a mandatory order or it can be adapted to the learning styles.

In addition of the learning styles, the system could manage a wide array of information about a student's learning progress and current stage, such as her learning entities unlocked, the attempts or time she need to unlock them, the assignments she solved, and whether she asked for solutions of certain assignments, to name a few.

5.3 Representation of assignments

The teacher would incorporate into the system the assignments, assigning them a set of learning entities and goals, and indicating their difficulty and estimated time, among other issues. Likewise, the teacher would indicate the default order in which the system presents the learning contents, that is to say, whether the system should display before the theoretical concepts or examples, alternate their presentation with certain assignments, etc.

The assignments could be of different types, namely multiple-choice, closed, and open assignments. The multiple-choice assignments present a statement with several possible solutions, and the student has to choose the correct one. In the closed assignments, incomplete solutions are provided to the student, and she has to set the missing part. For instance, in the case of implementing a function with a programming language, a set of instructions presented should be ordered by the student in a particular way to find the result given in the assignment statement. Finally, in open assignments, a student has to write the correct solution to a proposed problem, and presents it in a forum where the teacher and/or other students could make, modify or validate the student's response.

5.4 Adaptive selection of assignments

Since learning entities and assignments have different knowledge constraints, difficulty levels and estimated times, and the students have a dynamic learning profile, the system should take all the above information into account in order to effectively select which learning contents have to be presented next to a student. For example, a student with high level skills in a series of related concepts, and who currently can spend a maximum of one hour, the system may select assignments with medium-high difficulty level that require a few minutes to be completed.

Moreover, for a given assignment, both the number of failures and the time spent to solve it may be taken into account to present the student with the following assignment to solve or the next learning entities to study.

5.5 Representation and acquisition of gamification profiles

The player types we will consider for students will be socializers, achievers and philanthropists. Free spirits would not be considered because we could not validate them properly in term of both its inference and gamification mechanics. The students with such player type had difficulties understanding and putting into practice the associated mechanics, which were based on modifying and proposing assignments individually, and exploring new, unknown learning contents, something that requires extra effort and time during the learning period.

From the conclusions derived in Section 3.3.2, 3.3.3 and 3.3.4, the gamification mechanics that we would incorporate into the system would be Quest (A3), Social Status (S3), Social Networking (S4), Meaning/Purpose (P1) and Sharing Knowledge (P3). We could define in a different way Challenge (A1, A2), Level/Progression (A4), Certificate (A5), Team/Guild (S1), Competition (S2), Social Discovery (S5), Exploration (F1, F2), Care taking (P2), and Access (P4).

From the conclusions derived in Section 3.3.1, the items that would be included in the initial player type questionnaire are shown in *Table 3*. Since items 7, 8 and 10 were discarded to infer player types in the tested e-learning environment, it will be necessary to resort to new items.

Table 3. Effective questions inferring player types.

Questionnaire item	Player type
1 I usually help people (although they are not known) and I enjoy doing it.	Philanthropist
2 I usually book and dedicate part of my time helping people (although they are not known) and I enjoy doing it. For example, I work in a support centre, I contribute on Internet forums, etc.	
3 I usually share information or knowledge with people (although they are not known) and I enjoy doing it. For example, I write posts in blogs or wikis, I provide class notes in college, etc.	
4 I do not usually share my knowledge with others.	
5 By attending a course I do it purely for the sake of learning, not to get a degree or certificate.	Achiever
6 I tend to work in activities until I do them to perfection.	
9 I participate in social networks (Facebook, Twitter, etc.) regularly.	Socializer
11 For me, the number of friends/followers is most important measure of success in social networks, blogs, etc.	
12 Normally I share content with my friends/followers in social networks, blogs, etc. and I enjoy doing it.	

From time to time, questions may be asked to the students as they perform assignments. It is less tedious for a student to answer a few questions every few tasks instead of responding to large amount of questions when they start using the system. These questions not only would belong to the player type questionnaire, but also to infer the students' learning styles, or obtain from them feedback about the system and the learning contents.

5.6 Adaptive selection of gamification mechanics

For each student, the system would select those mechanics assigned to her inferred player type, but it does not mean that the student should not have access to other mechanics: a student confined to a series of mechanics could eventually dislike them, in a future study

we may show that some mechanics are shared by various player types, we may realize that assumed mechanics do not really correspond with their player types, or we the player type inference may be wrong.

Moreover, in order to select the appropriate gamification mechanics, we may also consider the students' current engagement stage. Usually, when a user is new in a system, basic goals and game elements may be enough. This, however, may be not the case for an experienced user who looks for more challenging tasks and novel and diverse contents. For example, while studying an Abstract Data Type for the first time, congratulating a student somehow for her first programming achievements is encouraging, and she can positively appreciate it for a short-term effort. As the student progresses through the course topics, the system should continue congratulating her for any achievement, since the student may think that she receives rewards for everything and may start losing her interest for unlocked tasks and contents. The system will thus fall into a failure of trivialization. A possible strategy could be not to put available all gamification mechanics at first, but present them progressively as the student makes progress in the course. Certain mechanics could be appropriate at early stages, e.g. badges or certificates, while others could be better at later stages, such as leader boards and social awards.

Chapter 6. Conclusions and future work

In this master thesis, we have applied and evaluated gamification to the educational domain. In an e-learning environment for a High Education context, we have empirically validated the effectiveness of particular game-design elements and their correspondences with assigned player types In a study conducted in the classroom with Computer Science students attending a computer programming subject, we assessed a personality-based questionnaire to infer the students' player types, proposed particular implementations of gamification mechanics for the context of interest, and evaluated the effectiveness of the considered player types and gamification mechanics.

Studying if all the items of the initial personality questionnaire were useful to infer the students' player types, we have identified the questions that allowed to infer *philanthropists*, *achievers*, and *socializers*. The effectiveness of the *free spirits* was not validated, neither in the player type inference stage nor in the gamification mechanics use stage, so this player type seems to be of no interest for the proposed educational context.

Studying if the considered gamification mechanics and their implementations as learning-based actions really correspond to the students' inferred player types, achievers and socializers recorded all the mechanics that were assumed for them. Philanthropists recorded all the mechanics assumed for them except *Collecting & Trading*, so its correspondence is doubtful. Members of all player types did not show interest in mechanics associated to free spirits. *Level/Progression* for achievers; *Social Status*, *Social Networking*, and *Competition* for socializers; and *Meaning/Purpose*, and *Access* for philanthropists, were the most representative and discriminative gamification mechanics. Finally, *Challenge*, *Quest* and *Certificate*, assumed for achievers, showed to be the most versatile gamification mechanics.

Studying which player types and gamification mechanics were effective in the tested e-learning environment, the students' preferences for mechanics associated to achievers and socializers match with the most performed mechanics inferred for such player types. Some of such mechanics, i.e., *Care taking*, *Access*, *Level/Progression*, and *Competition* were not effective but we believe they may be effective in a complete e-learning system used for a long period of time and with social networking functionalities. We observed a redundancy between *Unlockable/Rare Content* and *Access*, so they may be avoided in the future. Based on our results, *Collecting & Trading* and *Gifting* could not be effective in an e-learning environment where the main goal is (and has to be) the students' learning process and goals.

Studying how the students assessed the proposed gamification activities, in general, their appreciation for the activity was positive in terms of acceptance and enjoy, and was considered as effective for the students' learning process and goals, being preferred to conventional lectures. The success of the engagement aspect for *philanthropists* may be due to the fact that they worked in pairs, instead of individually or in large groups. In general, the students found the activity and its mechanics easy to understand and perform. Working alone and being motivated by the achievement of challenges, certificates and quests made the activity easier to understand, but provided certain degree of stress.

Based on the results and conclusions achieved in the study, we have presented a number of design proposals for the future implementation of an intelligent gamified e-learning framework, in which the students' player types are inferred and adapted automatically, and gamification mechanics are presented to the students in a personalized way according to their player types and learning profiles.

With a larger number of participants using the above system during a long period of time –e.g., an entire course–, we will better address the proposed research questions aimed to achieve an effective and engaging implementation of gamified learning activities.

O'Brien & Toms [49] described the development and evaluation of methods to measure user engagement in online shopping environments, identifying six key attributes to considered. Later, O'Brien & Cairns [50] found which were the dimensions of user engagement more stable in the online news domain. In the future, we may explore such methods to measure and adapt the students' engagement in the proposed e-learning environment.

Research about the relations between player types and learning styles is an issue that is under investigation along with personality traits. It is still needed to design valid and interrelated models, and find effective methods to acquire the students' learning and gaming profiles, especially for the player types, which is a much less explored topic in comparison with learning styles, studied in the education and psychology areas. As for personality traits, although in this thesis we have not addressed the issue, we do not discard its inclusion in future studies as Konert, Göbel, & Steinmetz have already done [44].

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Appendix A. Statements of available actions for every player type

RAZA	DINÁMICA DE TRABAJO	PERFIL
ELFOS	Individual	Se caracterizan por su Autonomía. Les gusta reflexionar, crear y explorar. Inicialmente cada elfo posee 4 Anillos de Lothlorien.
ENANOS	Individual	Se caracterizan por su Maestría. Les gusta superar nuevos retos y destacar. Inicialmente cada enano posee 4 Anillos de Moria.
HUMANOS	En "comunidades" de 3 ó 4 miembros	Se caracterizan por su Sociabilidad. Les gusta interactuar con otros. Inicialmente cada humano posee 4 Anillos de Góndor.
HOBBITS	En pareja	Se caracterizan por su Altruismo. Les gusta compartir y ayudar a los demás. Inicialmente cada hobbit posee 4 Anillos de La Comarca.

HUMANOS	
Posibles adquisiciones POSITIVAS	Galardones "Humano Caballero" por ser muy participativo en tu comunidad
	Vínculos de Hermanamiento con humanos afines a ti
	Galardones "Comunidad de Humanos Victoriosos" por ser la primera comunidad en resolver ejercicios
	Galardones "Humano Valiente" al escribir y explicar un ejercicio en la pizarra
	Título "Rey Humano" por número de galardones y anillos (convertidos a puntos)
Posibles adquisiciones NEGATIVAS	Galardones "Humano Escudero" por ser poco participativo en tu comunidad

Acciones individuales → El símbolo Φ indica que la acción la registra Sauron, ☺ indica que la debes registrar tú

Durante la sesión

1. Cambiar de raza **→ Φ**
2. Ir a otra comunidad de humanos **→ Φ**
3. Pedir ayuda a un hobbit o una pareja de hobbits
   Los hobbits tienen acceso a las soluciones de los ejercicios
   Pueden aceptar o rechazar tu petición
   Si te ayudan otorgarles el galardón **"Hobbit Bondadoso"**, y si no el de **"Hobbit de Bolsón Cerrado" → ☺**
4. Crear un **"Vínculo de Hermanamiento"** con otro humano que has descubierto que es afín a ti **→ ☺**
5. Regalar uno de tus **4 Anillos de Góndor** a un ser de cualquier raza **→ ☺**
   Los anillos se canjearán posteriormente por puntos
6. Intercambiar uno de tus **4 Anillos de Góndor** con el de un ser de otra raza **→ ☺**
   Los anillos se canjearán posteriormente por puntos
7. Obtener galardón **"Humano Valiente"** al escribir y explicar la solución de un ejercicio en la pizarra **→ Φ**

Al finalizar la sesión (individualmente)

8. Otorgar galardón **"Humano Caballero"** a un compañero de tu comunidad por ser muy participativo **→ ☺**
   Puedes otorgar este galardón a varios compañeros, pero solo una vez a cada uno de ellos
9. Otorgar galardón **"Humano Escudero"** a un compañero de tu comunidad por ser poco participativo **→ ☺**
   Puedes otorgar este galardón a varios compañeros, pero solo una vez a cada uno de ellos

Acciones de la comunidad → indicárselo a Sauron inmediatamente, la acción la registrará el ojo que todo lo ve

Durante la sesión

10. Recibir galardón **"Comunidad de Humanos Victoriosos" → Φ**
    Será otorgado a todos los miembros de tu comunidad si sois los primeros en resolver un ejercicio
    Debéis solicitárselo a Sauron enseñándole la solución al ejercicio
    Se pueden recibir varios galardones en una sesión

HOBBITS	
Posibles adquisiciones POSITIVAS	Galardones "Hobbit Bondadoso" en agradecimiento a tu esfuerzo y dedicación por tu ayuda si a quien has ayudado lo considera oportuno
	Galardones "Hobbit Aventurero" por salir de La Comarca hacia reinos de otras razas e interesarte por si otros necesitan ayuda
	Galardones "Hobbit Victorioso" por ser los primeros en resolver un ejercicio
	Galardones "Hobbit Valiente" al escribir y explicar un ejercicio en la pizarra
	Título "Rey Hobbit" por número de galardones y anillos (convertidos a puntos)

Acciones individuales → El símbolo Φ indica que la acción la registra Sauron, ☺ indica que la debes registrar tú

Durante la sesión

1. Cambiar de raza → **Φ**
2. Solicitar la solución de un ejercicio a Sauron → **Φ**
3. Aceptar o rechazar las peticiones de ayuda de seres de otras razas que se acercan a vosotros
   Podríais recibir el galardón **"Hobbit Bondadoso"** por parte de los seres a los que habéis ayudado
4. Ir solo o en pareja a ofrecer ayuda a enanos y/o elfos por voluntad propia → ☺
   Otórgate/os en formulario el galardón **"Hobbit Aventurero"** indicando si han aceptado o rechazado tu/vuestra ayuda
5. Recibir galardón **"Hobbit Victorioso"** → **Φ**
   Será otorgado a los dos miembros de la pareja si sois los primeros en resolver un ejercicio
       Debéis solicitárselo a Sauron enseñándole la solución al ejercicio
   Se pueden recibir varios galardones en una sesión
6. Regalar uno de tus **4 Anillos de La Comarca** a un ser de cualquier raza → ☺
   Los anillos se canjearán posteriormente por puntos en la tabla "La Comunidad del Anillo"
7. Intercambiar uno de tus **4 Anillos de La Comarca** con el de un ser de otra raza → ☺
   Los anillos se canjearán posteriormente por puntos en la tabla "La Comunidad del Anillo"
8. Obtener galardón **"Hobbit Valiente"** al escribir y explicar la solución de un ejercicio en la pizarra → **Φ**

ENANOS

Posibles adquisiciones POSITIVAS	Galardones "Enano Victorioso" por ser el primero en resolver un ejercicio
	Galardones "Enano Guerrero de nivel X" como reconocimiento a tu valía en la realización de todos los ejercicios de nivel de dificultad 'X'
	Galardones "Maestro Enano" debido al valor y poder mostrado al pedir y realizar un ejercicio correspondiente a un tema futuro del curso
	Galardones "Enano Valiente" al escribir y explicar un ejercicio en la pizarra
	Título "Rey Enano" por número de galardones y anillos (convertidos a puntos)

Acciones individuales → El símbolo Φ indica que la acción la registra Sauron, ☺ indica que la debes registrar tú

Durante la sesión

1. Cambiar de raza → **Φ**
2. Pedir ayuda a una pareja de hobbits → ☺
   Los hobbits tienen acceso a las soluciones de los ejercicios
   Pueden aceptar o rechazar tu petición
   Si te ayudan otorgarles el galardón **"Hobbit Bondadoso"**, y si no el de **"Hobbit de Bolsón Cerrado"** → ☺
3. Aceptar o rechazar ayuda ofrecida por parejas de hobbits a los que no has pedido ayuda
   Si te ayudan otorgarles el galardón **"Hobbit Bondadoso"**, y si no el de **"Hobbit de Bolsón Cerrado"** → ☺
5. Obtener galardón **"Enano Victorioso"** al ser el primero en resolver un ejercicio → **Φ**
   Debes indicárselo a Sauron inmediatamente antes de que se te adelanten
   Se pueden recibir varios galardones en una sesión
6. Obtener galardón **"Enano Guerrero de Nivel X"** → **Φ**
   Serás un "Enano Guerrero de Nivel 1" si realizas 3 ejercicios con distinto símbolo del tipo {♥, ♠, ♣, ♦}
   Serás un "Enano Guerrero de Nivel 2" si realizas 2 ejercicios con distinto símbolo del tipo {♥♥, ♠♠, ♣♣, ♦♦}
   Serás un "Enano Guerrero de Nivel 3" si realizas 1 ejercicio con símbolo del tipo {♥♥♥, ♠♠♠, ♣♣♣, ♦♦♦}
   Sauron debe validar tus soluciones antes de registrar el galardón en el formulario
   Puedes conseguir tantos galardones como niveles de dificultad haya
7. Obtener galardón **"Maestro Enano"** por pedir el enunciado y resolver un ejercicio de un tema que se verá posteriormente en la asignatura → **Φ**
   Sauron te proporcionará las presentaciones necesarias y una explicación del tema
   Sauron debe validar tu solución antes de registrar el galardón en el formulario
8. Regalar uno de tus **4 Anillos de Moria** a un ser de cualquier raza → ☺
   Los anillos se canjearán posteriormente por puntos en la tabla "La Comunidad del Anillo"
9. Intercambiar uno de tus **4 Anillos de Moria** con el de alguien de otra raza → ☺
   Los anillos se canjearán posteriormente por puntos en la tabla "La Comunidad del Anillo"
10. Obtener galardón **"Enano Valiente"** al escribir y explicar la solución de un ejercicio en la pizarra → **Φ**

ELFOS	
Posibles adquisiciones POSITIVAS	Galardones "Elfo Victorioso" por ser el primero en resolver un ejercicio
	Galardones "General Elfo" por enfrentarte y resolver ejercicios de mayor dificultad
	Galardones "Mago Elfo" por aportar modificaciones sobre los ejercicios entregados
	Galardones "Alto Elfo" por aportar ideas sobre nuevos ejercicios
	Galardones "Elfo Valiente" al escribir y explicar un ejercicio en la pizarra
	Título "Rey Elfo" por número de galardones y anillos (convertidos a puntos)

Acciones individuales → El símbolo Φ indica que la acción la registra Sauron, ☺ indica que la debes registrar tú

Durante la sesión

1. Cambiar de raza → **Φ**
2. Pedir ayuda a una pareja de hobbits → ☺
   Los hobbits tienen acceso a las soluciones de los ejercicios
   Pueden aceptar o rechazar tu petición
   Si te ayudan otorgarles el galardón **"Hobbit Bondadoso"**, y si no el de **"Hobbit de Bolsón Cerrado"** → ☺
3. Aceptar o rechazar ayuda ofrecida por parejas de hobbits a los que no has pedido ayuda
   Si te ayudan otorgarles el galardón **"Hobbit Bondadoso"**, y si no el de **"Hobbit de Bolsón Cerrado"** → ☺
4. Obtener galardón **"Elfo Victorioso"** al ser el primero en resolver un ejercicio → **Φ**
   Debes indicárselo a Sauron inmediatamente antes de que se te adelanten
   Se pueden recibir varios galardones en una sesión
5. Obtener galardón **"General Elfo"** por pedir el enunciado y resolver un ejercicio de mayor dificultad → **Φ**
   Puedes obtener varios galardones, pero antes Sauron debe validarlos
6. Obtener galardón **"Mago Elfo"** por modificar el enunciado de un ejercicio de forma interesante → **Φ**
   Puedes obtener tantos galardones como ejercicios modificados, pero antes Sauron debe validarlos
7. Obtener galardón **"Alto Elfo"** por proponer un nuevo ejercicio → **Φ**
   Puedes obtener tantos galardones como ejercicios propuestos, pero antes Sauron debe validarlos
8. Regalar uno de tus **4 Anillos de Lothlorien** a un ser de cualquier raza → ☺
   Los anillos se canjearán posteriormente por puntos en la tabla "La Comunidad del Anillo"
9. Intercambiar uno de tus **4 Anillos de Lothlorien** con el de un ser de otra raza → ☺
   Los anillos se canjearán posteriormente por puntos en la tabla "La Comunidad del Anillo"
10. Obtener galardón **"Elfo Valiente"** al escribir y explicar la solución de un ejercicio en la pizarra → **Φ**

Appendix B. Example worksheet

<div align="center">

Universidad Autónoma de Madrid

Escuela Politécnica Superior

Grado en Ingeniería Informática

Programación II

Hoja de ejercicios IV – Colas y Listas Enlazadas

</div>

El <u>TAD Lista</u> se ha implementado con la siguiente EdD:

```
struct _Nodo {
   Elemento *info;
   struct _Nodo *next;
};
typedef struct _Nodo Nodo;

struct _Lista {
   Nodo *first;
};
typedef struct _Lista Lista;
```

Asumir que el TAD Elemento tiene primitivas usadas en clase de teoría: `elemento_crear`, `elemento_copiar` y `elemento_liberar`.

Ejercicio 1 (♥)

Dar el código C de la función `nodo_crear` en dos versiones:

- No recibiendo ningún argumento de entrada.
- Recibiendo como argumento de entrada el elemento (`Elemento *`) a almacenar en el nodo creado.

Para cada una de las versiones anteriores, dar el código C correspondiente de la función `nodo_liberar`.

Ejercicio 2 (♠)

Dar el código C de la función `int lista_tamanio(Lista *pl)` que devuelve el número de elementos de una lista.

Ejercicio 3 (♦)

Dar el código C de la función `status lista_intercambiarNodos(Nodo *pn1, Nodo *pn2)` que "intercambia" los elementos (campos info) de dos nodos pn1 y pn2 en una lista enlazada.

Ejercicio 4 (♣)

Dar el código C de la función `status lista_intercambiar(Lista *pl)` que intercambia las posiciones de los elementos primero y último de una lista. Implementar la función intercambiando los punteros correspondientes, y no usando la función `elemento_copiar`.

Ejercicio 5 (♥♥)

Dar el código C de la función `status lista_insertarPos(Lista *pl, Elemento *pe, int pos)` que inserta el elemento pe en la posición pos de la lista pl.

Ejercicio 6 (♠♠)

Dar el código C de la función `Lista *lista_concatenar(Lista *pl1, Lista *pl2)` que devuelve una lista cuyos nodos son los de pl1 "concatenados" (seguidos) con los de pl2.

El <u>TAD Lista circular</u> se ha implementado con la siguiente EdD:

```
struct _Nodo {
   Elemento *info;
   struct _Nodo *next;
};
typedef struct _Nodo Nodo;

struct _ListaCicular {
   Nodo *last;
};
typedef struct _ListaCicular ListaCircular;
```

En ella el campo `last` apunta al último nodo insertado en la lista y el campo next del último nodo de ese último nodo apunta al primer nodo insertado en la lista.

Asumir que el TAD Elemento tiene primitivas usadas en clase de teoría: `elemento_crear`, `elemento_copiar` y `elemento_liberar`.

Ejercicio 7 (♥)

Dar el código C de la función `status listaCircular_insertarIni(ListaCircular *pl, Elemento *pe)` que inserta un elemento al inicio de una lista circular.

Ejercicio 8 (♠)

Dar el código C de la función `status listaCircular_insertarFin(ListaCircular *pl, Elemento *pe)` que inserta un elemento al final de una lista circular.

Ejercicio 9 (♦)

Dar el código C de la función `Elemento *listaCircular_extraerIni(ListaCircular *pl)` que extrae un elemento del inicio de una lista circular.

Ejercicio 10 (♣)

Dar el código C de la función `Elemento *listaCircular_extraerFin(ListaCircular *pl)` que extrae un elemento del final de una lista circular.

El <u>TAD Lista doblemente enlazada</u> se ha implementado con la siguiente EdD:

```
struct _NodoDE {
   struct _NodoDE *prev;
   Elemento *info;
   struct _NodoDE *next;
};
typedef struct _NodoDE NodoDE;

struct _ListaDE {
   Nodo *first;
};
typedef struct _ListaDE ListaDE;
```

Asumir que el TAD Elemento tiene primitivas usadas en clase de teoría: `elemento_crear`, `elemento_copiar` y `elemento_liberar`.

Ejercicio 11 (♠)

Dar el código C de la función `status listaDE_insertarIni(ListaDE *pl, Elemento *pe)` que inserta un elemento al inicio de una lista doblemente enlazada.

Ejercicio 12 (♠)

Dar el código C de la función `status listaDE_insertarFin(ListaDE *pl, Elemento *pe)` que inserta un elemento al final de una lista doblemente enlazada.

Ejercicio 13 (♦)

Dar el código C de la función `Elemento *listaDE_extraerIni(ListaDE *pl)` que extrae un elemento del inicio de una lista doblemente enlazada.

Ejercicio 14 (♣)

Dar el código C de la función `Elemento *listaDE_extraerFin(ListaDE *pl)` que extrae un elemento del final de una lista doblemente enlazada.

Ejercicio 15 (♦♦)

Dar el código C de la función `status listaDE_intercambiarNodos(Nodo *pn1, Nodo *pn2)` que "intercambia" las posiciones de dos nodos pn1 y pn2 en una lista doblemente enlazada.

Una implementación en C del <u>TAD Lista</u> tiene como único interfaz las primitivas:

- `Lista *lista_crear()`, que crea (reservando memoria), inicializa y devuelve una lista enlazada.
- `void lista_liberar(Lista *pl)`, que libera la memoria de una lista y sus elementos.
- `boolean lista_vacia(Lista *pl)`, que comprueba si una lista está vacía.
- `status lista_insertarIni(Lista *pl, Elemento *pe)`, que inserta un elemento en una lista al inicio de ésta.
- `status lista_insertarFin(Lista *pl, Elemento *pe)`, que inserta un elemento en una lista al final de ésta.
- `Elemento *lista_extraerIni(Cola *pl)`, que extrae y devuelve el elemento al inicio de una lista.
- `Elemento *lista_extraerFin(Cola *pl)`, que extrae y devuelve el elemento al final de una lista.

Asumir que el TAD Elemento tiene primitivas usadas en clase de teoría: `elemento_crear`, `elemento_copiar` y `elemento_liberar`.

Ejercicio 16 (♣♣)

Dar el código C de la función `int lista_tamanio(Lista *pl)` que devuelve el número de elementos de una lista usando las primitivas de Lista dadas arriba.

Una implementación en C del <u>TAD Cola</u> tiene como único interfaz las primitivas:

- `Cola *cola_crear()`, que crea (reservando memoria), inicializa y devuelve una cola.
- `void cola_liberar(Cola *pq)`, que libera la memoria de una cola y sus elementos.
- `boolean cola_vacia(Cola *pq)`, que comprueba si una cola está vacía.
- `boolean cola_llena(Cola *pq)`, que comprueba si una cola está llena.
- `status cola_insertar(Cola *pq, Elemento *pe)`, que inserta un elemento en la cola.
- `Elemento *cola_extraer(Cola *pq)`, que extrae y devuelve un elemento en la cola.

Asumir que un `insertar` precedido de un `extraer` sobre una cola no causa error.

Ejercicio 17 (♥♥)

Dar el código C de una función `status int cola_tamanio(Cola *pq)` que, usando las primitivas de arriba, devuelva el número de elementos almacenados en la cola de entrada pq.

Ejercicio 18 (♠♠)

Dar el código C de una función `status cola_insertarConPrioridad(Cola *pq, Elemento *pe)` que actualice la cola pq poniendo pe detrás de todos los elementos con mayor o igual prioridad y delante de todos los elementos con menor prioridad. Los elementos que ya estaban en la cola deben mantenerse tras la inserción en el mismo orden en el que se encontraban. Asumir que el TAD Elemento tiene una primitiva `int elemento_prioridad(Elemento *pe)`, que devuelve un entero indicando el nivel de prioridad. Asumir que a menor valor de ese entero, mayor prioridad del elemento: 0 sería máxima prioridad, seguida de 1, 2, 3, etc.

Ejercicio 19 (♦ ♦)

Dar el código C de una función `status cola_insertarEnOrden(Cola *pq, Elemento *pe)` que inserte un elemento `pe` en una cola `pq` manteniendo un <u>orden creciente</u> de los elementos de `pq`.

Para ello asumir la existencia de una función `int elemento_comparar(Elemento *pe1, Elemento *pe2)` que devuelve −1 si el contenido de `pe1` es "menor" que el de `pe2`, 0 si el contenido de `pe1` es igual al de `pe2`, y 1 si el contenido de `pe1` es "mayor" que el de `pe2`.

Ejercicio 20 (♣♣)

Dar el código C de una función `status cola_juntar(Cola *pq1, Cola *pq2)` que reciba dos colas `pq1`, `pq2` y modifique `pq1` situando a continuación de su último elemento los de la cola `pq2` (que debe de quedar vacía si la unión de colas se efectúa con éxito) en su orden propio. La función sólo debe utilizar las primitivas anteriores y hacer el control y recuperación de errores pertinente.

Los <u>TAD Lista y Cola</u> se han implementado con las siguientes EdD:

```
struct _Nodo {
   Elemento *info;
   struct _Nodo *next;
};
typedef struct _Nodo Nodo;

struct _Lista {
   Nodo *first;
};
typedef struct _Lista Lista;

struct _Cola {
   Lista *pl;
};
typedef struct _Cola Cola;
```

Asumir que el TAD Elemento tiene primitivas usadas en clase de teoría: `elemento_crear`, `elemento_copiar` y `elemento_liberar`.

Ejercicio 21 (♥ ♥ ♥)

Realizar el ejercicio 17, i.e., implementar la función `status int cola_tamanio(Cola *pq)`, accediendo y modificando el contenido de `pq` a través de los nodos de la lista.

Ejercicio 22 (♠ ♠ ♠)

Realizar el ejercicio 18, i.e., implementar la función `status cola_insertarConPrioridad(Cola *pq, Elemento *pe)`, accediendo y modificando el contenido de `pq` a través de los nodos de la lista.

Ejercicio 23 (♦ ♦ ♦)

Realizar el ejercicio 19, i.e., implementar la función `status status cola_insertarEnOrden(Cola *pq, Elemento *pe)`, accediendo y modificando el contenido de `pq` a través de los nodos de la lista.

Ejercicio 24 (♣ ♣ ♣)

Realizar el ejercicio 20, i.e., implementar la función `status status cola_juntar(Cola *pq1, Cola *pq2)`, accediendo y modificando el contenido de `pq1` y `pq2` a través de los nodos de las listas.

Appendix C. Evaluation questionnaire

The Fellowship of the Ring - Review of activity

General opinion. The following questions are aimed to collect your opinion about the activity in general.

Did you like the activity?

- o   No
- o   Yes, but little
- o   Yes
- o   Yes, a lot

Did you see the activity more or less fun than the "typical" exercise class?

- o   A lot less
- o   Less
- o   Equal
- o   More
- o   Much more

Have you learned with the activity?

- o   No
- o   Yes, but little
- o   Yes
- o   Yes, a lot

Have you learned more or less with the activity than with the "typical" exercise class?

- o   Much less
- o   Less
- o   Equal
- o   More
- o   Much more

Would you like to continue with these activities?

- o   No
- o   Yes, but only in the subject PROG2
- o   Yes
- o   Yes, in a lot/all the subjects

Which "actions" (you can select multiple) you find interesting for this kind of activities in line with your personality and way of learning?

- Challenges (for example, be the first solving a problem)
- Adventure (for example, solve X given problems)
- Levels (for example, reach a level having solved X problems of a certain degree of difficulty)
- Certificates (for example, receive a certificate by reaching several challenges, adventure or levels)
- Exploration (for example, choose voluntarily problems of high difficulty)
- Unlock (for example, choose voluntarily to see "rare" problems or problems of other topic)
- Customizing (for example, to propose changes or extensions to the problems)
- Creativity (for example, to pose and solve new problems)
- Team (working in group)
- Competition (holding points and an individual or team ranking)
- Social status (for example, receiving award from teammates)
- Social network (for example, establishing links with classmates)
- Social discovery (for example, knowing or working with classmates with who you do not usually work)
- Purpose (for example, receiving an award for having helped a fellow)
- Care (for example, voluntarily helping a fellow)
- Sharing (for example, sharing a solution with classmates)
- Access (for example, asking the teacher the solution to a problem that does not get resolved)
- Collectables (for example, collecting and exchanging badges or rewards during activity)
- Gift (for example, giving badges or rewards to classmates)

Opinion about your preferred learning dynamic

The following questions are aimed to collect your opinion about the learning dynamic that helps you more. The considered dynamics in the activity were:

- *Socializers (Humans/Men)* have dynamics to work in communities. They are characterized by their sociability, and like to interact with others.
- *Free Spirits (Elves)* have dynamics to work alone. They are characterized by their autonomy, and like to create and explore.
- *Achievers (Dwarves)* have dynamics to work alone. They are characterized by their mastery, and like to address challenges and achieve victories.
- *Philanthropists (Hobbits)* have dynamics to work in pairs. They are characterized by their altruism, and like to help and share with others.

What has been your favourite learning dynamic?

- o Elves
- o Dwarves
- o Humans/Men
- o Hobbits

How much difficulty have you had with the dynamic understanding and putting it into practice?

- o Very difficult
- o Difficult
- o Easy
- o Very easy

How much stress have you had following the dynamic in the activity?

- o Very stressful
- o Stressful
- o Stressful, but a little
- o No stressful

How much fun have you had following the dynamic in the activity?

- o Boring
- o Not boring, not funny
- o Funny
- o Very funny

In addition to the preferred dynamic, is there another learning dynamic that fits you well?

- o No, only fits with me the chosen one
- o Yes, Elves
- o Yes, Dwarves
- o Yes, Humans/Men
- o Yes, Hobbits