

# Teaching Teamwork in Logistics Engineering Through a Board Game\*

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This article discusses the design and implementation of a board game to develop both the knowledge and the skills of Logistics Engineering students in a pre-university environment. This experience aims to create a learning environment from a playful perspective to promote interest in and encourage teamwork in the area Logistics Engineering among pre-university students. The game has been designed by applying the Fun Experience Design methodology, based on user-centered design and user experience techniques. Pre-design surveys were conducted on potential students ( $N = 140$ ) to improve the initial design and after the playtest on stakeholders ( $N = 7$ ) and students ( $N = 16$ ) to rate their acceptance of the game and to detect aspects that could be improved upon. The methodology for the development of the experience is presented, as well as the qualitative data obtained before and after the design and its implementation. Our results show that the use of game in the classroom contributes to the acquisition of knowledge and the development of skills such as teamwork in the users.

**Keywords:** teamwork; gamification; user experience; board game; logistics engineering

## 1. Introduction

Teamwork is a form of educational experience that requires the identification of the profiles of the team members that will integrate the team, the roles that they will take on and a clear description of the tasks that they will develop throughout the activities. Therefore, designs based on gamification, which require a definition of the profile of the participants, together with their corresponding roles and activities have proven useful. Is it possible to encourage the students of Logistics Engineering to work as a team through a board game?

This article discusses the design and implementation of a board game to develop both the knowledge and the skills of Logistics Engineering in a pre-university environment, in order to create a playful and enjoyable learning environment to promote interest in Logistics Engineering and to encourage teamwork in related activities. The Fun Experienced Design (FED) methodology was used to design this experience, since it met a double objective. On the one hand, user experience [1] and design thinking [2] techniques were used to meet the profile and the needs of the potential users of the game, given that the author had no previous experience of working with this type of student; on the other hand, the methodology was tested in a new environment, different from its previous implementation, as it is a game to be used in an extracurricular way.

### 1.1 Logistic Vocations

The Santa Perpètua de Mogoda area (Barcelona) is experiencing a boom in logistics and thanks to increased investment, is becoming a logistics hub in Catalonia (Spain). The demand for trained professionals is greater than the supply available in the area, so companies are forced to look outside the area for staff. In view of this problem, the municipality of Santa Perpètua de Mogoda, has introduced a series of measures to encourage studies in logistics among the younger population. In recent times, the use of alternative to traditional methodologies, such as inverted classes [3], use of virtual reality [4] or video games [5], both for learning soft skills, including teamwork [6] as for the promotion of engineering in young people [4]. In this context, one of these actions is the promotion of the profession of logistics and its associated skills, such as teamwork, through gamification [7].

The project managers of the municipality of Santa Perpètua de Mogoda contacted the Group of REsearch in Technology Enhanced Learning (GRETEL) of La Salle-Ramon Llull University to design this game, given the previous experience of working together on gamified projects. The assignment consisted in the creation of a game in which high school pupils and students of vocational training modules in the area were given the opportunity to learn the concepts and skills associated with the sector of logistics.

## 1.2 Gamification

The introduction of the game concept in environments other than entertainment such as marketing [8–10], quickly spread to other areas such as banking [11], health [12], driving [13] or education [14, 15]. Gamification has become a widespread practice as evidenced by the growing number of existing publications in these areas [16–18]. There are numerous definitions of gamification. One of the first and most popular is “Use of game mechanics in a non-playful context” [19]. The concept of gamification can be better understood by applying its relation to the game [20] and the user experience techniques. The game can be broken down into three elements: the mechanics (M), the rules that make up the system game; the dynamics (D), the relationship, the interaction that is established between the system and the users, and the aesthetics (A) or perceptions of the users. There is also a relationship between emotions, interaction and usability from user experience techniques (Fig. 1). The existence of this relationship made it possible for us to apply a gamification methodology to solve this problem.

A further consideration is the correct alignment of game and non-game elements and their respective objectives (Fig. 2). In a gamified system, game

elements, non-game elements and targets form a self-contained whole. Serious games are systems, in general, with a game-like appearance that are designed to meet objectives by themselves, without the need for non-game elements, although they may be present in the form of extra content or complementary information which is not associated with the system itself. In this case non-game elements may be added if considered necessary. In the case of the use of this type of game experience in education, it is called game-based learning (GBL) [21–23].

In addition, a literature study has been carried out, in which it has been found that it is an increasingly common practice to apply gamification to obtain both knowledge and soft skills (such as teamwork) [24]. There has also been an upward trend in the application of gamification in the field of logistics [25], although this application is basic, focusing in most cases, in the application of points, badges and leaderboards.

Thus, when faced with the premise of encouraging teamwork, it was decided that, instead of applying game mechanics in isolation, it would be more appropriate to create a complete game, (a serious game) that integrates all the necessary elements:

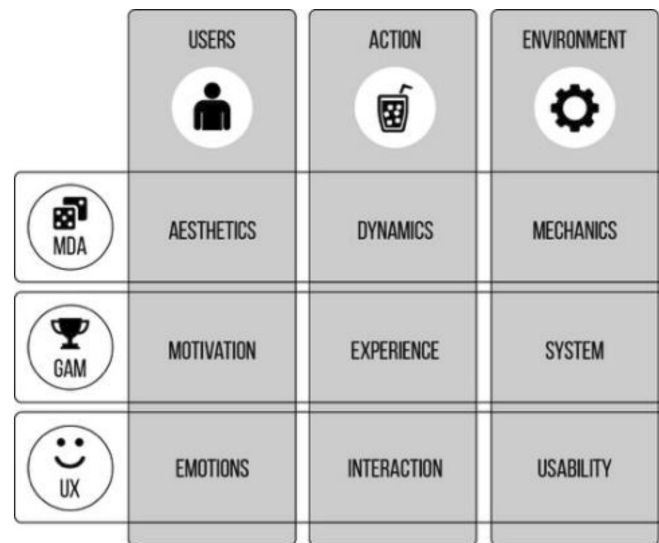


Fig. 1. Summary table of the relationships between game methodologies, gamification and UX.

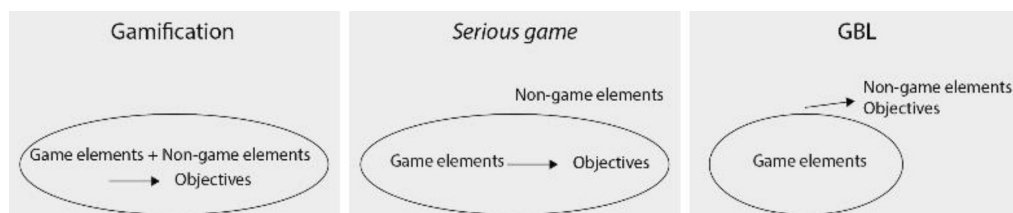


Fig. 2. Relationship between game elements, non-game elements and objectives.

- **Mechanics:** It required the inclusion of a series of technical skills (hard skills) such as transportation, storage, infrastructure, 4.0 technologies, etc.
- **Dynamics:** It was necessary to align the objectives with social skills (soft skills), such as teamwork, communication, active listening, self-leadership, proactivity, negotiation, etc.
- **Perceptions:** A change was sought in behaviors and perceptions of users about the studies in logistics engineering and on teamwork.

## 2. Fun Experience Design Methodology

The author did not have any previous experience or first-hand knowledge on the type of user who was going to play. For this reason, the application of the Fun Experience Design (FED) methodology was considered, in order to obtain an accurate description of the motivations, perceptions and frustrations of the students who were going to be users of the game. In addition, this enabled us to check if the tools the methodology provides effectively contribute to the creation of a game-based system from scratch, without any prior knowledge.

The FED methodology [26] was developed in the field of engineering at La Salle Campus Barcelona (Universitat Ramon Llull), as part of the MDA framework [20] within the discipline of User Experience (UX) [27]. It has been successfully applied to the subject of Design and Usability 1, a first-year engineering core subject for students of multimedia, computing, telematics, telecommunications, electronics, audiovisual and ICT management, at La Salle Campus Barcelona (Universitat Ramon Llull) since the academic year 2012/2013 to the present.

As shown in Fig. 3, the FED methodology consists of the following stages:

- **Stage 1: Exploration.** Prior to the design stage, UX techniques are used to extract data from users.
- **Stage 2: Creation.** With the knowledge acquired in the previous phase, a gamified system is designed, using the most appropriate mechanics to achieve the objectives that are to be achieved and which are aligned with the characteristics of the users to whom it is intended.
- **Stage 3: Review.** During and / or after the implementation, as the characteristics of the gamified project allow, new data is collected, this time to determine the motivations, needs and emotions of the users once they have used the system.
- **Stage 4: Redesign.** The analysis of the qualitative data will provide information on the mechanics of

the gamification that have to be implemented, modified or eliminated.

### 2.1 Exploration Phase

The first part of the process consists of obtaining first-hand knowledge of the concerns and needs of the end users. We needed to know their perception of their study habits, so the questionnaires used in the evaluation techniques were used to both define the profile and to determine their needs and concerns.

#### 2.1.1 Evaluation Techniques

The surveys that were conducted were:

- **Demographic data:** classification of students by gender and age.
- **Study habits.**
- **Classroom relationships.**
- **Enjoy of the activities in the classroom.**
- **Frequency of carrying out activities in the classroom.**
- **Perception of studies.** Pocket BLA survey [28, 29] (Socratic technique [30] of psychological exploration). What did they value most and what they least valued from their studies.
- **Emotional assessment questionnaire** (based on the research of the German Schmidt-Atzert [31]. Survey in which they value what emotions their studies cause them.

#### 2.1.2 Analysis of Data

In September 2018, a series of demographic surveys, study habits and perception of the present-day study programmes were conducted on a sample of N = 140 high school students. The surveys were

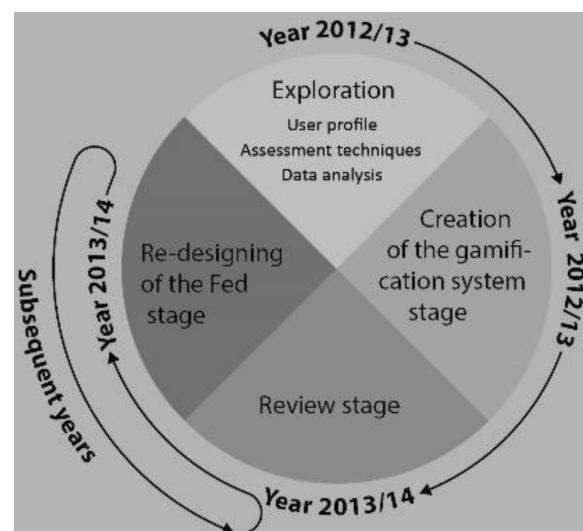


Fig. 3. Labrador, E.; Villegas, E. (2014). Phases of the FED methodology from Fun experience design applied to learning, ICEILT14.

**Table 1.** Results of the student study habits questionnaire

Average	Questionnaire Ways to Study
20.6%	Alone / In group
55.5%	Memorizing / Understanding
74.2%	Continuously / Before the exam
40.3%	Doubts to classmates / Teacher
31.0%	Sufficient / Insufficient class examples
16.3%	Class / External examples
29.2%	I participate in class / I don't
43.1%	Material set / Separately
26.7%	I can create exercises / I can't
32.0%	Help Partners / Solo
48.8%	Useful / I want to approve
22.1%	Practices / Exams
26.2%	Enough / Insufficient Comments
53.6%	About my progress I speak / I do not speak
42.0%	I try to understand / I memorize
90.0%	Content First Day / Step by step
50.4%	Share marks / Don't Share
5.4%	I understand each parts / I do not understand each parts
51.2%	Useful exams / To pass
23.7%	Progressive / Uniform Difficulty

filled out on paper and submitted by the students (Phase 1 of the FED). Elicitation of the elements: the students were asked to list the positive and negative points that influence design.

An example of results is the questionnaire on study habits (Table 1) that shows how they are more used to studying alone than with others and that they do not have regular study habits but tend to study only before exams. Furthermore they participate little in class and the reason they study is simply to pass. They also perceive that exams are not useful learning tools and that student to teacher communication is limited. In general, a lack of engagement with the studies is perceived.

Another example of results is the questionnaire of aspects they consider important inside the classroom. The data showed, among other things, that the students have a great need to feel that they belong to a group and that they are very social, preferring to be recognized for their personality as

opposed to their knowledge and although they are not competitive, they prefer to work as a team to solve challenges instead of doing tests individually (Table 2). The potential study variables are interest / motivation.

Considering the results of all the test and the academic requirements of the course, it was decided to increase this interest / motivation, through a board game. The chosen mechanics aimed to enable students to learn both the necessary knowledge in the subject and to acquire the skills associated with teamwork within the subject of Logistics Engineering.

## 2.2 Creation Phase of the Game

From the data collected in phase 1, the FED methodology continued to be applied, interpreting them and creating the elements that will lead to the final game design. The different types of surveys enabled us to find a good number of insights, statements and triggers.

**Table 2.** Result of one of the surveys made to students about the importance they give to different issues

How important do you think the following issues are?	Have more knowledge than others	That in a group everyone has different knowledge	Being accepted in a group	Be respected	Be loved	Practice instead of exams	Receive a reward after passing a practice	Be recognized for your personality	Be recognized for your knowledge	Participate in a ranking with your colleagues	Be able to customize some content	Learn new contents, beyond those that you provide in class	That all the parts of a subject are related
Average	36.9%	73.1%	85.5%	94.4%	73.3%	72.4%	52.3%	68.8%	60.2%	27.4%	53.4%	61.1%	73.2%

Examples of insights and statements obtained from the surveys:

- **Teamwork**

Although they like to help their classmates when necessary, students prefer to study alone, they do not have group study habits.

- How might we encourage them to prefer to play as a team rather than alone?

- **Group Membership**

Students have an almost unanimous need to belong to a group. To be respected, even more than loved, and that it is for their personality at the same level as for their knowledge.

- How might we take advantage of their need to belong to a group so that they acquired knowledge through the game?

- **Classmates**

A good atmosphere is perceived in the classrooms, with companionship. The institute is a place to make friends.

- How could we make a good atmosphere, a place to share with friends during the course of the game?

On the other hand, the surveys also helped the generation of triggers, which were the basis of design attributes. These triggers will help to choose the game elements that will be aligned with the insights and resolve the statements raised. Some examples of triggers are:

- **Collaborative**

Boost collaboration instead of competition so they understand the benefits of working in teams

- **Feedback**

Implement a feedback system that makes them understand the value of dialogue.

- **Experiential**

Plan case studies that will have to be resolved. The theory will be implicit and will serve as an accompaniment.

The objective of the game (Fig. 4) is to understand the entire process of logistics, from the acquisition of raw materials, to the recycling of waste, through storage, transport, transformation and delivery to the customer. The game emphasizes important issues such as hiring people and services 4.0.

The goal of the game is to have the best logistics service in Catalonia. For this, the best distribution chain has to be achieved, which includes warehouses, factories, trucks, hiring of the best qualified personnel and the best strategy for purchasing raw materials and customer service, as well as the best waste management.

In turn, players must receive orders from different parts of Catalonia, which vary in delivery times. They must buy the raw materials needed to manu-

facture the products, pay for them according to the supply and demand at the time, take them to the factories, transform them into orders, take the orders to the corresponding population and finally take the waste to the recycling plants. To optimize performance, students must select the appropriate staff, computer services and transportation fleet to complete each part of the process.

The player who completes a series of orders or has the most complete distribution chain in a given time wins the game. The game consists of a series of game elements (Fig. 4) such as the map of Catalonia, with a limited number of populations and their connections. There are several player cards with the type and quantity of raw material, the processed materials that can be stored and with the description and prices of materials and products that they possess. There is also a fleet of trucks, trains and boats. In addition, 6, 10 and 12 sided dice are used to obtain customer order details.

Although the game can be played individually, in the playtest it has been observed that the level of engagement is much higher when students play with a partner, in addition to further enhancing one of the main objectives of the game, teamwork. The game requires constant decision making and search strategies which force the pairs of players to negotiate the best decisions in order to achieve the objectives.

While players need to collaborate with team members to win the game, teamwork is also encouraged among other players:

- In the phase that the customers place orders, orders which one player choose not to accept can be picked up by other players.
- The negotiation phase of supply and demand is executed by system, not between players, yet it requires their consensus to ensure that they buy everything that is foreseen for each of the orders they have taken on, so the price per unit of raw material may be higher. Students are also able to make the purchase in another shift, which means that they will have to complete the order later.
- When goods have to be distributed to places far away from a player's factories, they can negotiate transportation with another player.
- Consolidation centers between several players can be created to enable players to store joint merchandise provisionally before its final delivery to customers. This process requires negotiating the percentage that each one contributes and therefore the capacity of use.
- Leaving waste without recycling has a negative impact not only on the player who does it, but also on all other players. They can collaborate in the transportation of waste to the recycling plants.

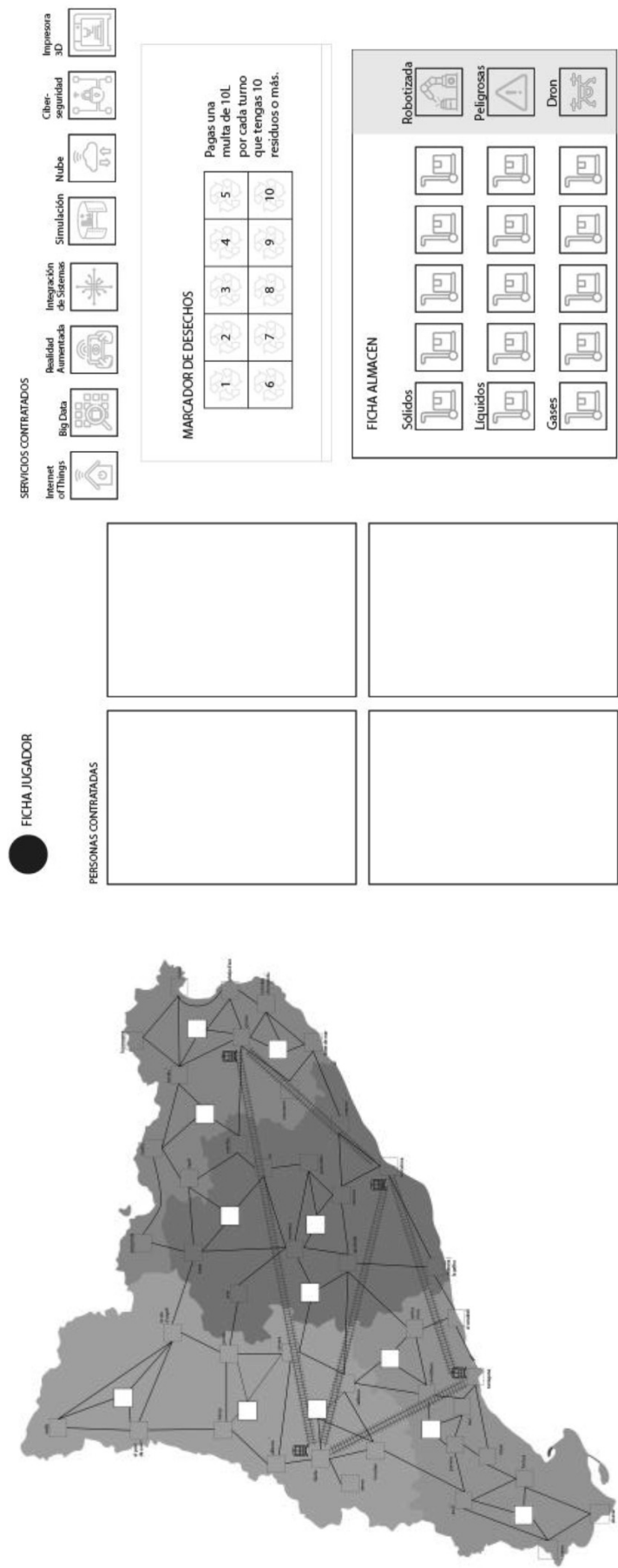


Fig. 4. Examples of the material used during the game: Map of Catalonia, card with 4.0 technologies that can be used and player card with all the elements to manage.

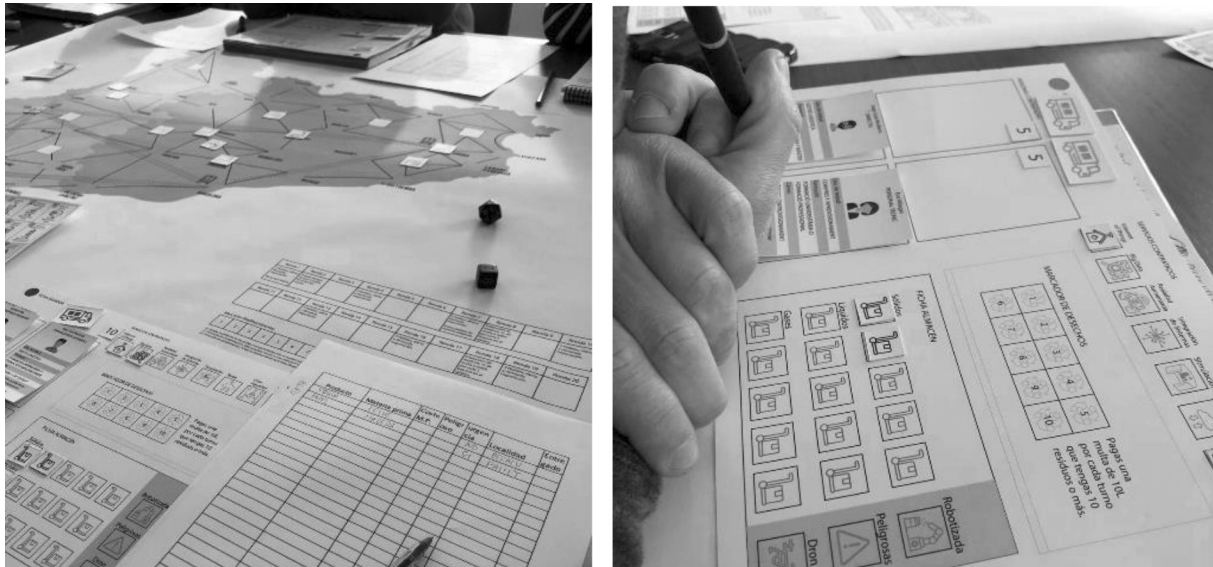


Fig. 5. Images of the playtest with stakeholders.

This logistics game is designed so that there is a high interaction between the players that control a logistics line and the other players so that they better understand the complexity of logistics and how teamwork facilitates the achievement of objectives.

### 2.2.1 Playtest with Stakeholders

After the design of the game, a playtest was made with the stakeholders of the project, people from the town hall that had made the assignment, logistics teachers and monitors from the schools that will be responsible for energizing the game in class. During the playtest (Fig. 5) both the rules of the game and the way in which the game should be applied in the classroom were explained, telling how each module is designed to understand a part of the logistics process, so that everything can be explained the set to know the complete process or any of the parts to deepen it.

After the playtest, the surveys were delivered to the stakeholders (N = 7). The surveys chosen were those that could give data comparable to those of the students, that is, the Pocket BLA interview and the emotional value survey. The other surveys referred to students' personal aspects, so they served to create the game, but not for later evaluation.

Table 3. Positive common elements of the stakeholders

Common positive elements		
Element	Mention index	Average score (out of 10)
Teamwork	71.4%	8.2
Degrees of difficulty	71.4%	9.2
Relationship with the objectives	57.1%	8.8

Regarding their ratings in the Pocket BLA survey, as positive (Table 3), more than 71% of them mentioned the great work done by the game in favor of teamwork. The rating was 8.2 out of 10. Another aspect that the students appeared to like was that the game has different degrees of difficulty, which means that it can easily adapt to different educational levels. The third most mentioned item, at 57.1% was that the game meets the objectives set, such as the acquisition of knowledge about logistics and the practice of skills such as teamwork, communication and negotiation.

Regarding the ratings of the aspects to improve, the most common complaints (Table 4) have been that the beginning of the game is complicated, since there are many logistics and game mechanics to understand. This also links to the second most mentioned item, which is the excessive duration of the game. Both elements are a consequence of the fact that the curriculum that was to be implemented was very broad and complex, and this had to be reflected in the game. It can be observed that although they are considered negative elements, their score is 5 out of 10, which implies that they are not considered as very serious.

Table 4. Common elements of improvement of the stakeholders

Common negative elements		
Element	Mention index	Average score (out of 10)
Complicated onboard	57.1%	5.0
Give more importance to hiring people	28.6%	6.0
Difficulty in establishing strategy	28.6%	3.5
Excessive game duration	57.1%	5.5

**Table 5.** Common positive elements of the Pocket BLA survey of students after the playtest of the game

Common positive elements		
Element	Mention index	Average score (out of 10)
Learn logistics	50.0%	9.1
It's fun	50.0%	8.4
Teamwork	31.3%	9.2
The materials used	18.8%	8.7
Makes you think	18.8%	8.3
It's hard	12.5%	9.0

**Table 6.** Common negative elements of the Pocket BLA survey of students after the playtest of the game

Common negative elements		
Element	Mention index	Average score (out of 10)
It is a slow game	81.3%	4.3
Hard to understand until you get it	18.8%	6.0
Not having finished the game	12.5%	4.5
Being paper is messy	12.5%	3.5

### 2.2.2 Playtest with Students

Once the teachers had become familiar with the game and its educational possibilities, a playtest was scheduled with real students. As in the previous case, after the playtest, the Pocket BLA survey and the emotional value survey were given to the students ( $N = 16$ ) to know their opinions and perceptions about the game.

The most important common positive elements are shown in Table 5.

As for the common negative elements of the students, except in a specific element, there was not as much consensus as in the positive ones (Table 6). The students named quite different ele-

ments as improvable, so the table of common negative elements has lower mention values. Except for one, the points to improve the game do not have a great impact.

## 3. Discussion

With the FED methodology, there is a real record of the needs and motivations of users beyond subjective or biased perceptions. The methodology adapts its tools to the needs of each environment and to the accessibility of its users. In addition, it enables us to obtain quantitative and qualitative data in all phases of the implementation of the system, from before the design begins until after it has been used. These data serve both to create a more successful system and to monitor its validity and make adjustments if necessary.

It can be affirmed that, in general, the stakeholders liked the board game as much as the students, although their perception of certain aspects such as the content may be quite different and therefore difficult to compare. However, although they perceive it as complex and not very fun, students do not think like them and although they see it as complex, they find it fun, interesting and generate confidence.

Pocket BLA surveys show the different perceptions that stakeholders and students have regarding the board game on logistics. Regarding the emotional assessment that was carried out by stakeholders and students, as shown in table 7, the students' perceptions of their studies in general are quite low. The highest value is 63.1% and corresponds to the importance of the subject content. Students rely relatively on the content of the subjects they study. At this point, all values fall, highlighting the fact that they are considered as fun (31.6%) complex, (39.5%) conventional (41.7%), unattractive (41.8%) and boring (50.5%) On the

**Table 7.** Results of emotional value surveys during the Case Study of the board game on logistics

Emotional Assessment Questionnaire	Content confidence / Distrust	High quality / Low quality	Useful for the studies / Not useful	Interesting / boring	Family / Unknown	Comfortable / uncomfortable	Attractive / Unattractive	Innovative / Conventional	Simple / Complex	Next / Far	Funny / not funny
Students about their studies in general	63.1%	60.6%	59.9%	50.5%	59.1%	54.7%	41.8%	41.7%	46.7%	52.3%	31.6%
Stakeholders about the board game	62.0%	76.8%	78.6%	94.6%	89.3%	78.6%	76.8%	87.5%	44.6%	73.2%	50.4%
Students about the board game	81.3%	79.5%	78.1%	85.9%	57.8%	70.3%	66.3%	73.4%	39.5%	60.9%	78.1%



other hand, his perception of the board game is totally opposite, almost all parameters are quite high, highlighting that they consider it interesting (85.9%), with an important subject content (81.3%), high quality (79.5%), and that it is fun and useful, both with (78.1%). On the contrary, they find it complex (39.5%) and not very intuitive (57.8%).

In general, it can be said that the game can become a very powerful learning instrument as it motivates students more than their usual learning methods. Using board games for education is increasingly common given its relative low production cost (compared to other systems such as a video game) and the high motivation it causes [32–34].

This experience has also enabled us to affirm that there are several criticisms of gamification. Even after having successfully completed two implementations (taking into account the previous application of the FED), there are several considerations that must be taken into account when you want to gamify a system. The main criticism is the difficulty of measuring the results in most gamified systems, either because this need has not been taken into account, or because no measurement mode has been designed, due to ignorance or negligence. This aspect is of particular interest in the FED methodology, which provides techniques and tools so that it does not happen.

Another criticism that is often made is whether the acceptance of gamification, both by the client and by the user, is based on the attractiveness of the fun layer, detracting from the utility for which it has been developed. This implies a double damage: loss of the original sense of applying gamification and discredit of gamification, which can be considered as a simple game that distracts users from their main task in the best case [35, 36], or as a poisoned apple, or, as it is popularly known, a chocolate-covered broccoli [37, 38], in which users end up performing tasks – which they would not do willingly – in order to obtain the promised rewards, real or virtual, or under the constraint of social pressure. For this reason, it is very important to introduce users to the design process so that value is really being added to their needs, and not only to those of the client.

#### 4. Conclusions

Two objectives are covered in this work:

- The promotion of teamwork, which is carried out in two layers. On the one hand, the actions required to exchange information to achieve a gamified teamwork system between an engineering school, a public administration and a net-

work/group of schools. On the other, the project itself, which encourages teamwork among engineering students.

- The validation of the FED methodology as a means to determine the motivations and needs of engineering students in the design of a new learning strategy.

So, the contributions that are made from this research are:

- *Show how the game is a suitable means to encourage professional vocations in engineering logistics.* The serious game that has been tested has been defined by the professors and facilitators of the game as a useful tool that can be of great help when it comes to helping students find out about the logistics discipline and therefore, they can consider doing these studies.
- *The game helps to acquire hard and soft skills.* It has been demonstrated with qualitative data how stakeholders and students perceive that the game helps them to acquire knowledge about logistics and to work soft skills such as teamwork, an element that they spontaneously manifest.
- *Show the teachers' interest in innovative tools.* The playtest with the teachers showed that they are in favor of using innovative tools such as in this case the use of a serious game to teach both hard skills (knowledge) and soft skills (abilities), especially teamwork.
- *Underline the importance of having user data before beginning to design a gamified strategy.* Without the data that was collected from the students through the surveys on the previous course to establish the gamification, the only data that would have been those of the marks of the practical works. In order to apply a suitable gamified strategy, it is necessary to know the users, their motivations and their needs, in accordance with the data that observation allows, given its obvious limitations.

The use of board games has proved to be a useful tool when it comes to achieving objectives of both knowledge acquisition and social skills and abilities. The game proposed to the Santa Perpètua City Council could become a very appropriate instrument to achieve its objectives. The next steps to take are:

- Playtest with students. Two playtests are planned with students who will have two objectives. On the one hand observe the reactions of students and understand how useful the game really is and on the other hand see how teachers develop using the game tool in the classroom. For both parties it is a challenge that must be documented.
- Post-game use surveys. Once the game has been

tested, surveys will be conducted on the students to know firsthand their perceptions about the game, so that their effectiveness can be evaluated.

- Redesign the game. With the results of the surveys will be able to assess the game and see what elements have worked and which have to be

redesigned to have a product tailored to the needs of users.

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