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# Design, Implementation and Evaluation of a Gamified Digital Cultural Probe in the Context of Energy Consumption

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## Thanks

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## Abstract

Cultural Probes (CP) is a HCI technique used to gather data about people (feelings, thoughts, interactions, knowledge, etc) in order to inspire the design of applications. It consists in giving participants a series of tasks to perform, which they return after some time so the information can be analyzed by the design team. This project proposes the design and implementation (as a mobile application) of a gamified Cultural Probe in the context of energy consumption. Given that one of the drawbacks of CP is the low completion rate and, therefore, the lack of data gathered, the use of gamification is believed to enhance the participation of users by motivating them to complete the tasks. The particular approach of this CP is that participants not only provide data about themselves, but also about other people. Specifically, it is designed to be completed by children, who have to perform four different tasks taking the role of a psychologist, a detective, an electrician and a journalist (depending on what the task is about) to gather information about their own and also their families' electric consumption. Additionally, the realization of the CP might raise awareness on them about energy and environmental related issues. After the implementation of the proposed design as an Android app, the CP has been evaluated with children from two primary schools in Barcelona, who have interacted with two different versions (gamified and non gamified) of the app, to test the hypothesis that gamified Cultural Probes may show better results than non gamified ones. Even though the evaluation showed slightly better results for the non gamified CP, the difference is not statistically significant, opening a door to do more research on the subject.

## Resum

Les Cultural Probes (CP) són una tècnica HCI utilitzada per a recopilar dades sobre les persones (sentiments, pensaments, interaccions, coneixements, etc.) amb l'objectiu d'obtenir inspiració per el disseny d'aplicacions. Consisteix en donar als participants una sèrie de tasques a realitzar, les quals tornen després d'algun temps perquè la informació pugui ser analitzada per l'equip de disseny. Aquest projecte proposa el disseny i implementació (en una aplicació mòbil) d'una Cultural Probe gamificada en el context del consum energètic. Donat que un dels inconvenients de les CP és el baix percentatge de terminació i, per tant, la falta de dades obtingudes, es creu que l'ús de la gamificació és una forma de millorar la participació dels usuaris motivant-los a completar les diferents tasques. L'enfocament particular d'aquesta CP és que els participants no només proporcionen dades sobre si mateixos, sinó també sobre altres persones. Específicament, està dissenyada per a ser completada per nens, que han de realitzar quatre tasques diferents prenent els papers de psicòleg, detectiu, electricista i periodista (depenent de què tracti la tasca) per recopilar informació sobre el seu consum elèctric i el de les seves famílies. A més, la realització de la CP podria augmentar la seva consciència sobre temes relacionats amb l'energia i el medi ambient. Després de la implementació del disseny proposat com una aplicació per a Android, la CP ha estat avaluada amb nens de dues escoles primàries de Barcelona, que han interactuat amb dues versions diferents (gamificada i no gamificada) de l'aplicació, per provar la hipòtesi que les Cultural Probes gamificades podrien mostrar millors resultats que les no gamificades. Tot i que l'avaluació va presentar resultats lleugerament millors per a la CP no gamificada, la diferència no és estadísticament significativa, fet que obre una porta a investigar més sobre el tema.

## Resumen

Las Cultural Probes (CP) son una técnica HCI utilizada para recopilar datos sobre las personas (sentimientos, pensamientos, interacciones, conocimientos, etc) con el objetivo de obtener inspiración para el diseño de aplicaciones. Consiste en dar a los participantes una serie de tareas que realizar, las cuáles devuelven después de algún tiempo para que la información pueda ser analizada por el equipo de diseño. Este proyecto propone el diseño e implementación (en una aplicación móvil) de una Cultural Probe gamificada en el contexto del consumo de energía. Dado que uno de los inconvenientes de las CP es el bajo porcentaje de terminación y, por tanto, la falta de datos obtenidos, se cree que el uso de la gamificación es una forma de mejorar la participación de los usuarios motivándolos a completar las diferentes tareas. El enfoque particular de esta CP es que los participantes no sólo proporcionan datos sobre sí mismos, sino también sobre otras personas. Específicamente, está diseñada para ser completada por niños, que tienen que realizar cuatro tareas diferentes tomando los papeles de psicólogo, detective, electricista y periodista (dependiendo de qué trate la tarea) para recopilar información sobre su consumo eléctrico y el de sus familias. Además, la realización de la CP podría aumentar su conciencia sobre temas relacionados con la energía y el medio ambiente. Después de la implementación del diseño propuesto como una aplicación para Android, la CP ha sido evaluada con niños de dos escuelas primarias de Barcelona, que han interactuado con dos versiones diferentes (gamificada y no gamificada) de la aplicación, para probar la hipótesis de que las Cultural Probes gamificadas podrían mostrar mejores resultados que las no gamificadas. A pesar de que la evaluación presentó resultados ligeramente mejores para la CP no gamificada, la diferencia no es estadísticamente significativa, lo cual abre una puerta a investigar más sobre el tema.

# Content

## Figures and Tables

# 1. Introduction

Throughout the university years I had to develop countless assignments related to the subjects studied, but only one of them has led to a major venture, this final degree project: the assignment we did in teams during the course of *Factors Humans i Computació* (FHiC), subject related to the HCI (Human Computer Interaction) field. The main goal was to design a user-centered website related to energy consumption and the SmartGrid[1]. This website would inform users about their use of electricity and give them useful recommendations and tips to change habits, save energy and make a responsible use of it.

The user-centered methodology consists in going iteratively through three phases in software development: Analysis (A), Prototyping (P) and Evaluation (E). First iteration was fulfilled in the FHiC project (A1, P1 and E1 phases of *Figure 1.2*). The web, named "Control Consum" (see *Figure 1.1*), was designed, implemented and tested (only the front-end and basic functionalities) with some users. Specifically, the first step in the development was users' analysis, which consists in knowing the users (their needs and their values). In this step we followed different techniques of users' analysis studied in the course: semi structured interviews, questionnaires, direct observations while navigating on similar websites, etc.



*Figure 1.1. Main page of the web developed in FHiC*
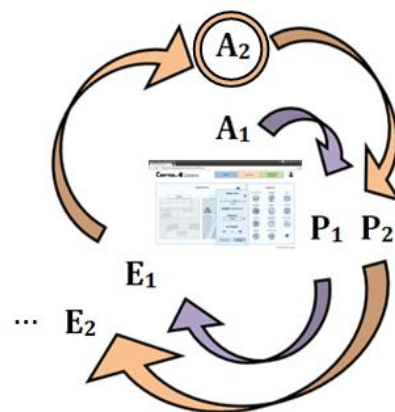


*Figure 1.2. Phases in iterative design (Analysis, Prototyping and Evaluation)*

Nevertheless, the use of these techniques to get insight and analyze users properly was not an easy task. First, both time and number of available users devoted to task was limited due to being a curricular project. Second, their answers or behaviors could be conditioned by the fact that they personally knew the interviewers. Additionally, as they were being observed, they could feel tension and pressure while interacting with the website.

Since those techniques can result intrusive, we proposed the use of a methodology for users' analysis called Cultural Probes (CP), which is useful to inform and inspire applications design. This technique would allow us to sympathize more with the users, given that they can complete the proposed tasks at their own pace and from their own homes. Consequently, we would be able to collect and analyze more interesting data about their families in relation to energy habits and consumption. The paper about this proposal was sent to the womENcourage 2016 ACM conference.

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[1] The SmartGrid is a technology-based electricity network that is used to supply electricity to prosumers (producers & consumers) using a two-way digital communication between the utility and them.

Cultural Probes technique was originally conceived as a package with artifacts (camera, diary) and tasks, which was given to participants to record events, feelings and interactions (see *Figure1.3*). Afterwards, CP were also deployed as mobile applications.



*Figure 1.3. Classical Cultural Probes package with
tasks and elements to perform them*

However, and whatever form they take, CP rely on participants being responsible and remembering to complete tasks at the assigned time and as instructed, which results on one of the drawbacks of Cultural Probes: the lack of participation of users, sometimes returning back the CP almost empty. It is in this context that the main hypothesis of this research is placed: gamification (the use of game elements in non-game contexts) of Cultural Probes may encourage a more active and fruitful participation of users. In order to test this hypothesis, a non gamified version of the CP is also developed to compare results.

This project aims to design, develop and evaluate a digital CP (as a mobile application) to inform the redesign of the "Control Consum" website. The development and evaluation of the CP app situates in the $A_2$ phase of the iterative design depicted in *Figure 1.2*. Our CP is different from other contributions in the state of the art so far because of the concepts: "who the package is for" and "whose information we obtain", and because it promotes the use of gamification and automatic data gathering, via database management, in user study methods, an approach that does not count with remarkable documentation written about. Specifically, our proposal involves giving the CP to the children, who are responsible to perform the indicated tasks and, through them, obtain information about them and, also, about their families. The focus is on children because Cultural Probes require time and interest from the user and they tend to have more free time and are more interested in this kind of dynamic activities than adults.

Participants of the digital CP have to develop tasks to provide us with information about families' habits of energy consumption, and their knowledge and interest in energy related issues. The use of a narrative, in the gamified version of the CP, aims to engage the participant in a mission to fight an evil wizard, where they get rewards every time they complete a task and, to add even more motivation, they compete with other children to win a final prize (being able to see each other's scores on a leaderboard).

Both versions of the digital CP consist in an Android application in 2D, developed using a powerful game engine: Unity. The database management has been done through *bplaced* [1], an online database host, using MySQL and PHP.

This report continues with the main goals of this project and the related work. Later on, the design phase of the CP tasks and the gamification are detailed, as well as the implementation as a mobile application and the final user evaluation with the obtained results. For each phase, methodologies and technologies used are briefly introduced. Finally, this report ends with conclusions and future work with some ideas to continue and improve the project.

Additionally, there are three appendixes. The first one includes the evaluation material, and the other two are the technical manual and the user manual, which include important information to who they are addressed to (developers and participants/players, respectively).

## 2. Goals

The main goals of this project are the following:

- Extend the design of our previous proposal of a Cultural Probe [2] incorporating gamification and developing the mobile application:

    - Design the gamification of the Cultural Probe, meaning, which will be the game elements (mechanics, rewards, prize, etc) that will motivate the CP users. [3]

    - Design and implement the gamified digital CP (software application) that will facilitate the automation in the collection and analysis of data.

    - Design and implement the non gamified digital version of the CP, which will allow the later comparison and study.

- Evaluate the deployed CP with real users:

    - Recruit users to carry out the CP (gamified and non-gamified) and follow their progress during its duration. Permission to participate will be required and personal data will be protected following university's ethical code.

    - Assess whether or not the gamification of CP provides better results in terms of users' involvement and, consequently, in terms of number of tasks completed.

    - Get valuable insight on families' energy related habits in order to inform the design of an application that provides family members with detailed information about their use of electricity and give them useful recommendations to change their bad habits.

    - Analyze the collected data and draw conclusions for a redesign of the proposal made in the first iteration of the development (*Figure 1.2*).

- Collaterally, try to raise awareness on energy and environmental issues, both on the kids and their relatives.

Besides the academic goals, there are also personal points to achieve:

- Do research and be able to segregate and use the correct information.

- Deepen on HCI methods such as UCD (User Centered Design) and Cultural Probes.

- Acquire knowledge about gamification techniques and design.

- Acquire knowledge about software libraries for multiplatform software development.

- Improve work planning and organization, and time and resources management.

- Be able to work in collaboration (team work).

- Apply knowledge acquired throughout the Computer Engineering's degree.

## 3. Related work

In the past years, the number of projects related to smart energy has increased [4] [5]. In this context, and in order to raise users' awareness, other projects have used gamification to influence and shape their behavior (see *Figure 3.1*) [6] [7]. Also, even energy companies have developed gamified applications to engage and motivate their customers in order to save energy.

However, in the context of energy consumption and lifestyle, designing platforms and using gamification on them in a deep level (not only using PBL – Points, Badges and Leaderboards –) is not easy since designers need to get into the emotional side of users and their habits. That is why we propose Cultural Probes to get valuable and meaningful insight on users.

Since their proposal [8], CP have been used in many projects in order to obtain information about the user's behavior. Its classical approach consists in giving a package to each participant in the study, get tasks done in return after some time and obtain valuable data about the participant, meaning, it is the same subject the one in charge of performing CP tasks and the one that designers want to collect data about. Our proposal differs from this classical approach as we give the CP to children in order to get data not only from them, but also from those they live with or are close to.



*Figure 3.1. Example of some Enerbyte's app screens*

Research using CP with children has already been conducted following the classical approach [9] [10], and as digital CP involving the use of mobile phones, where the device was used for taking photos and recording audio clips [11].

The idea is to combine previous approaches and take full advantage of mobile apps and gamification to foster the participation of children in the energy related CP.

# 4. Design

## 4.1. Cultural Probe Tasks

As explained in previous sections, Cultural Probes consist in, independently of its form (analog or digital), giving participants a series of tasks and the necessary elements to perform them, tasks that are used to obtain data about them.

Participants of this CP are voluntary children between 10 and 12 years old who receive a digital CP (mobile app). To participate, a consent form (see *Appendix A.1*) must be signed by their parents, who will be informed about data anonymity and the use of said data only for research purposes.

Below, there is a description of the CP tasks the participants are asked to perform and the main objective of each one of them. These tasks are the same for the gamified version and the non gamified one of the CP:

- Become a psychologist: *"Analyze your family. Your task is to ask the members of your family (including yourself) which electrical appliances they use the most and how they feel when using them."*

  Through this task, emotional information of participants and their family is obtained to guide us on the design of how to influence the change of habits. Depending on the mood while using an appliance, tips (or the way they are given) to save energy through that appliance can be more or less effective. For example, influencing a change in the use of some appliances can be easier if people feels negative about them, and it would be necessary to explore other less or non electric alternatives to the use those appliances that they feel positive about.

- Become a detective: *"Investigate your family. Your task is to observe each member of your family (including yourself) to indicate which energy related behaviors they carry out (from a predefined list) and how good they are."*

  Through this task, the recollected data is about the habits of electricity usage and energy saving of participants and their relatives. That information can provide knowledge about how much they care for the environment and energy saving, and if they know what actions are good or bad for those matters (thanks to an open question that allows the kids to explain why they think that their relative's behavior is good or bad, and if they observed some other interesting behaviors that are not on the proposed list). For example, if they have a responsible behavior, it could be interesting to prize it and try to maintain it. Also, it is possible to establish a correlation between the mood they expressed to feel while using an appliance on previous CP task and the correctness (bad or good) of that appliance's usage, which complements information gathered on previous task.

  Collaterally to data gathering, this task may raise children awareness on energy saving and its environmental impact, as the children may reflect about their own behaviors and learn which are more correct than others. Moreover, they can share what they observed with their relatives, influencing a change on them at the same time.

- Become an electrician: *"Build your house plan. Your task is to indicate the electrical appliances you have in each room of your house and, afterwards, indicate their usage frequency on labor days and weekend days."*

Thanks to this task it is possible to learn about the electrical appliances owned by families, their distribution and frequency of use. This helps to obtain data about family's habits as a whole, instead of individually, which complements the information extracted on the previous CP tasks. Moreover, it can help make children aware of the usage of energy at their homes, so when they answer an open question at the end of this task, they can think over it and identify a possible excess of electricity use.

- Become a journalist: *"Interview your family. Your task is to ask a series of questions related to energy issues to the members of your family (including yourself) and mark their answers."*

This task can be used to gather data about families' needs of information about their use of electric energy, their preferences and their predisposition to change habits. Also, it helps to obtain information about what knowledge members of the family have about energy consumption, the Smart Grid and green behavior.

For a summed up version of the tasks described above, see *Table 4.1*.

| TASK | DESCRIPTION | ELEMENTS | GOALS |
|---|---|---|---|
| **Psychologist** | Ask family members which electrical appliances they use the most and how they feel when using them | ▪ List of family members<br>▪ List of electrical appliances<br>▪ List of moods | ▪ Get users' emotional information to influence habit changes |
| **Detective** | Observe family members to indicate their energy related behaviors and how good they are | ▪ List of family members<br>▪ List of behaviors<br>▪ Open question | ▪ Get users' energy related habits and behaviors<br>▪ Know users' compromise with environment and saving<br>▪ Raise awareness |
| **Electrician** | Indicate the electrical appliances in each room of the house and specify their usage frequency on labor days and weekend days | ▪ List of house's rooms<br>▪ List of electrical appliances<br>▪ Frequencies rank<br>▪ Open question | ▪ Know users' frequency of use of electrical appliances<br>▪ Get usage habits from families as a whole<br>▪ Raise awareness |
| **Journalist** | Ask energy related questions to family members and mark their answers | ▪ List of family members<br>▪ Closed questions<br>▪ Multiple choice answers | ▪ Get users' knowledge, needs and preferences of energy related information<br>▪ Know users' predisposition to changes |

*Table 4.1. Summary of the CP tasks, the elements provided to perform them and their goals*

Next section describes the gamification process of these CP tasks in order to encourage and engage its participants into completing them.

## 4.2. Gamification

Gamification is the use of game elements in non-game contexts to motivate and influence user behavior [12]. It has been used in different contexts, such as tourism or sustainability, to engage users in fun and motivating experiences. The success of gamification greatly depends on the context where the gamification is applied, on the final users, and mainly on the design of the gamification, being necessary to define clear objectives and follow well defined steps [13].

Below, the common steps for gamification are briefly described:

1. **Define objectives and target behaviors:** state why using gamification, the behaviors to influence, and what are the benefits that the gamification provides to the system.

2. **Describe the players:** know the potential players, their needs, goals and what they find enjoyable and appealing.

3. **Devise fun activity loops:** define the game elements and mechanics (not only external rewards, but also those related to intrinsic motivation) that will be used to engage the players.

4. **Deploy, play-test:** test the gamification with users in a real environment to refine details of gamification mechanics.

5. **Evaluate the effectiveness of the gamification:** collect and analyze data to track user activity and measure the degree of achievement of the goals defined in the first step.

The main issue when it comes to gamification is the need to decompose the design into steps and different elements for a better guidance. That is why, for this project, GMC (Gamification Model Canvas) [14] is used to guide the process (see *Figure 4.1*).
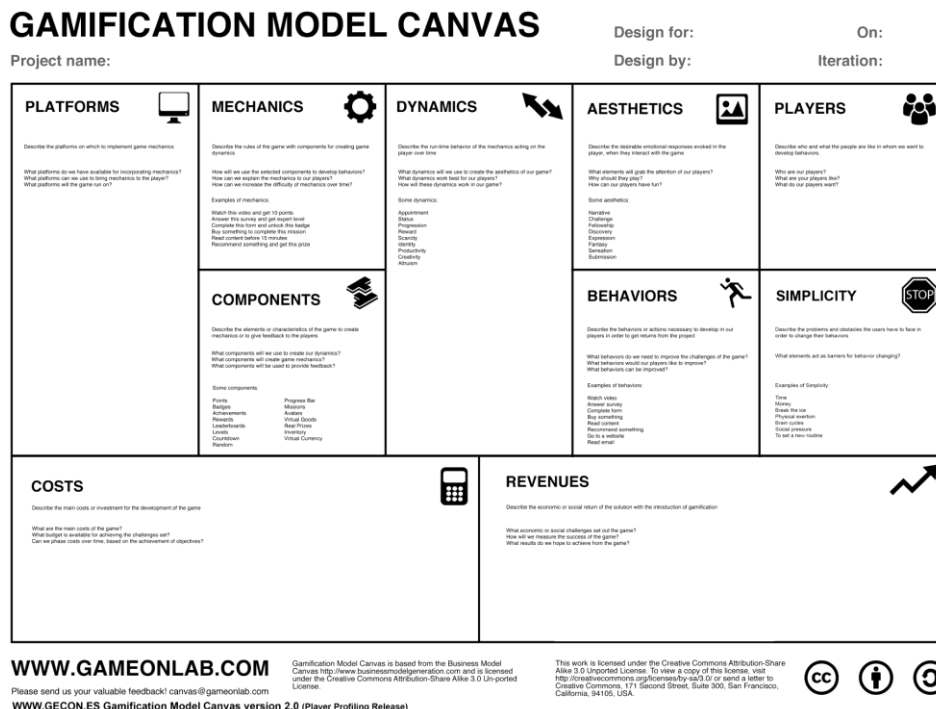


*Figure 4.1. Gamification Model Canvas*

The GMC is a gamification design framework that follows a methodology based on Playful Design and Design Thinking, so it is useful to generate proposals of gamification for diverse types of projects (related to business, education, events, etc).

Below, the gamification design is specified and detailed referring to the nine elements proposed by this framework:

- <u>Revenues</u>: *Economic or social return of the solution with the introduction of gamification.*

    The main goal to achieve with the gamification of the CP is that children complete an elevated number of CP tasks by incrementing the participation and motivation, therefore, be able to obtain as much information as possible.

- <u>Players</u>: *Who and what the people are like in whom we want to develop behaviors.*

    In this case, players are participants of the CP. They are children from 10 to 12 years old, who might be considered as newbies in relation to using a digital Cultural Probe for the first time and masters in relation to playing in gamified experiences. As proposed by the GMC framework, their corresponding player types could be self seekers, consumers, exploiters, killers, explorers, achievers and socializers (types mainly driven by extrinsic motivations but also need some meaningful incentives) [15]. Moreover, they are voluntary kids interested and excited to perform this kind of activity.

- <u>Simplicity</u>: *Problems and obstacles the users have to face in order to change their behaviors*.

    It should be critical to effectively engage children in the very beginning of the CP (break the ice) given that kids could not have much free time due to both curricular and extracurricular activities which can cause them to think that participating in the CP is a waste of time. That is why the experience needs to be appealing and well explained.

- <u>Behaviors</u>: *Actions necessary to develop in our players in order to get returns from the project.*

    Participants, from now on called players, have to develop a series of actions, which means to complete the tasks designed for the Cultural Probe (see *Table 4.1*), in order to get meaningful insight for this project's purpose.

- <u>Aesthetics</u>: *Desirable emotional responses evoked in the player, when they interact with the game.*

    Players are expected to feel that they are in charge and they are the ones responsible of finishing the CP tasks, so they should be challenged and motivated to explore the system and discover what it has to offer to them and what they can offer in return. Furthermore, their engagement could improve their family bonding (fellowship) achieving also children's discovery and awareness in the energy context (behaviors, usage, etc) as a family.

    In order to grab the kids attention from the beginning, this proposal includes to use a narrative, that is, a story to get them into character and motivate them to complete the gamified CP tasks, which is one of the main game mechanics agreed in the literature [16] [17].

The main aspects of the narrative are the following:

- **A hero:** the CP player. Players are told to have been selected from the Energy Protectors' Special Agency to become part of a very important operation to save people enchanted by an evil spell. To do so, they will perform a series of missions in different disguises (taking several roles) to infiltrate and obtain information about their families, while they might as well raise awareness about the energy issue on them.

- **A villain:** an evil wizard who has cast a spell on the population. The spell is a curse that makes people waste energy like crazy, provoking them to lose all their energy related knowledge, to have an irresponsible behavior towards environment and to make an excessive use of electrical appliances. The wizard absorbs all the wasted energy to get stronger, and the only way to stop him is to counteract his negative influences with an antidote.

- **A mission:** to obtain relevant information about energy related knowledge and behaviors from people who are not affected by the spell (players' families), to help the agency make an antidote for the curse and defeat the wizard by recovering all the wasted energy (kWh) he absorbed.

- Dynamics: *Run-time behavior of the mechanics acting on the player over time.*

  - **To visualize the progress.** In order to give feedback to players through the CP completion and enhance the feeling of advance in the narrative towards the goal, they are able to see their progression. The existence of a final goal (defeat the wizard) and the visualization of the progress (how far is the end) both engage the user to finish the tasks to achieve that end. It would not happen in a scenario without a final objective, so it is safe to say that this dynamic is very important in order to structure the process in the users' mind and motivate them.

  - **To enhance the identity.** Players can identify themselves in the CP through the owning of an avatar of their choice. Being able to have a character representation generates a user's identity projection to it, creating or increasing an emotional link to the avatar. This helps to keep the user connected to the gamified system.

  - **To compete.** Players are able to see their status in relation to the rest of players. In line with the above classification on player type, a dynamic that allows status visualization, compared to others, will especially motivate the killer players.

  - **To win a reward.** Everybody likes to win a prize (extrinsic motivation) or acquire that social identity or status linked to the prize. Again, being able to win rewards, every time an effort (action) with a positive effect is carried out, is an element that increases the motivation of the players and keeps their attention focused on the goal.

- Components: *Elements or characteristics of the game to create mechanics or to give feedback to the players.*

  - **Missions**. The previously mentioned CP tasks correspond to the narrative's missions, where players have to take different roles depending on the mission they choose to perform. They allow players to achieve the main goal of the CP and interact with the system. The missions are: Psychologist's mission, Detective's mission, Electrician's mission and Journalist's mission.

  - **Points.** The progress system is based on points, specifically, the points are recovered kWh (energy) that were stolen by the wizard. The player receives them for each completed mission or part of it.

  - **Badges.** The player receives a specific medal for each mission to acknowledge they were fully completed in time.

  - **Countdown.** The CP itself has a limited duration, so a global countdown is a visible element. Moreover, and to facilitate participants' planning and ensure they remember to perform the tasks, all missions have a local countdown, so they need to be accomplished in time to get a badge and obtain a maximum number of kWh (points).

  - **Progress bar.** In order to give direct feedback to the players about their current status on the CP, there is a progress bar with indicating the energy (kWh) they recovered (their score) and the wizard's remaining energy.

  - **Leaderboard.** The possibility for players to see their score in a ranking compared with other participants' score is believed to increase their motivation by reaching their competitive spirit.

  - **Avatar.** A visual representation of the players within a community, through an image of their choice, helps to create a link between them and the CP. Also, they can identify themselves and their progress on the leaderboard.

  - **Physical prize.** At the end of the CP duration, children with the first positions in the ranking receive a real physical prize, which is an additional motivation to complete all the CP tasks and be more competitive.

- Mechanics: *Rules of the game with components for creating game dynamics.*

  The gamified CP consists of four main missions. The CP is considered done when all the missions are completed, but the "game" also ends if the duration of the CP is over: they have 8 days to complete it all. Players who recover more kWh from the wizard are the CP winners.

  The CP starts with an introduction to the story where players begin in the role of a special agent. After that, players have to register into the CP by indicating 3 members of their family (who live with them or they see frequently) and themselves, choosing an avatar that represents them. The evil wizard starts the story with 1.000.000 stolen kWh that players (with 0 kWh) have to recover as an agent.

To do so, players are assigned a set of 4 missions, implicating to disguise as different characters. Each one needs to be accepted in order to begin the countdown: once the mission is accepted, it has to be completed before 2 days to obtain the maximum reward and the correspondent badge. Otherwise, players only receive the 60% of the points assigned to that subtask of the mission. Missions can be completed in any order and there can be overlapping between them: more than one mission can be accepted at the same time, which lets players do the subtasks alternatively. Giving them freedom to explore it all and not attach them to a strict sequential order is believed to get better results.

The missions and their specific mechanics are specified next:

- **Psychologist's mission.** In this mission, children play the role of a psychologist and their task is to analyze their family by asking them which electrical appliances they use the most and their mood while using them. To complete the mission they have to indicate 5 combinations (appliance – mood) for each family member, for which they obtain 40.000 kWh (points) and, if it is completed in time, they receive a badge consisting in a psychologist's diploma. The whole mission is worth 120.000 kWh.

- **Detective's mission.** In this mission, kids take the role of a detective and their task is to investigate their family and observe their energy related behavior and good it is. To complete the mission they have to indicate the behaviors of each family member, for which they obtain 60.000 kWh and, if it is completed in time, they gain a pair of detective's binoculars as a badge. The whole mission is worth 240.000 kWh.

- **Electrician's mission.** In this mission, children are asked to act as an electrician and their first task is to indicate the electrical appliances in each room of their house, for which they receive 80.000 kWh. After that, from the previously added appliances, they have to indicate their frequency of use on labor days (any day from Monday to Friday on average) and weekend days (any Saturday, Sunday or festivity). For each type of day completed they get 80.000 kWh more. To complete the mission they have to indicate the appliances and their usage frequency on both type of days and, if it is completed in time, they earn a badge picturing some electrician's tools. The entire mission is also worth 240.000 kWh.

- **Journalist's mission**. In this mission, players get in the role of a journalist and their task is to interview their family about energy related issues. To complete the mission they have to interview and indicate the answers of each family member, for which they are rewarded with 90.000 kWh and, if it is completed in time, they achieve a press accreditation as a badge. The entire mission is worth 360.000 kWh.

Once the duration of the CP is over (8 days), it ends. If the player completes all missions in time (therefore, they get the 4 missions' badges) they also obtain a special agent badge.

Moreover, if the whole CP is fully completed in less than 2 days, players get to recover 50.000 extra kWh. This is a surprise element that aims to reward the dedication and involvement of those who show more interest and urge to participate, putting them on the top of the ranking.

- ▪ Platforms: *Platforms on which to implement game mechanics.*

  The proposed CP is designed to be a digital application and work on mobile devices (phone or tablet) in Android system. This way, we can reach a wide public and the tracking and gathering of data can be done more efficiently.

This table below (see *Table 4.2*) sums up the key elements of the designed gamification according to the GMC steps:

| Players | ▪ Voluntary | ▪ 10 to 12 years old | ▪ In between newbies and masters |
|---|---|---|---|
| Simplicity | ▪ Break the ice | ▪ Time | |
| Behaviors | ▪ To complete the tasks | | |
| Aesthetics | ▪ Challenge | ▪ Discovery | ▪ Fellowship | ▪ Narrative |
| Dynamics | ▪ To visualize progress | ▪ To enhance the identity | ▪ To compete | ▪ To win a reward |
| Components | ▪ Missions | ▪ Points | ▪ Badges | ▪ Countdown |
| | ▪ Progress bar | ▪ Leaderboard | ▪ Avatar | ▪ Real prizes |

*Table 4.2. Summary of the gamification elements for each step of the GMC framework*

See *Table 4.3* below, which contains an abstract of the gamified CP mechanics:

| MISSION | TO COMPLETE | IN TIME (2 days) | | | OUT OF TIME |
|---|---|---|---|---|---|
| | | SUBTASK POINTS | TOTAL POINTS | BADGE | SUBTASK POINTS |
| Psychologist | 4 family members | 40.000 kWh | 160.000 kWh | Diploma | 24.000 kWh |
| Detective | 4 family members | 60.000 kWh | 240.000 kWh | Binoculars | 36.000 kWh |
| Electrician | House plan and 2 type of days | 80.000 kWh | 240.000 kWh | Tools | 48.000 kWh |
| Journalist | 4 family members | 90.000 kWh | 360.000 kWh | Accreditation | 54.000 kWh |
| TO COMPLETE CP (8 days) | | TOTAL POINTS | EXTRA POINTS (in 2 days) | BADGE (all missions in time) | |
| 4 missions | | 1.000.000 kWh | 50.000 kWh | Special Agent badge | |

*Table 4.3. Summary of the gamified CP mechanics*

All the game elements described in this section are not present on the non gamified version of the CP, which means some of the screens of the final app slightly differ (compare *Figure 5.3* with *Figure 5.23*, and *Figure 5.4* with *Figure 5.24* to see some of the differences).

## 4.3. Use Case diagram

This section shows the Use Case diagram for the gamified version of the Cultural Probe (depicted in *Figure 4.2)*. As can be seen, there are two actors in the system: the player and the database. Even though the CP app is not a game, participants are considered players in the following sections when talking about the gamified version, because they interact with game elements. As secondary actor, there is the database that stores all the relevant progress and data.

The non gamified app would present a simplified version of this diagram given that is more limited for not having gamification elements. Morever, the main actor would be considered as user or participant, not as player.
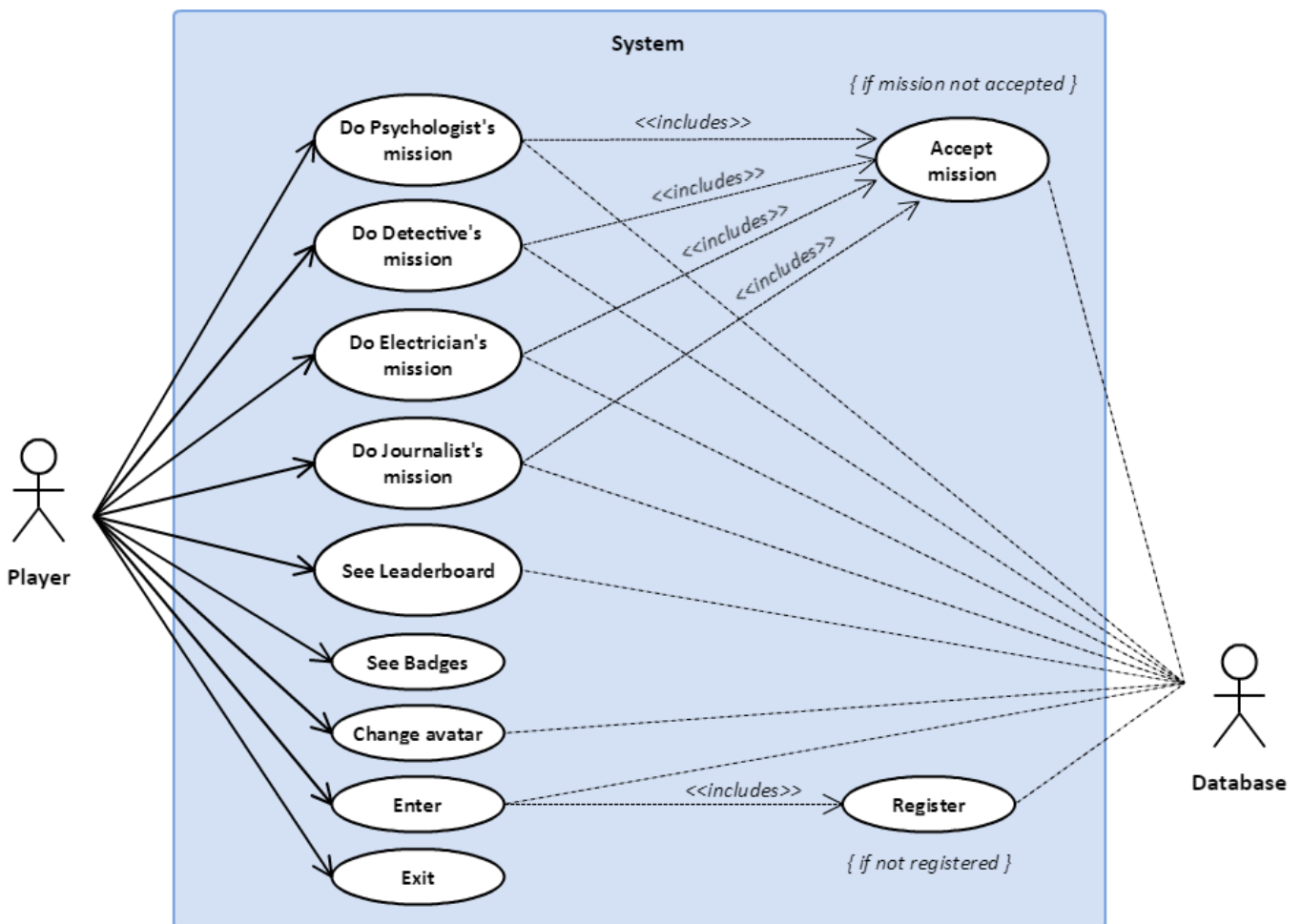


*Figure 4.2. Use Case Diagram of the gamified CP app*

## 4.4. Use Cases description

Next, there is a description for each Use Case shown in the diagram (for the gamified version of the digital Cultural Probe):

| Name | UC 1. Register |
|---|---|
| Actor | Player and database |
| Description | Player has to register into the app to be able to interact with it. |
| Preconditions | Player has entered the app for the first time. |
| Normal flow | 1. The system shows a screen with a brief explanation of what to do, some input fields to fill and 4 dropdowns.<br>2. The player indicates 3 members of his/her family and his/her gender by interacting with the dropdowns and introduces the members' names and an email address. Then, the player clicks the "Next" button.<br>3. The system shows a screen with a set of avatars and an input field.<br>4. The player chooses an avatar, introduces his/her name and clicks the "Next" button.<br>5. The system stores the player's registration information on the database and shows the dashboard screen. |
| Alternative flow | 2. If the email address doesn't exist in the database, a message is shown.<br>5. If the connection with the server fails, the app shuts down and nothing is saved. |
| Postconditions | The player has successfully registered into the app. |

| Name | UC 2. Enter |
|---|---|
| Actor | Player and database |
| Description | Player wants to get in the app to be able to interact with it. |
| Preconditions | Player has installed the app in a mobile device. |
| Normal flow | **1.** The player clicks the "Enter" button on the main screen of the app.<br>**2.** The system shows a screen with the introduction to the story.<br>**3.** The player has to register if he/she is not registered already (go to **UC 1**).<br>**4.** The system shows the dashboard screen with the player's avatar and progress, the mission's buttons and a series of other options. |
| Alternative flow | **1.** If the connection with the server fails, the system shows a message and the player remains in the same screen. |
| Postconditions | The player has successfully entered the app. |

| Name | UC 3. Accept mission |
|---|---|
| Actor | Player and database |
| Description | Player has to accept a mission to be able to do it. |
| Preconditions | Player is registered and has selected a mission on the dashboard screen. |
| Normal flow | **1.** The system shows a screen with the mission's name, its context related to the CP narrative, the task explanation and the main goal.<br>**2.** The player clicks the "Accept" button.<br>**3.** The system updates the mission's information (now accepted) on the database and shows the following screen. |
| Alternative flow | **2.** The player clicks the "Do not accept" button (goes to dashboard screen).<br>**3.** If the connection with the server fails, the app shuts down and nothing is saved. |
| Postconditions | The player has successfully accepted the mission. |

| Name | UC 4. Do Psychologist's mission |
|---|---|
| Actor | Player and database |
| Description | Player wants to start the Psychologist's mission. |
| Preconditions | Player is registered and on the dashboard screen. |
| Normal flow | 1. The player selects the mission's button on the dashboard screen. |
| | 2. The player has to accept the mission (if it is not accepted already, go to **UC 3**). |
| | 3. The system shows buttons of the family members and a brief explanation of what to do next. |
| | 4. The player selects a family member. |
| | 5. The system shows the selected member, the combinations (appliance – mood) made so far and a button to add a new combination. |
| | 6. The player selects the "Add combination" button. |
| | 7. The system shows a brief explanation of the task, a list of electrical appliances, a list of moods, the selected member and some boxes to fill in. |
| | 8. The player drags an appliance and a mood into the defined slots and clicks the "Confirm" button. |
| | 9. The system asks for a confirmation to save the combination made for the selected member (appliance and how she/he feels while using it). |
| | 10. The player confirms the saving. |
| | 11. The system updates the saved information on the database (go back to step 5 until it has been done five times for each family member). |
| Alternative flow | 5. If the member already has 5 combinations, the player clicks on the "Previous" button and the system shows the obtained reward (go to step 3). |
| | 9. If the combination already exists for the selected member, the system shows a message and the player remains on the same screen. |
| | 10. The player cancels the saving (remains on the same screen). |
| | 11. If the connection with the server fails, the app shuts down and nothing is saved. |
| Postconditions | The player has successfully added a combination to the selected member. |

| Name | UC 5. Do Detective's mission |
|---|---|
| Actor | Player and database |
| Description | Player wants to start the Detective's mission. |
| Preconditions | Player is registered and on the dashboard screen. |
| Normal flow | 1. The player selects the mission's button on the dashboard screen. |
| | 2. The player has to accept the mission (if it is not accepted already, go to **UC 3**). |
| | 3. The system shows buttons of the family members and a brief explanation of what to do next. |
| | 4. The player selects a family member. |
| | 5. The system shows a brief explanation of the task, the selected member and a list of positive energy related behaviors. |
| | 6. The player selects those behaviors he/she wants to become negative, clicks "Next" and does the same. Then, the player clicks the "Confirm" button. |
| | 7. The system asks for a confirmation to save the behaviors the player left visible. |
| | 8. The player confirms the saving. |
| | 9. The system updates the saved information on the database and shows the obtained reward (go back to step 3 until it has been done for each family member). |
| Alternative flow | 8. The player cancels the saving (remains on the same screen). |
| | 9. If the connection with the server fails, the app shuts down and nothing is saved. |
| Postconditions | The player has successfully indicated the behaviors of the selected member. |

| Name | UC 6. Do Electrician's mission |
|---|---|
| Actor | Player and database |
| Description | Player wants to start the Electrician's mission. |
| Preconditions | Player is registered and on the dashboard screen. |
| Normal flow | 1. The player selects the mission's button on the dashboard screen.<br><br>2. The player has to accept the mission (if it is not accepted already, go to **UC 3**).<br><br>3. The system shows a brief explanation of what to do next, buttons of different rooms of a house and a button to add a new room.<br><br>4. The player selects a room.<br><br>5. The system shows a brief explanation of the task, the empty selected room and a list of electrical appliances.<br><br>6. The player drags the appliances she/he has in that room into the slots and clicks the "Confirm" button.<br><br>7. The system asks for a confirmation to save the filled up room.<br><br>8. The player confirms the saving.<br><br>9. The system updates the saved information on the database (go back to step 3 until it has been done for each room).<br><br>10. The system shows a brief explanation of what to do next and two buttons of different days.<br><br>11. The player selects a type of day button.<br><br>12. The system shows a brief explanation of the task and the previously indicated electrical appliances into the correspondent rooms.<br><br>13. The player selects an appliance.<br><br>14. The system shows a panel with the selected appliance and a frequency rank.<br><br>15. The player indicates the frequency of use of the selected appliance and clicks the "Confirm" button.<br><br>16. The system updates the appliance information on the database (go back to step 12 until it has been done for each appliance). |
| Alternative flow | 4. **(a)** The player selects the "Add room" button and the system shows the new added room in the screen.<br><br>**(b)** If all the rooms are completed, the player clicks on the "Previous" button and the system shows the obtained reward (go to step 10).<br><br>8. The player cancels the saving (remains on the same screen).<br><br>9 & 16. If the connection with the server fails, the app shuts down and nothing is saved.<br><br>13. If all the appliances are checked, the player clicks on the "Previous" button and the system shows the obtained reward (go to dashboard screen). |
| Postconditions | The player has successfully indicated the appliances into the selected room and selected their usage frequency. |

| Name | UC 7. Do Journalist's mission |
|---|---|
| Actor | Player and database |
| Description | Player wants to start the Journalist's mission. |
| Preconditions | Player is registered and on the dashboard screen. |
| Normal flow | 1. The player selects the mission's button on the dashboard screen. |
| | 2. The player has to accept the mission (if it is not accepted already, go to **UC 3**). |
| | 3. The system shows buttons of the family members and a brief explanation of what to do next. |
| | 4. The player selects a family member. |
| | 5. The system shows a brief explanation of the task, the selected member and a list of questions with multiple choice answers. |
| | 6. The player selects the answers to each question clicks "Next" and does the same in the following screens. Then, the player clicks the "Confirm" button. |
| | 7. The system asks for a confirmation to save the answers the player marked. |
| | 8. The player confirms the saving. |
| | 9. The system updates the saved information on the database and shows the obtained reward (go back to step 3 until it has been done for each family member). |
| Alternative flow | 10. The player cancels the saving (remains on the same screen). |
| | 11. If the connection with the server fails, the app shuts down and nothing is saved. |
| Postconditions | The player has successfully marked the answers of the selected member. |

| Name | UC 8. See Leaderboard |
|---|---|
| Actor | Player and database |
| Description | Player wants to see the leaderboard with the ranking. |
| Preconditions | Player is registered and on the dashboard screen. |
| Normal flow | **1.** The player selects the Leaderboard's button on the dashboard screen.<br>**2.** The system connects to the server's database to obtain all the players' scores and shows them in a ranking (with their names and avatars). |
| Alternative flow | **2.** If the connection with the server fails, the app shuts down. |
| Postconditions | The player has successfully seen her/his progress on the leaderboard. |

| Name | UC 9. See Badges |
|---|---|
| Actor | Player |
| Description | Player wants to see the badges achieved during the CP. |
| Preconditions | Player is registered and on the dashboard screen. |
| Normal flow | **1.** The player selects the Badge's button on the dashboard screen.<br>**2.** The system shows the badges with their names. |
| Alternative flow | – |
| Postconditions | The player has successfully seen her/his achieved badges. |

| Name | UC 10. Change avatar |
|---|---|
| Actor | Player and database |
| Description | Player wants to change the current avatar or him/her name. |
| Preconditions | Player is registered and on the dashboard screen. |
| Normal flow | 1. The player selects the Change avatar's button on the dashboard screen.<br>2. The system shows a screen with a set of avatars, the current avatar and an input field with the current player's name.<br>3. The player chooses a new avatar and/or changes his/her name and clicks the "Next" button.<br>4. The system updates the player's registration information on the database and shows the dashboard screen. |
| Alternative flow | 4. If the connection with the server fails, the app shuts down. |
| Postconditions | The player has successfully changed the avatar or name. |

| Name | UC 11. Exit |
|---|---|
| Actor | Player |
| Description | Player wants to exit the CP app. |
| Preconditions | Player is registered and on the dashboard screen. |
| Normal flow | 1. The player selects the Exit's button on the dashboard screen.<br>2. The app shuts down. |
| Alternative flow | – |
| Postconditions | The player has successfully exited the CP app. |

## 4.5. Sequence diagrams

This section presents a more detailed version of some of the Use Cases described above, specifying all the method calls between the different classes of the mobile application when there is a player interaction. Only sequence diagrams for the more significant Use Cases are depicted below. Note that Use Case 2 (Enter) also includes Use Case 1 (Register) as stated in the Use Case description.
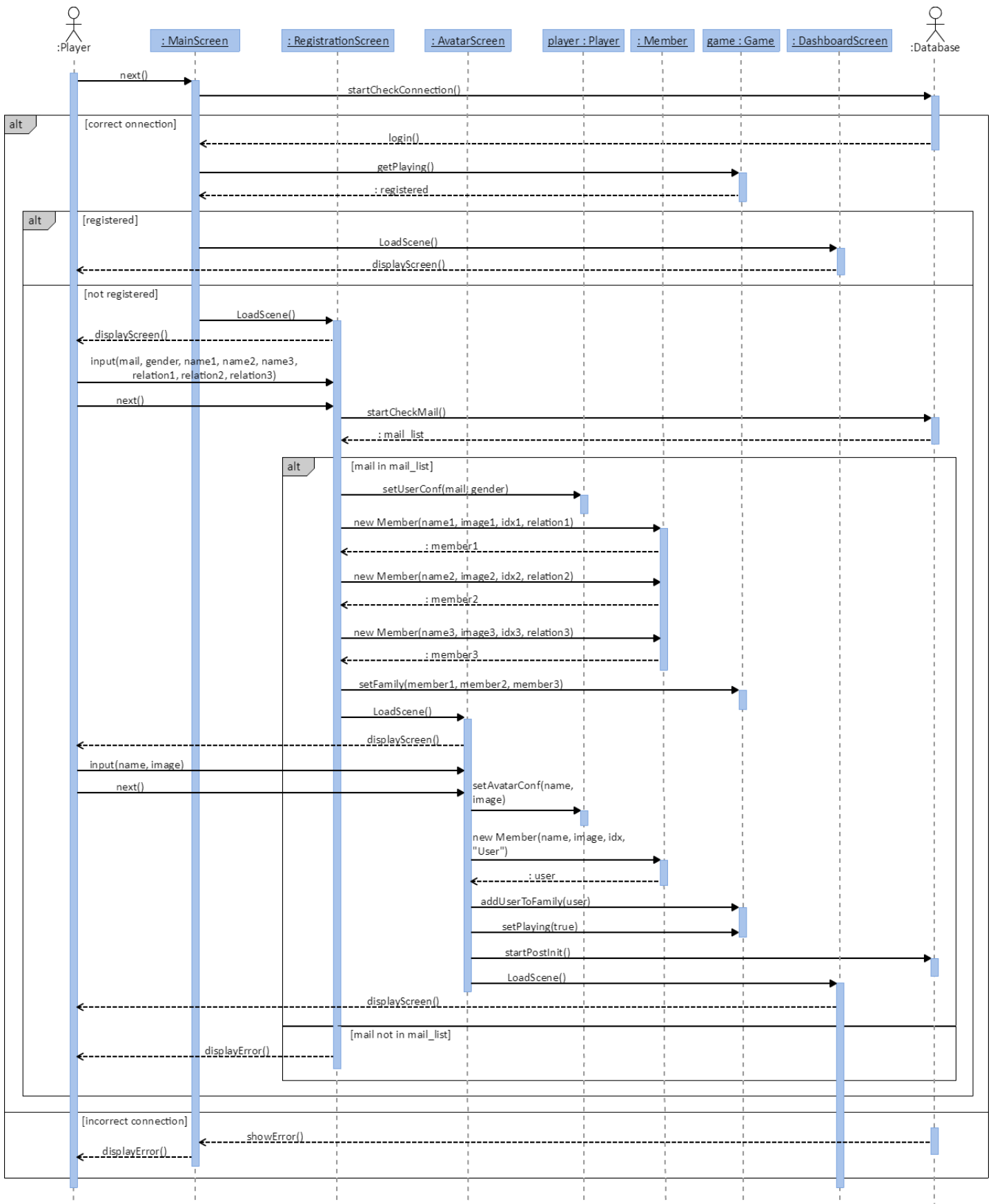
## 4.5.1. UC 2 – Enter



Figure 4.3. Sequence Diagram of Use Case 2 (Enter)
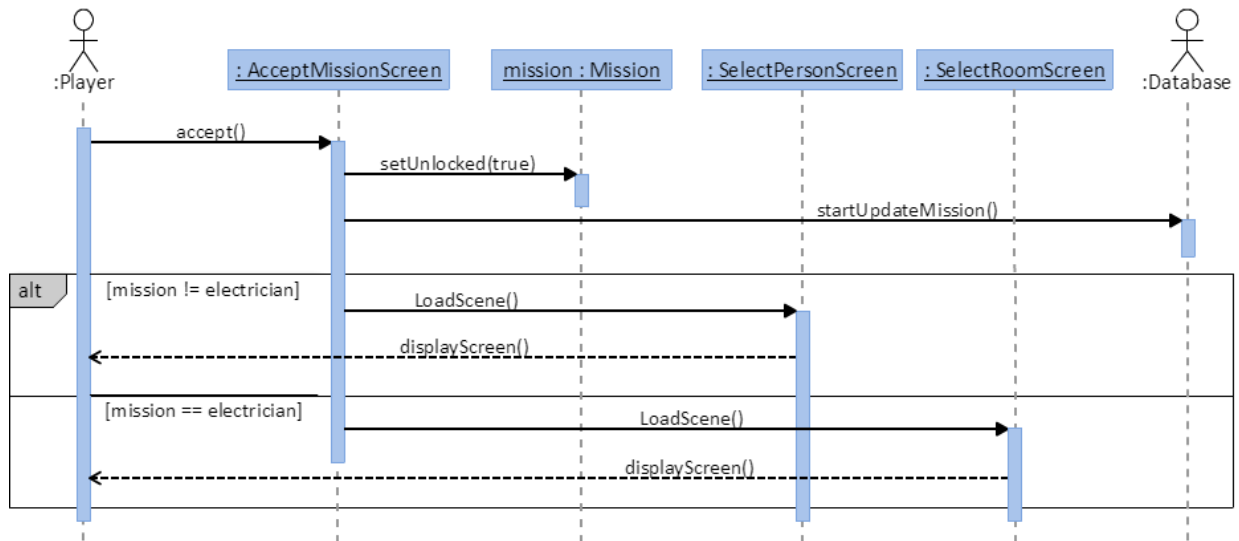
### 4.5.2. UC 3 – Accept mission



*Figure 4.4. Sequence Diagram of Use Case 3 (Accept mission)*
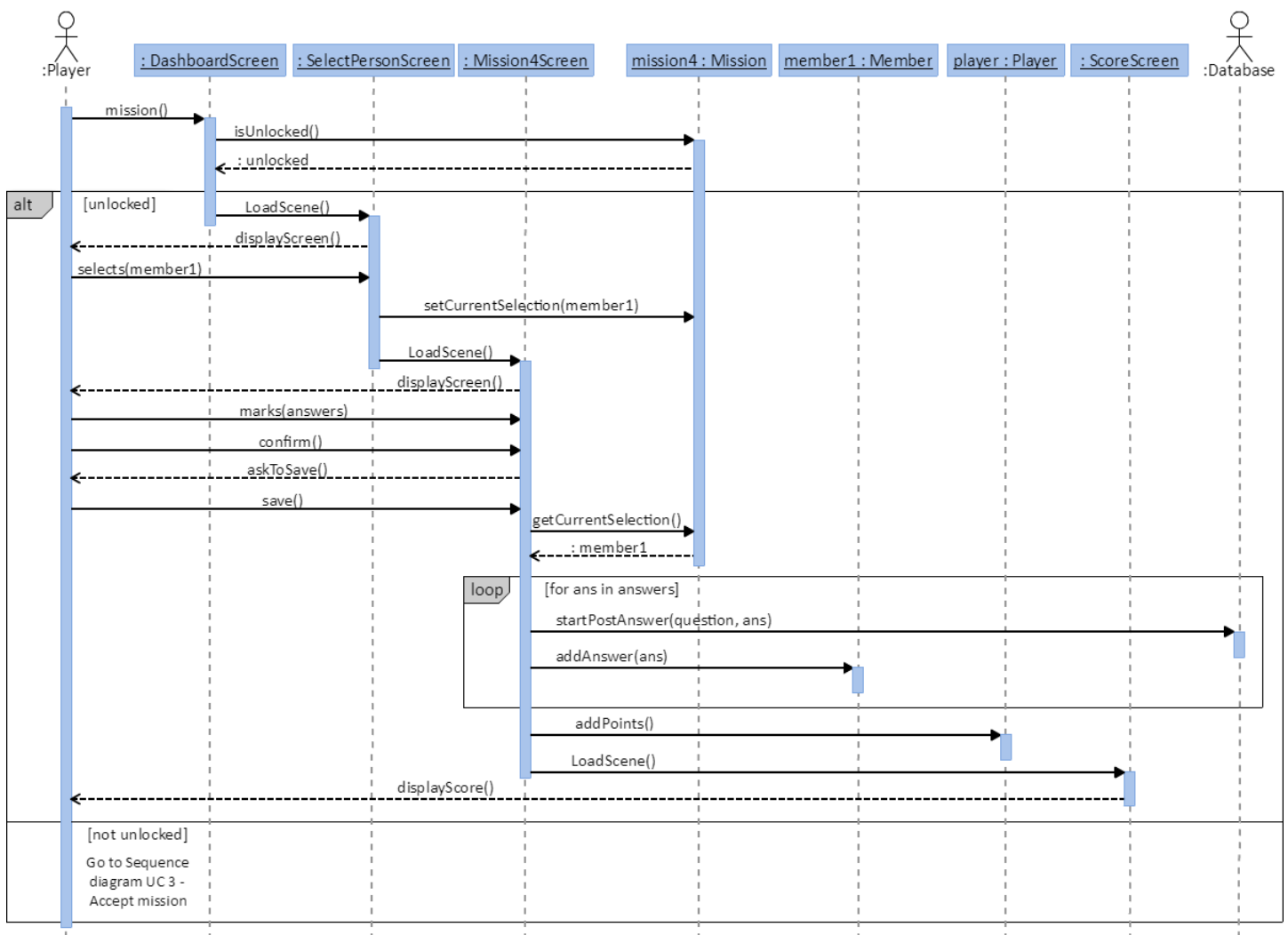
### 4.5.3. UC 7 – Do Journalist's mission



*Figure 4.5. Sequence Diagram of Use Case 7 (Do Journalist's mission)*

Use Cases 4, 5 and 6 have a very similar flow of calls (between classes and to the database), therefore, this diagram gives a global vision of the interaction that the rest of missions have with both the player and the database, actors of the system.

### 4.5.4. UC 8 – See Leaderboard
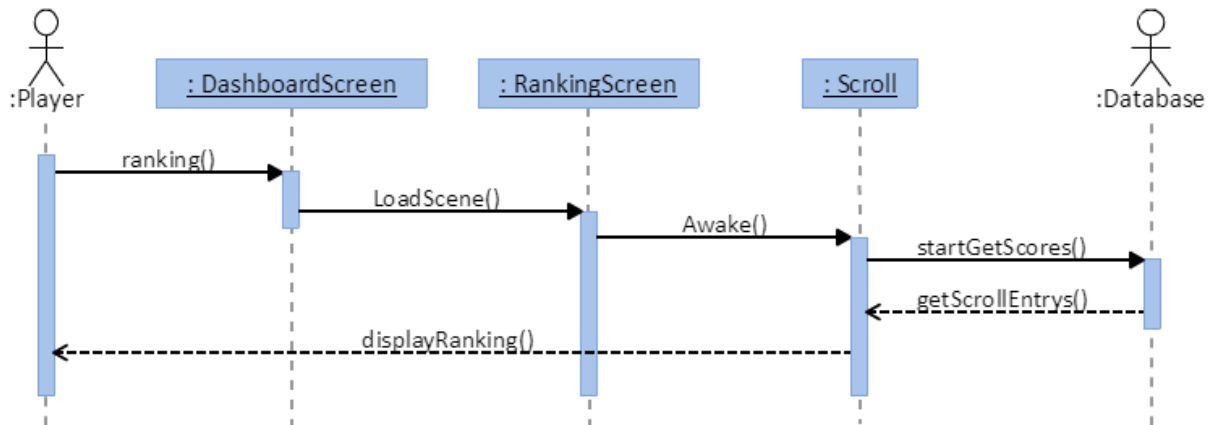


*Figure 4.6. Sequence Diagram of Use Case 8 (See Leaderboard)*

## 4.6. Mockups

A mockup is a sketched model of an app used to evaluate its design and its main functionalities (a prototype). They are really useful to test the design and usability of the app in order to make the necessary changes in early steps of the development, so that can be done with a clear vision of how the final product is going to be.

For this project, mockups of the different screens, links and functionalities have been carefully designed after defining the CP tasks and the gamified experience. Considering that the usability of the app is a key element to engage children to use it, the design has to be both understandable and appealing. Nevertheless, mockups for the non gamified version of the CP have also been made, taking the ones of the gamified CP as a base. Balsamiq is the software used to make them, a wireframing tool that reproduces the experience of sketching on a whiteboard.

Below, only the mockups of the main functionalities of the gamified app are shown. As can be seen, the name of the CP app is Energy Madness, in line with the story context and the subject it revolves around.

## 4.6.1. Main screens' mockups
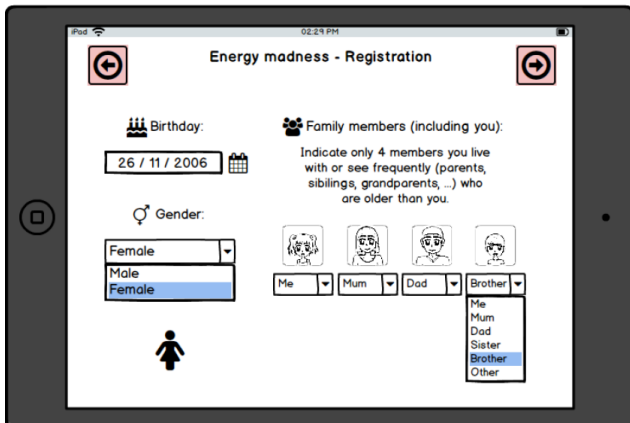


*Figure 4.7. Registration screen mockup*
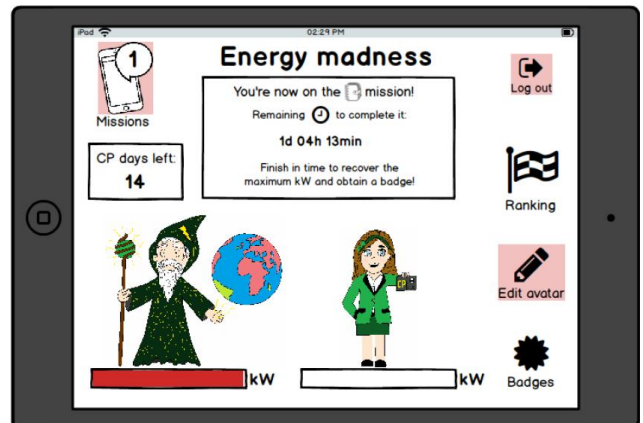


*Figure 4.8. Dashboard screen mockup*
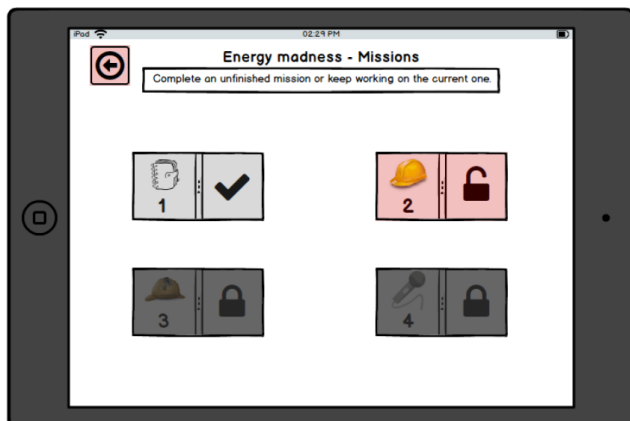


*Figure 4.9. Missions screen mockup*
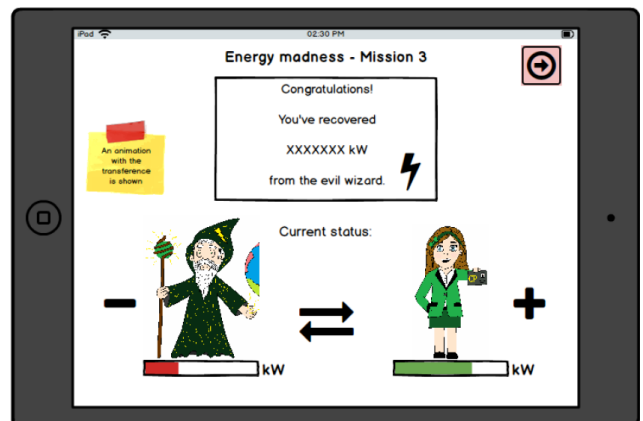


*Figure 4.10. Points gain screen mockup*
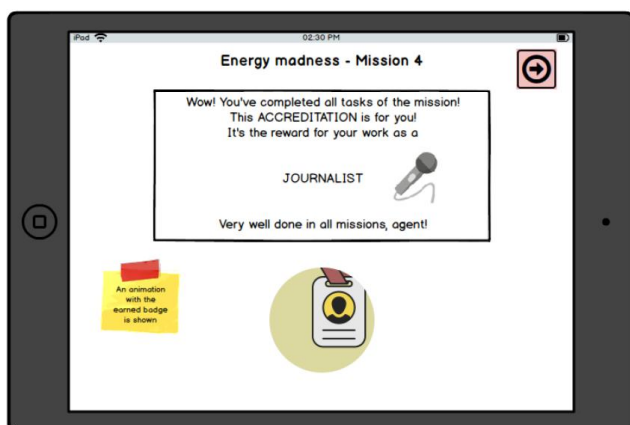


*Figure 4.11. Badge obtainment screen mockup*
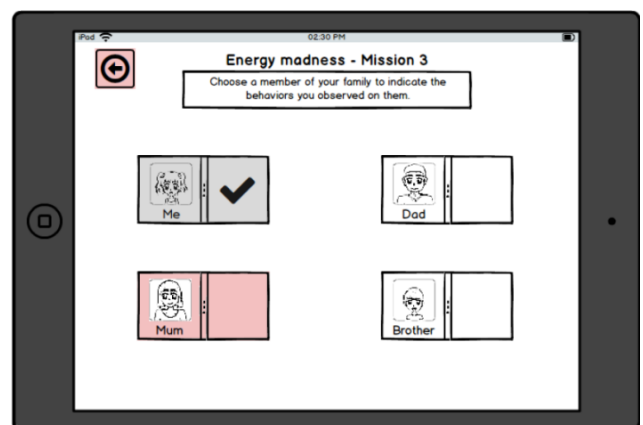


*Figure 4.12. Member selection screen mockup*

## 4.6.2. Psychologist's mission mockups
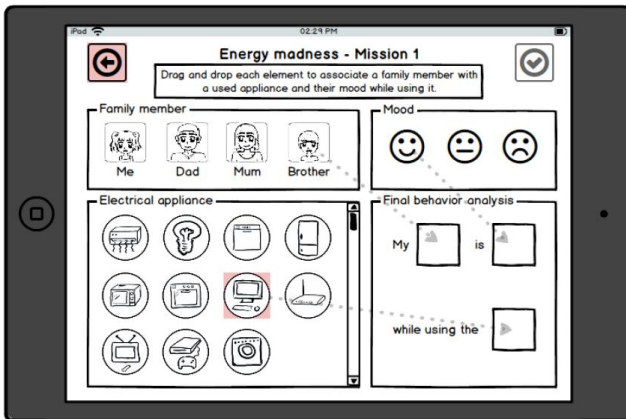


*Figure 4.13.Psychologist's mission screen mockup*
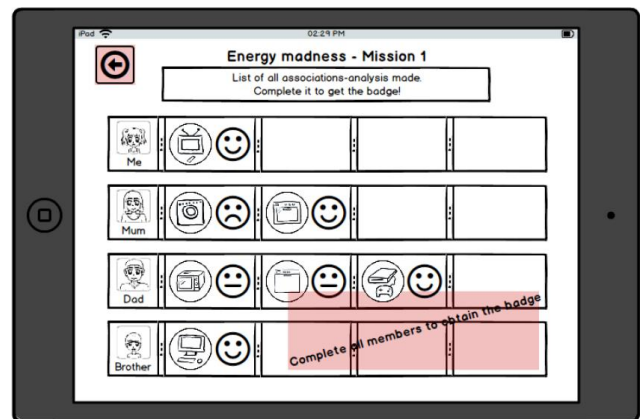


*Figure 4.14.Combinations list screen mockup*

## 4.6.3. Detective's mission mockups
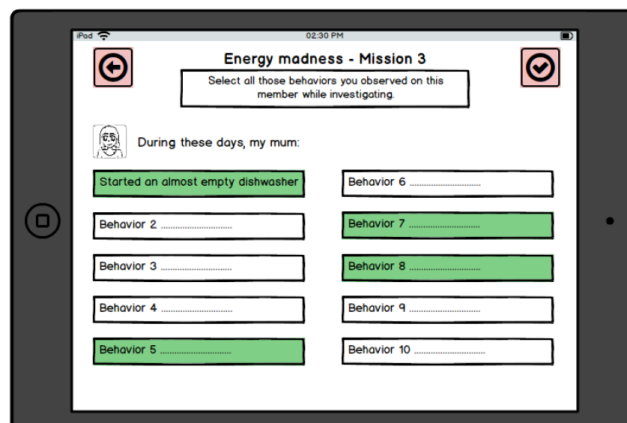


*Figure 4.15. Detective's mission screen mockup*

## 4.6.4. Electrician's mission mockups
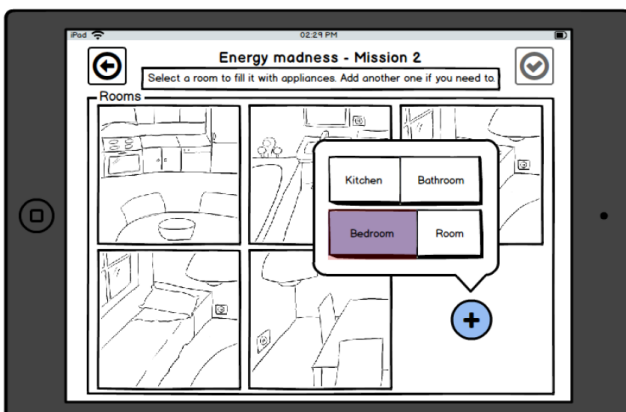


*Figure 4.16. Room selection screen mockup*
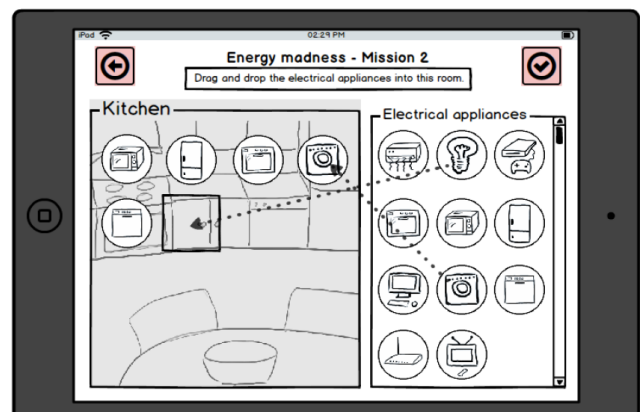


*Figure 4.17. Electrician's mission (part 1) screen mockup*
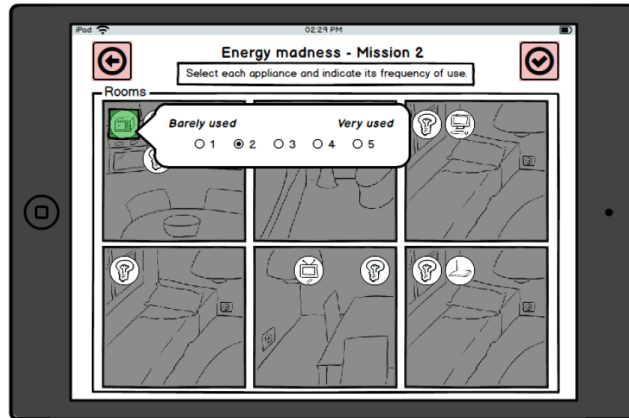
*Figure 4.18. Electrician's mission (part 2) screen mockup*

### 4.6.5. Journalist's mission mockups
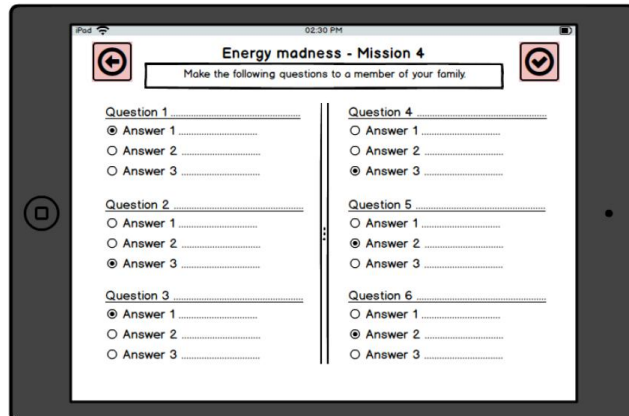


*Figure 4.19. Journalist's mission screen mockup*

# 5. Implementation

This section describes implementation details and presents the final product. This project has been designed and created to be in 2D and to be executed in mobile devices (specifically Android, due to some restrictions when it comes to upload an app to the Apple Store), which is why Unity has been the chosen engine to develop the CP as a mobile application. Unity allows to develop projects in 2D and 3D, and to build the final product into multiple platforms, making it the perfect fit to develop the app. Also, it provides plenty of GUI elements and the possibility to handle user interface events.

In regard to storing all the data introduced into the app by participants (players), it is needed to design and create a remote database. To do so, the choice has been to use *bplaced*, a free online server host. This service provides a web domain acting as a local host server, where up to 8 different MySQL databases (among other types) can be created.

## 5.1. Structure

### 5.1.1. Scenes and Scripts

This project has been started from scratch, which means that code has not been reused and all the screens have been developed incrementally. However, many sources of information have been visited for ideas, always adapting and modifying them to fit the specific problem to solve.

In order to make the different screens of the app, several Unity Scenes have been created, designed and adjusted (see *Figure 5.1*). Each one of them focuses on its main functionality and has a descriptive name, as well as all the UI elements inside of it. The local changes of the screen have been handled by code.
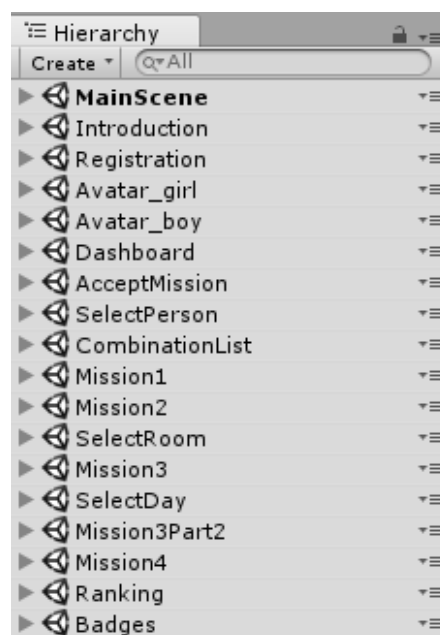


*Figure 5.1. View of all the Scenes that build the gamified app*

To manage all the user events and store the desired data, each scene has a canvas (UI element) with one or more scripts attached to it, as well as some panels, buttons etc. Moreover, there are some scripts that contain the main classes of the mobile application, that is, all the relevant data that needs to be saved (see *Table 5.1*), both locally (data persistence on the device) and in a database. The data stored in the device consists in an instance of the class "Game", which contains all the information of the app. That way, when players exit the app, they don't lose all the progress made and they can continue where they left off when they run it again. The data stored in the database consists, exclusively, in the relevant information related to the CP (for later study) and the players (in order to show their progress on the leaderboard). The programming language chosen to write the Unity scripts has been C Sharp (C#).

As was previously mentioned, one of the goals of this project is to compare the results (in quantity and quality) of a gamified CP to a non gamified CP. Therefore, two apps have been developed. The fully finished and tested gamified CP has been taken as a base to develop the non gamified CP, given that the later has the same visual aspect, elements and tasks than the first, minus the gamified experience (no avatar, no points, no badges, no leaderboard, etc). However, some slight modifications needed to be done to the code and some screens layout had to be redistributed.

| Game scenes | Game info | UI functions |
|---|---|---|
| ▪ AcceptMissionScreen.cs | ▪ Action.cs | ▪ DragTransform.cs |
| ▪ AvatarScreen.cs | ▪ Answer.cs | ▪ ImageControl.cs |
| ▪ BadgesScreen.cs | ▪ Appliance.cs | ▪ PanelControl.cs |
| ▪ CombListScreen.cs | ▪ Badge.cs | ▪ ProgressBar.cs |
| ▪ DashboardScreen.cs | ▪ Combination.cs | ▪ Scroll.cs |
| ▪ IntroductionScreen.cs | ▪ GameControl.cs | ▪ SelectButton.cs |
| ▪ MainScreen.cs | ▪ Member.cs | ▪ SlotMission1.cs |
| ▪ Mission1Screen.cs | ▪ Mission.cs | ▪ SlotMission3.cs |
| ▪ Mission2Screen.cs | ▪ Mission1.cs | ▪ TimePanel.cs |
| ▪ Mission3P2Screen.cs | ▪ Mission2.cs | ▪ ToggleButton.cs |
| ▪ Mission3Screen.cs | ▪ Mission3.cs | ▪ UsagePanel.cs |
| ▪ Mission4Screen.cs | ▪ Mission4.cs | |
| ▪ RankingScreen.cs | ▪ Player.cs | **Init** |
| ▪ RegistrationScreen.cs | ▪ Room.cs | |
| ▪ ScoreScreen.cs | | ▪ BadgeCreation.cs |
| ▪ SelectDayScreen.cs | **Network** | ▪ RoomCreation.cs |
| ▪ SelectPersonScreen.cs | | |
| ▪ SelectRoomScreen.cs | ▪ BDControl.cs | |

*Table 5.1. Scripts in each folder of the gamified app project according to their functionality*

In order to adapt the app screen to multiple sizes and resolutions the different devices may have, it has been crutial to work with the Anchors of the Unity elements (Game Objects) and get them to adjust correctly in the desired way. The use of Prefabs[2] has been very useful to place common elements on some screens by reusing a previously created model.

For the communication with the server, the language used is PHP (which is server centered). Many PHP files have been created to send to the server the action to perform (post, update, get) and the data to operate with. The internal code of those files consists in several SQL queries.

## 5.2. Database

This section shows the developed database design (see *Figure 5.2*) and describes its tables and attributes (for the gamified version of the CP). The version for the non gamified CP differs from this one only in the lack of some attributes, but the tables and their relations are the same.

### 5.2.1. Tables relation diagram
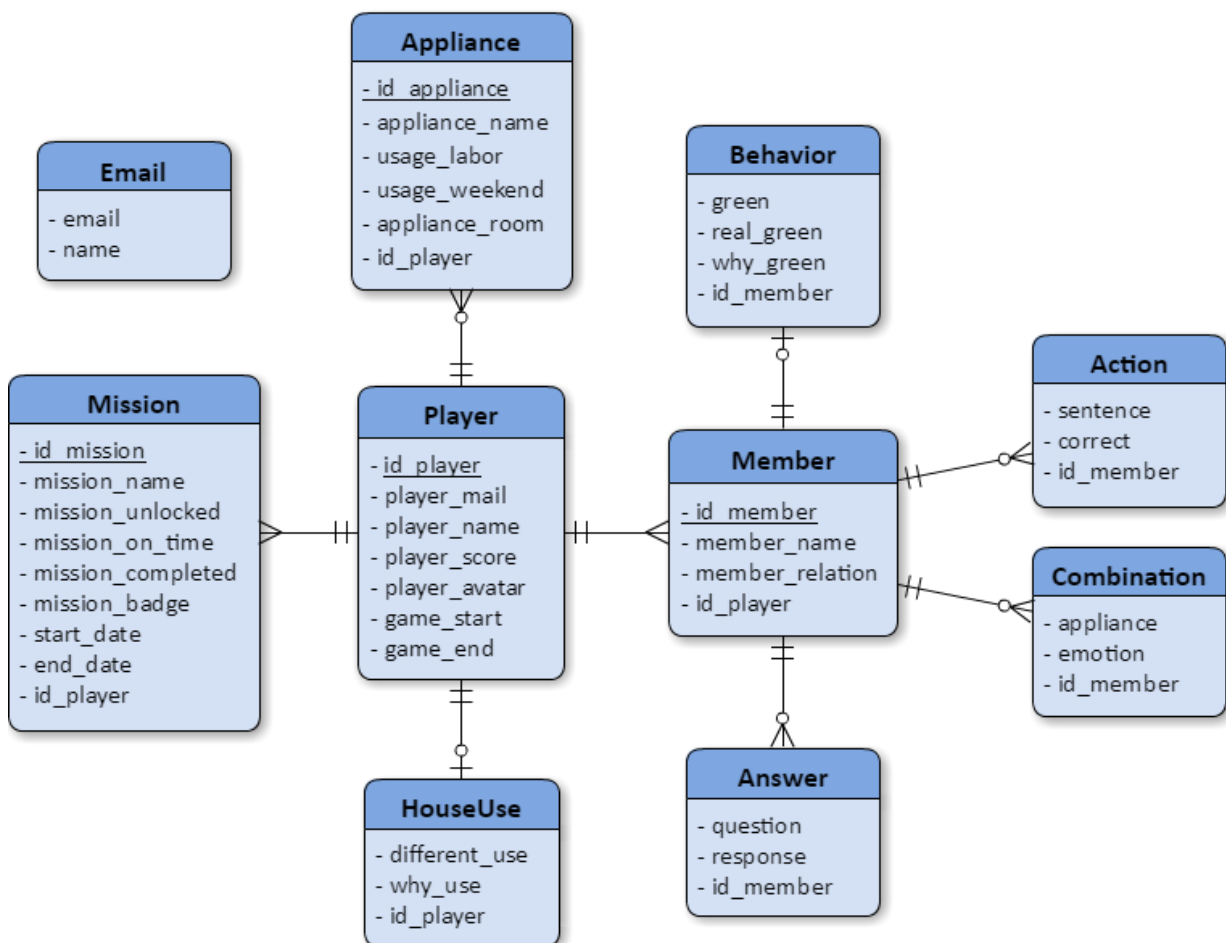


*Figure 5.2. Relations between all the tables of the database*

---

[2] A Prefab, in Unity, is a copy of a Game Object, or hierarchy of Game Objects, converted into a reusable asset (prefabricated object).

### 5.2.2. Tables description

- <u>Player:</u> Information about the player.
    - **id_player:** identifier of the player (primary key). It consists in the user's email address local-part (before the "@" symbol) to ensure it is unique.
    - **player_mail:** email address of the player (where information might be sent to).
    - **player_name:** name of the player in the CP.
    - **player_score:** amount of points the player has in the CP.
    - **player_avatar:** name of the image of the avatar chosen by the player.
    - **game_start:** date and time when player starts the CP.
    - **game_end:** date and time when player finishes all the tasks of the CP.

- <u>Mission:</u> Information about a mission.
    - **id_mission:** identifier of the mission (primary key). It is encoded as a combination of the player's identifier and the mission's number (1, 2, 3 or 4).
    - **mission_name:** name of the mission.
    - **mission_unlocked:** a state of the mission (locked or unlocked).
    - **mission_on_time:** a state of the mission (in time or not in time).
    - **mission_completed:** a state of the mission (completed or not completed).
    - **mission_badge:** a state of the mission (achieved badge or not achieved).
    - **start_date:** date and time when player unlocks the mission.
    - **end_date:** date and time when player finishes the mission.
    - **id_player:** identifier of the player (foreign key).

- <u>Appliance:</u> Information about an electrical appliance (Electrician's mission).
    - **id_appliance:** identifier of the electrical appliance (primary key). It is encoded as a combination of the player's identifier and the appliance number (automatically assigned by code).
    - **appliance_name:** name of the electrical appliance.
    - **usage_labor:** frequency of usage of the appliance on a labor day (from 1 to 6).
    - **usage_weekend:** frequency of usage of the appliance on a weekend day (from 1 to 6).
    - **appliance_room:** name of the house room the electrical appliance was assigned into.
    - **id_player:** identifier of the player (foreign key).

- HouseUse: Information about household energetic use (Electrician's mission).

    - **different_use:** player's affirmation or denial about making a different use depending on the type of day.

    - **why_use:** player's explanation (open question) about why the use is different or not.

    - **id_player:** identifier of the player (foreign key).

- Member: Information about a member of the family.

    - **id_member:** identifier of the family member (primary key). It consists in a combination of the player's id and the member's number (0, 1, 2 or 3).

    - **member_name:** name of the family member.

    - **member_relation:** relationship between the player and the family member.

    - **id_player:** identifier of the player (foreign key).

- Combination: Information about a family member's combination (Psychologist's mission).

    - **appliance:** name of the electrical appliance.

    - **emotion:** name of the emotion/mood.

    - **id_member:** identifier of the member (foreign key).

- Action: Information about a family member's action or behavior (Detective's mission).

    - **sentence:** full action or behavior's text.

    - **correct:** state of that action (correct or not correct in relation to energy saving).

    - **id_member:** identifier of the member (foreign key).

- Behavior: Information about a family member's green behavior (Detective's mission).

    - **green:** player's affirmation or denial about the behavior being responsible towards environment and saving (green behavior).

    - **real_green:** automatically calculated affirmation or denial about the behavior being green by checking the introduced actions.

    - **why_green:** player's explanation (open question) about why they think the behavior is green or not.

    - **id_member:** identifier of the member (foreign key).

- Answer: Information about a family member's interview (Journalist's mission).

    - **question:** text of the question.

    - **response:** text of the marked answer.

    - **id_member:** identifier of the member (foreign key).

- Email: Information about the participants of the CP. If a participant's email is not in the database, he/she cannot register into the app and cannot become a player.

  - **email:** email address of the participant.
  - **name:** full name of the participant.

## 5.3. Final gamified app – Energy Madness

This section shows the most relevant screens and elements of the final gamified app, and describes some of the CP details that show up during the interaction. The app has been implemented in Catalan, focusing on being evaluated with real users who might not have a high level of English. All the icons used to enhance the visual aspect of the app have been obtained from Flaticon[3].

### 5.3.1. Main Screens

Once the app has been installed in the participants' devices and they first enter the app, the main screen shows up right after Unity's logo animation. If participants click "Enter", the screen shows an introduction to the CP story[4] and how they can collaborate in it and, after that, the app asks them to register by indicating 3 members of their family, their gender and email address.



*Figure 5.3. Registration screen of the gamified app*

To do so, the app provides the possibility to add: mother, father, sister, brother, grandmother, grandfather, other man and other woman. Each one of them has assigned a faceless representative icon with the only purpose to help players identify the member throughout the CP. Moreover, kids must introduce their relatives' names to personalize the experience even more (see *Figure 5.3*).

---

[3] Icons made by Freepik, Eucalyp, Vectors Market, Madebyoliver, Nikita Golubev and DinosoftLabs from www.flaticon.com

[4] Extract of the story: "Welcome! You've been selected by the Energy Protectors' Special Agency to become a part of a very important mission. An evil wizard has cast a curse over a great portion of the population …"

In the next screen, they encounter a set of avatars (depending on their gender) and are asked to choose one and indicate their name (see *Figure 5.5*).

Once users are registered, they go directly to the most important screen of the app, the dashboard (see *Figure 5.4*). This screen has all the information they need: the remaining days to finish the CP, their avatar, their progress and the current status of each one of the missions. Also, from here they can consult a brief text with the rules and they can go to change their avatar (see *Figure 5.5*), to the leaderboard (see *Figure 5.6*), to the achieved badges (see *Figure 5.7)* and exit the app.



*Figure 5.4. Dashboard screen of the gamified app*

The app has a general green tone assigned to the main screens to match the subject: energy saving and green behavior (responsible use of energy towards the environment).

Note that each mission has its own color and a representative icon assigned to make it easier for the children to distinguish them, and keep them always aware of where they are and what are they doing. Furthermore, in the dashboard, several icons appear onto the missions' buttons:

- **Lock:** it means the mission has been accepted (see *Figure 5.8*), so it is an indicative for the kids to know that the mission is started.

- **Clock:** it means the mission is accepted and there is still time to complete it to get the full points reward (see *Figure 5.9*) and the correspondent badge. This icon is also a button that allows players to see how much time they have left to complete the mission in time.

- **Check:** it means the mission is completed, so it indicates them that the mission is not available.

- **Badge:** it means that the mission has been completed in time, so the player achieved that mission's badge (see *Figure 5.10*).

For the Psychologist, Detective and Journalist's missions, players have to select the member of the family they want to perform the task about (see *Figure 5.11*) and, for the Electrician's mission, they have to select the house room they want to add appliances to (see *Figure 5.12*).
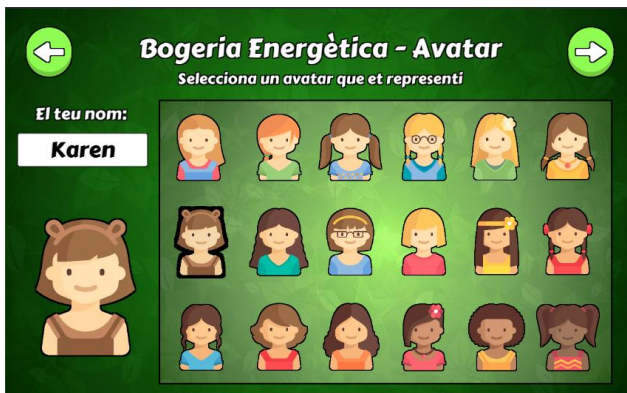


*Figure 5.5. Avatar selection screen of the gamified app*



*Figure 5.6. Leaderboard screen of the gamified app*



*Figure 5.7. Badges screen of the gamified app (all achieved)*
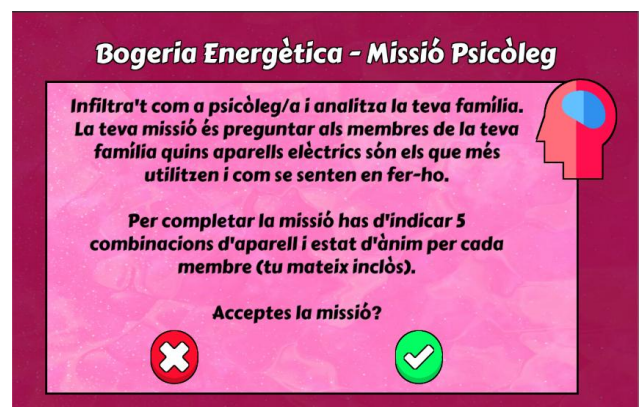


*Figure 5.8. Accept mission screen of the gamified app (Psychologist's mission)*



*Figure 5.9. Points gain screen of the gamified app (Journalist's mission)*



*Figure 5.10. Badge obtainment screen of the gamified app (Journalist's mission)*

Figure 5.11. Member selection screen of the gamified app (Detective's mission)



Figure 5.12. Room selection screen of the gamified app (Electrician's mission)

### 5.3.2. Psychologist's mission screens

As mentioned above, to perform this mission, players have to select a family member. Once they do it, a screen with the selected member and the combinations (appliance – mood) associated to him/her, if there are any, appears (see *Figure 5.13*).



Figure 5.13. Members' combinations screen of the gamified app

When players click the "Add" button, next step is to make a new a combination by dragging a mood (joy, boredom, sadness or anger) and an electrical appliance (there are up to 35 to choose) into the empty boxes of the new screen (see *Figure 5.14*). The mechanic of this task simulates a sentence completion: "Member's name" (first box) "feels" (second box) "while using the" (third box).

*Figure 5.14. Psychologist's mission screen of the gamified app*

### 5.3.3. Detective's mission screens

In this mission, players have to select a family member just like in the previously explained one. When they do it, a new screen with a list of energy related behaviors/actions shows up (see *Figure 5.15*). The particular mechanic of this mission consists in selecting the actions, which are initially good (in black font and light blue background) to turn them into their opposite (bad, in white font and dark blue background) and leave visible the ones observed in the selected member.



*Figure 5.15. Detective's mission screen of the gamified app*

To adapt the behaviors for the two main groups of family members (children and adults), specific ones have been chosen for each. The table below (see *Table 5.2*) depicts the behaviors [18][19] added to the app for both groups in their good and bad version.

| CHILDREN | |
|---|---|
| **GOOD BEHAVIOR** | **CORRESPONDING BAD BEHAVIOR** |
| Opens faucet in cold water for short uses | Opens faucet in hot water for short uses |
| Turns off the TV, computer or game console when not using it | Leaves the TV, computer or game console on or in standby when not using it |
| Closes the fridge carefully, checking if it closes correctly | Closes the fridge sharply, not checking if it closes correctly |
| Lifts the blinds or removes the curtains from the windows so sunlight can enter | Doesn't let sunlight in and turns on the lights when is daylight |
| Turns off the lights that she/he or other people leave turned on | Leaves the lights of every room turned on |
| Unplugs the phone/tablet once the load is complete | Leaves the phone/tablet plugged in when the load is complete |
| Turns on only the light he/she needs or the most powerful of the room | Turns on several lights of the same room (ceiling, desk, nightstand, …) |
| Leaves the windows or balconies closed when the air conditioning or heating is on | Opens windows and balconies when the air conditioning or heating is on |
| **ADULTS** | |
| **GOOD BEHAVIOR** | **CORRESPONDING BAD BEHAVIOR** |
| Starts a full laundry or doesn't do laundry | Starts an almost empty laundry |
| Lifts the blinds or removes the curtains from the windows so sunlight can enter | Doesn't let sunlight in and turns on the lights when is daylight |
| Opens the fridge the exact time needed to get what he/she needs | Stares at the content of the fridge with the door opened for a while |
| Turns off the extractor after cooking or doesn't use it | Leaves the extractor on for a while when not cooking |
| Lets clothes dry outdoors or doesn't dry them | Dries clothes automatically in the drier |
| Covers all food and liquids stored in the refrigerator | Stores food and liquids into the refrigerator without covering them |
| Preheats the oven for the indicated necessary time or doesn't use it | Preheats the oven for longer than necessary |
| Ventilates the house a few minutes every day opening windows or balconies | Doesn't open windows or balconies to ventilate the house a few minutes a day |

*Table 5.2. Detective's mission behaviors (good and bad version) for children and adults*

After players save the visible behaviors, a panel shows up (see *Figure 5.16*) asking them the following questions:

- "Do you think [member's name] is responsible towards environment, in other words, has a green behavior?" (Closed question with options "Yes" or "No").

- "Why? Is there something you observed on him/her that is not on the previous list?" (Open question with optional response).

Right after, players are given feedback about that member's behavior (quite responsible, not very responsible or balanced) basing on how many good or bad actions they selected (see *Figure 5.17*).
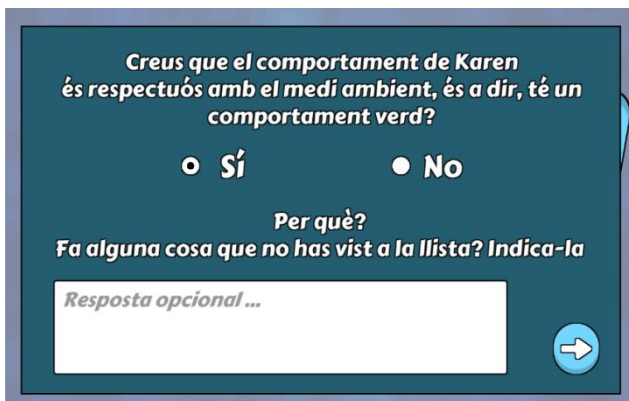


*Figure 5.16. Detective's mission questions screen of the gamified app*
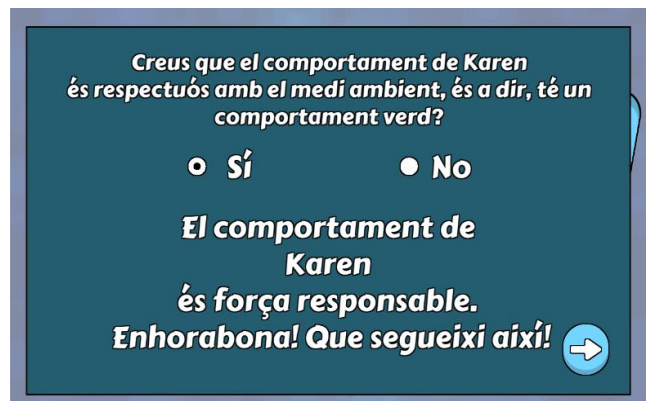


*Figure 5.17. Detective's mission feedback screen of the gamified app*

### 5.3.7. Electrician's mission screens

Previously, it was mentioned that, in order to perform this mission, players have to select a house's room from a set of types (kitchen, bathroom, living room and dorm).



*Figure 5.18. Electrician's mission (part 1) screen of the gamified app*

Initially, there are 5 rooms as default (one of each type and a second dorm), which is the minimum amount of rooms that are in a family house, but, if they need to, they can add an extra room of any type (see *Figure 5.12*). Once they do it, a screen with the empty selected room appears, and has to be filled by dragging those electrical appliances of the list that players have in that room onto the spots (see *Figure 5.18*).

This mission is particular for having two parts: the room completion and the frequency of usage indication. First part has been explained above and, once the players complete all the rooms, second part consists in indicating the frequency of use (in labor days and weekend days) of each appliance previously added to each room.

For that purpose, a screen to select the type of day (labor or weekend) is up next (see *Figure 5.20*), and for each type of day there is a screen depicting the completed rooms with the added appliances. When an appliance is selected, a panel with frequency ranges pops up, and all they have to do is mark one (see *Figure 5.19*).
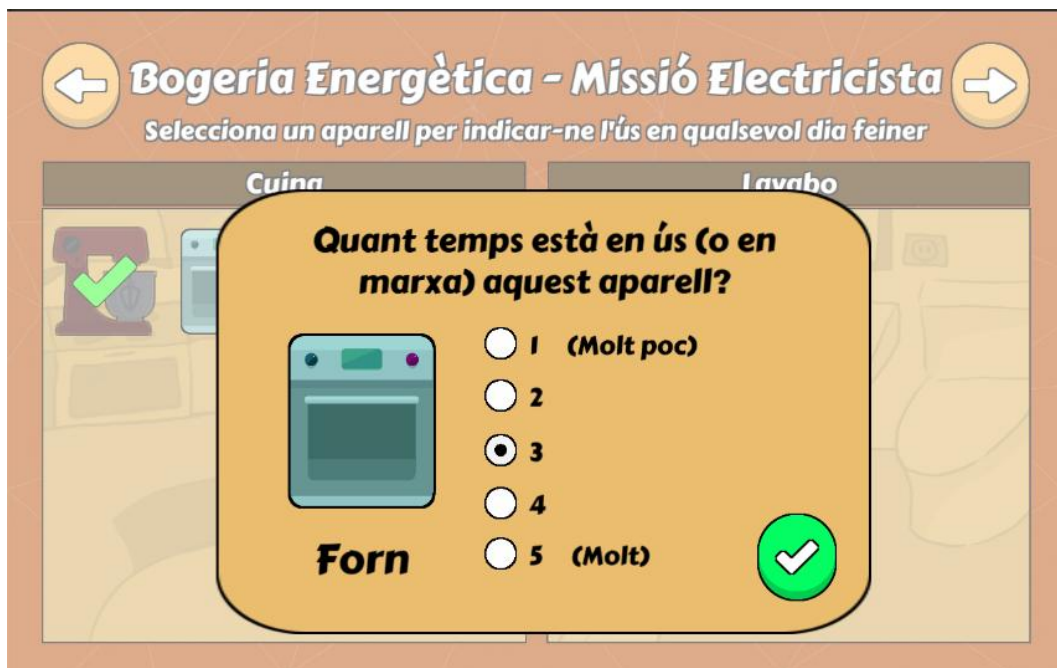


*Figure 5.19. Electrician's mission (part 2) screen of the gamified app*



*Figure 5.20. Day selection screen of the gamified app*
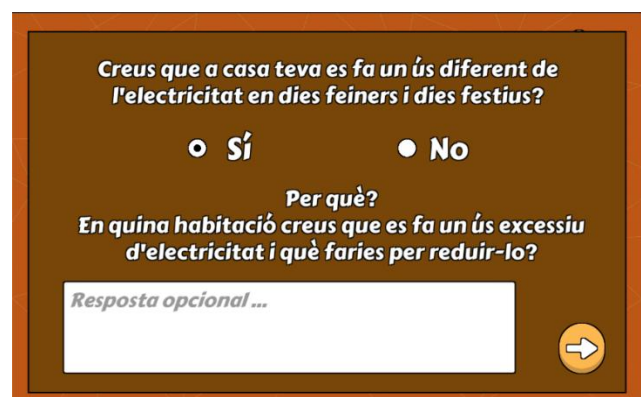


*Figure 5.21. Electrician's mission questions screen of the gamified app*

Finally, when all the frequencies are indicated, a panel shows up (see *Figure 5.21*) asking them the following questions:

- "Do you think that the use of electricity is different on labor days than on weekend days at your house?" (Closed question with options "Yes" or "No").

- "Why? In what room do you think the use of electricity is excessive and what would you do to reduce it?" (Open question with optional response).

### 5.3.8. Journalist's mission screens

In this mission, once players select a family member, there is a series of screens where they have to mark the answers to the proposed questions (see *Figure 5.22*).

The number of questions is, specifically, 12 for children and 16 for adults, depending on who is the selected member. Some questions are common to both groups (the first 10), and others are more adapted to their role in relation to energy management, knowledge and bill's payment. To take a look at the complete questionnaire of this task, see *Appendix A.4*.



*Figure 5.22. Journalist's mission screen of the gamified app*

## 5.4. Final non gamified app – Energetic family

The non gamified version of the CP app is called Energetic Family, which goes on the line with the subject of the project but doesn't suggest anything related to a story like the title of the gamified version does.

Briefly, the screens that change from the gamified app to the non gamified are presented. These are the registration screen (see *Figure 5.23*) and the dashboard screen (see *Figure 5.24*). In this version's dashboard, there are only locks and checks' icons for the missions, given that there is no limit of time to do them and no badges are achieved. Moreover, users (not considered players) cannot visualize their progress or a representative avatar of their choice: the avatar is a faceless icon like the rest of family members' representation in the app.




*Figure 5.23. Registration screen of the non gamified app*    *Figure 5.24. Dashboard screen of the non gamified app*

# 6. Evaluation
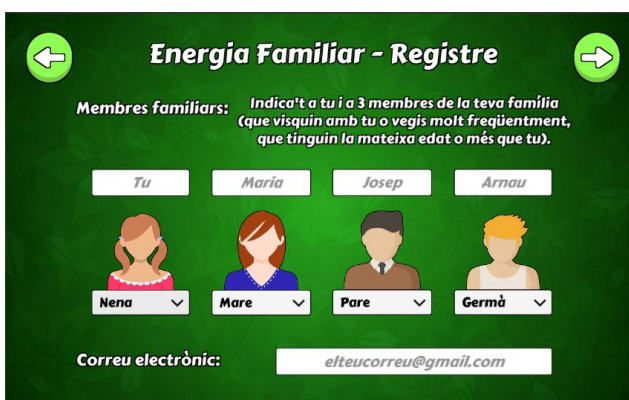
The main goal of this project is to compare results between the gamified CP and the non gamified CP. To do so, both of the apps have been tested and evaluated by real users. After the test, measures of task completion in both groups have been taken, both at the higher level of the entire CP and at the finer level of each task/mission to be completed. Also, it is interesting to analyze the qualitative data obtained in the evaluation and gather children opinions related to the entire experience, such as how much they enjoyed the CP activities and what is their perception of own and family's level of awareness in energy related issues, before and after performing the CP (i.e. using the app).

## 6.1. Methodology

The CP evaluation methodology is a between-subjects design with two groups of users, one considered as the treatment group, receiving a "special" treatment (gamified app) and the other is the control group, which receives no treatment and is used as a reference (non gamified app).

The collaboration of Rubí Brilla (energetic initiative of the town hall of Rubí) [20] has been essential for this part of the project. Thanks to them, voluntary children from two different schools were recruited to participate in the Cultural Probe evaluation (after making sure that their parents approved their contribution to this project by providing them a consent form, depicted in Appendix A.1, that they had to sign). The main requirement that they had to meet was having an Android device, and it was preferable that they lived in a house with 3 more family members, older than them.

Each one of the versions of the CP app was randomly assigned to each school:

- Gamified CP – Escola Montessori (14 participants)
- Non Gamified CP – Escola 25 de Setembre (11 participants)

Next step, after the participants recruiting, was to go to each of the schools (separately) to present the project, explain some concepts, briefly describe what the purpose of the app and tell participants that the one who completed better the CP (in quantity and quality) would receive a prize. The existence of two different versions of the app was never mentioned, in order not to previously condition the outcomes, so the particularities (goals and tasks) of the CP were equally described in both schools. The plan was to get the app installed on all the kids' devices, although some of them installed it once they arrived home, and to ask them to fill a pre-test questionnaire (see *Appendix A.2*).

During the CP duration, designed to be of 8 days, participants had to interact with the app in their homes while all data was being stored to the remote database. Meanwhile, a daily tracking was made to ensure everything was working correctly and to check their progress in the CP. After the 8 days, the schools were visited again to summarize the information gathered through the CP tasks and to deliver the prize to the winners. Three winners were chosen from each school basing on their score in the ranking (only in the gamified version) and the quality of their responses to the open questions that appeared throughout the app. The same day, they were asked to answer a post-test questionnaire (see *Appendix A.3*) in a computers classroom to ensure that all of them did it.

The mentioned questionnaires contain questions that made it possible to use them for the participants of both versions of the CP. That is because the main information to be obtained through them was the same to both experiences: level of energy awareness before and after, most liked tasks, etc.

*Figure 6.1. Participants of the CP from Escola 25 de Setembre (non gamified)*



*Figure 6.2. Participants of the CP from Escola Montessori (gamified)*

The app was also tested on another school (our acknowledgments to Escola del Mar), but its data has not been used to measure the rate completion results due to the fact of recruiting an insufficient number of children for the non gamified CP. However, the contribution to the questionnaires (previous and later to the app use) of the participants who tested the gamified app has been aggregated to the other two Rubí schools' information.

The following subsection shows the comparison between the results of pre and post-test questionnaires (percentages are over a total of 27 kids who tested the app and answered to both of the questionnaires).

## 6.2. Questionnaires feedback (Pre and post-test)

Through the questionnaires, the fact of whether the children's awareness on energy related issues, such as saving or being responsible towards environment, has raised or not can be checked.

For starter, the **"Do you know if yours and your family's energy related behavior is respectful with the environment?"** question is pretty focused to see if the Detective's task provided them with knowledge about what behaviors are good and if they became self-conscious about it. As can be seen, those kids who didn't know if they behavior was responsible, were more aware after the usage of the app, as well as the ones who just were a little conscious.

Pre-test
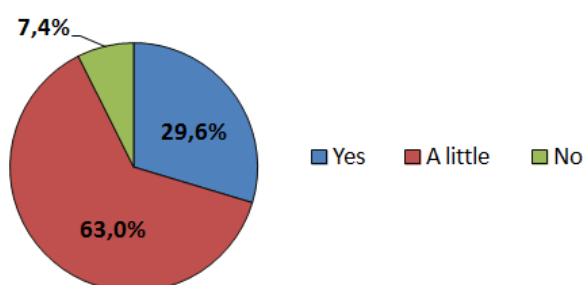
Post-test
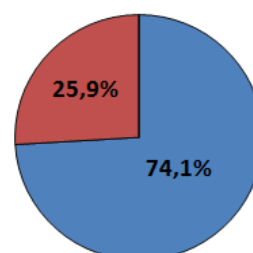
The **"Are you aware of your household electricity usage?"** question goes in the same line than the previous one, but in this case, the task expected to have created more awareness on electricity consumption is the Electrician's task. Apparently, only a few ones had more knowledge after performing the CP.

Pre-test                                                            Post-test
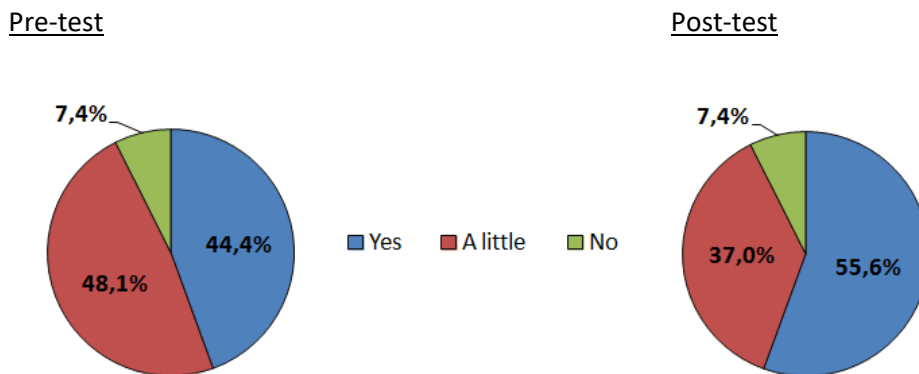


In order to know if performing the CP tasks had motivated the children to know more about electricity, their energy consumption and other ways to be respectful with the environment, the next three questions were asked to them:

- **"What is your level of interest about knowing how much energy you consume and how much you are capable to save?"**

Pre-test                                                            Post-test
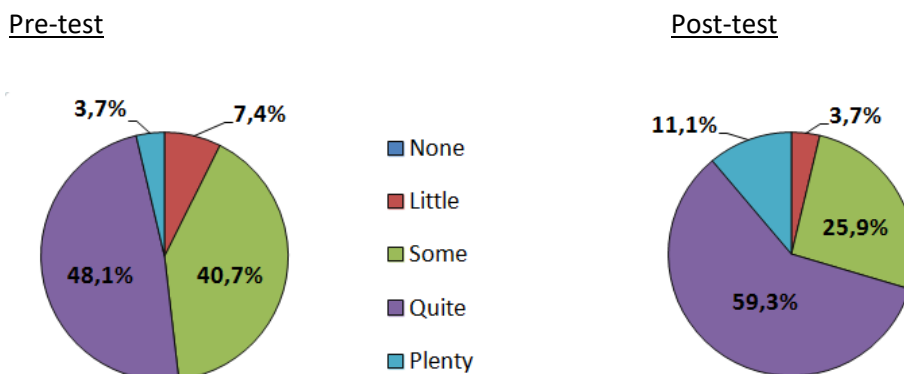


- **"What is YOUR level of compromise about making a responsible use of energy?"**
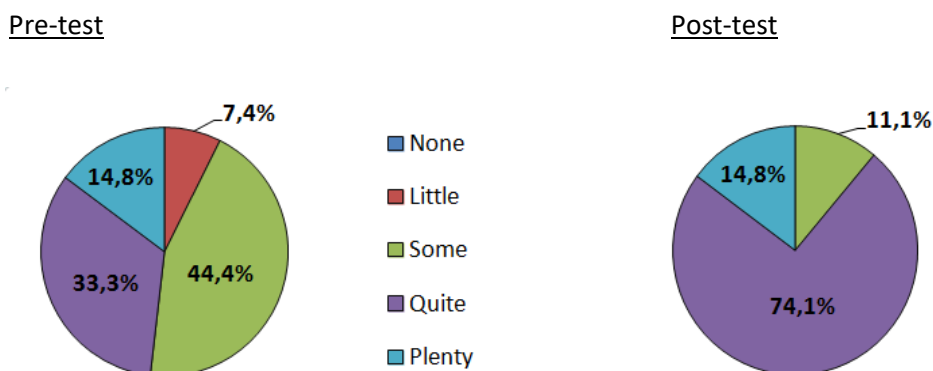
Pre-test                                                            Post-test

- **"What is your FAMILY's level of compromise about making a responsible use of energy?"**
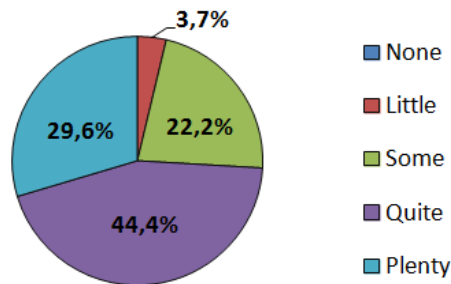
Pre-test                                                    Post-test
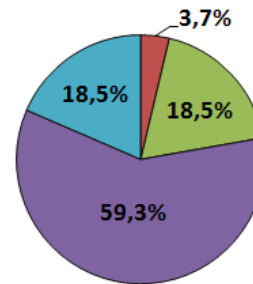


It would be safe to say that the app didn't have an effect on the kids' relatives (at least from their point of view), but it had quite an impact on themselves, raising their awareness and making them want to be more responsible when it comes to consume energy.

Additionally to comparing the pre and post-test results about energy awareness, it was thought to be interesting to make a few questions more specific about the app. For instance, the answers to **"What motivated you to do the tasks of the app?"** can be synthesized in:

- They wanted to help being more careful with the environment.

- They wanted to know about their electric consumption and how to reduce it.

- They like games and they had fun with the app (which wouldn't have been the case if the CP was given to them in its non digital – physical artifacts – version).

- They wanted to get a lot of points to be first on the ranking and win the final prize (only in the gamified version).

- They are interested in energy related subjects.

- They were curious to discover what they had to do exactly in each task (briefly explained at the presentation session done at schools).

Moreover, in order to get more feedback, they were asked about the tasks (which one they liked and which one they didn't like) and had to explain their experience when performing them. That could be useful for a possible redesign of the Cultural Probe tasks or the app gamification.

This is the result of the **"What task did you like the most?"** question:
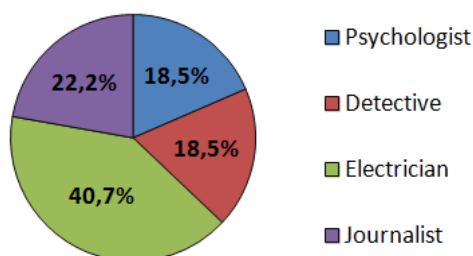


The Electrician's mission clearly stands out for being the most liked task of all. As for the given reasons to why they liked the task selected, there is a summary below.

Psychologist's task:

- They found it fun because they bonded with their family.

- They were not aware that using appliances provoked emotions on them.

Detective's task:

- They liked to investigate and discover how their relatives behaved.

Electrician's task:

- They liked being more aware of their electrical appliances and their usage.

- They found it the most entertaining one.

Journalist's task:

- They enjoyed asking question to their relatives.

This is the outcome to the "**What task did you like the least?**" question:
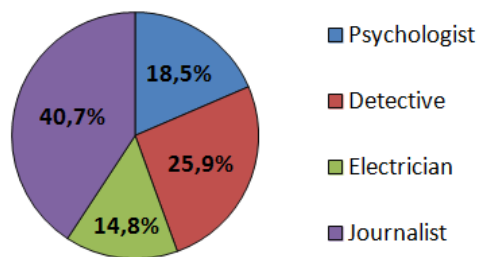


In this case, there is also one task that stands out for being the least liked: the Journalist's task. Below, there is a compilation of the reasons given to why they didn't like the task selected.

Psychologist's task:

- They found it boring and/or absurd.

Detective's task:

- They didn't understand the mechanic of the task and did it wrong.

Electrician's task:

- They found it chaotic to go around the house looking for electrical appliances.

Journalist's task:

- They found it too long to be completed (too many questions) and they got tired.

- Their relatives didn't have time to answer the questions.

- They generally don't like interviewing.

In regard to the **"What didn't you like about the app?"** question, some negative, but really useful, feedback was obtained. Nevertheless, 11 children indicated that they had liked everything about the app. This is a summary of the most common answers:

- They found it too short (only 4 activities). They claimed they would have liked to continue performing more tasks.

- The app suddenly shut down or it was running too slow.

- They didn't like the fact that extra points were given because they didn't know (it was a surprise element of the CP presented in the *Mechanics* paragraph of the section *4.2. Gamification)*.

- They didn't like the narrative.

- They didn't know what to answer to the questions asked through the CP.

Finally, to try to understand them better and learn from their ideas, they were asked **"How do you think the app could be improved?"** and, besides some children who said they liked everything, possible improvements for the app can be summarized in:

- Adding more tasks to make the app last longer.

- Changing (or reducing) the questions asked through the CP.

- Explaining specific energy-related terms that may be unfamiliar to them.

- Adding the possibility to win virtual goods or buy things with virtual currency.

On the other side, data gathered through the CP has been also analyzed. In the Psychologist's task, it stands out that the "Joy" emotion was used a lot more than the other three to describe how someone felt while using an appliance. Next, in the Detective's task, it was surprising to see how most of the participants and their relatives had a green behavior and, those who didn't, acknowledged their mistakes and how they would do to change their habits. Also, in the Electrician's task, it was interesting how all the kids answered that, indeed, there is a difference between the use of electricity on labor days and the use on weekend days, but from two different points of view. Some kids claimed that electricity usage was higher on labor days because they dedicated the weekends to spend time with family or go out. On the other hand, the rest of the kids defended that the electricity usage was higher on weekend days because they had the chance to play videogames, watch TV, cook, etc (things they cannot do on labor days because they spend half the day at school or at work). Lastly, in the Journalist's task, questions revealed that most people: didn't know they could consult their electricity consumption or did it through their electric company, think they could reduce their consumption without much effort, understand consumption data better in Euros, agree that their kids will contribute to reduce the consumption if they got some reward in return, etc.

## 6.3. Statistical results

In order to test the main hypothesis of this project claiming that gamified CP may get better results than non gamified ones, measures have been calculated and passed through a significance test to know what is the difference and if it can be considered significant or, otherwise, is due to chance. Therefore, the null hypothesis equals both versions of the CP obtaining the same results.

Relevant measures to take are the CP completion rate, the task completion rate and the time to complete the CP rate. First measure's data is discrete: each user CP is assigned a 0 if not completed, and 1 if completed. The other two measures' data is continuous: a task consists in a series of subtasks to perform, so the task completion rate can take a value from 0 to 4 (from none tasks completed to all tasks completed) and the time is a quantity in hours. In total, there are results from 25 different users.

### 6.3.1. CP Completion Rate

For the CP completion rate, proportion of participants who completed the CP from the total numbers of participants is calculated. To test the significance between the results' difference, a comparison between populations has been performed given that the measures' data is discrete.

| CP | GAMIFIED | NON GAMIFIED |
|---|---|---|
| Participants | 14 | 11 |
| Completed | 11 | 9 |
| Completion rate (%) | 78,57 | 81,82 |

*Table 6.1. CP completion results*

After comparing both results (see *Table 6.1*), it is concluded that there is a 15,65% chance that the proportions are different (in fact, the non gamified CP seems to have obtained better results). However, given that 0,8435 is the p-value obtained, and this value is greater than 0,05 (significance level with a confidence interval of 95%), the difference of completion between both CP is not significant enough to reject the null hypothesis.

### 6.3.2. Task Completion Rate

For the task completion rate, amount of tasks completed by participants (all of them, not only the ones who finished the CP) are recollected (see *Table 6.3* and *Table 6.4*). Rate is calculated in proportion to the total of 4 tasks to perform in the CP. To test the significance between the results' difference, the choice is to perform an unpaired t-test, given that the variables are not related and the measures' data is continuous.

As a result of the test, the p-value is 0,2473 (greater than the significance level of 0,05), therefore, the difference of tasks completion between both CP is not considered to be statistically significant either. Even if the task completion rate has been greater on the non gamified CP, again, the null hypothesis cannot be rejected. Statistical values used to perform the test are depicted in *Table 6.2*.

| TASK COMPLETION | Mean | min | max | sd | rate (%) |
|---|---|---|---|---|---|
| Gamified | 3,54 | 1 | 4 | 1,01 | 88,5 |
| Non gamified | 3,91 | 3,25 | 4 | 0,23 | 97,75 |

*Table 6.2. Task completion statistical values for both CP*

| TASK COMPLETION RATE | | | | | |
|---|---|---|---|---|---|
| **GAMIFIED** | **Psychologist** | **Detective** | **Electrician** | **Journalist** | **Total tasks** |
| **User 1** | 1 | 1 | 1 | 1 | 4 |
| **User 2** | 0 | 0 | 1 | 0 | 1 |
| **User 3** | 1 | 1 | 1 | 1 | 4 |
| **User 4** | 1 | 1 | 1 | 1 | 4 |
| **User 5** | 1 | 1 | 1 | 1 | 4 |
| **User 6** | 1 | 1 | 1 | 1 | 4 |
| **User 7** | 1 | 1 | 1 | 1 | 4 |
| **User 8** | 1 | 1 | 1 | 0 | 3 |
| **User 9** | 1 | 1 | 1 | 1 | 4 |
| **User 10** | 1 | 1 | 1 | 1 | 4 |
| **User 11** | 1 | 1 | 1 | 1 | 4 |
| **User 12** | 1 | 1 | 1 | 1 | 4 |
| **User 13** | 0 | 0,25 | 1 | 0,25 | 1,5 |
| **User 14** | 1 | 1 | 1 | 1 | 4 |
| **Average** | **0,8571** | **0,875** | **1** | **0,8035** | **3,54** |

*Table 6.3. Task completion results in the gamified CP*

| TASK COMPLETION RATE | | | | | |
|---|---|---|---|---|---|
| **NON GAMIFIED** | **Psychologist** | **Detective** | **Electrician** | **Journalist** | **Total tasks** |
| **User 15** | 1 | 1 | 1 | 0,25 | 3,25 |
| **User 16** | 1 | 1 | 1 | 1 | 4 |
| **User 17** | 1 | 1 | 1 | 1 | 4 |
| **User 18** | 1 | 1 | 1 | 1 | 4 |
| **User 19** | 1 | 1 | 1 | 1 | 4 |
| **User 20** | 1 | 1 | 1 | 1 | 4 |
| **User 21** | 1 | 1 | 1 | 1 | 4 |
| **User 22** | 1 | 1 | 1 | 1 | 4 |
| **User 23** | 1 | 1 | 1 | 1 | 4 |
| **User 24** | 1 | 1 | 1 | 1 | 4 |
| **User 25** | 1 | 1 | 1 | 0,75 | 3,75 |
| **Average** | **1** | **1** | **1** | **0,909** | **3,91** |

*Table 6.4. Task completion results in the non gamified CP*

### 6.3.3. CP Completion Time Rate

For the CP completion time, the amount of hours that participants spent using the CP until they completed it is counted (see *Table 6.5* and *Table 6.6*). Rate is calculated in proportion to the total of 192 hours they had to finish the CP (8 days). To test the significance between the results' difference, the choice is to perform an unpaired t-test, given that the variables are not related and the measures' data is continuous.

| TIME | |
|---|---|
| **GAMIFIED** | **Total time (h)** |
| User 1 | 19,8 |
| User 2 | – |
| User 3 | 20,2 |
| User 4 | 173,8 |
| User 5 | 16,8 |
| User 6 | 121,1 |
| User 7 | 171,4 |
| User 8 | – |
| User 9 | 98,5 |
| User 10 | 25,5 |
| User 11 | 25,7 |
| User 12 | 140,1 |
| User 13 | – |
| User 14 | 118,9 |
| **Average** | **84,71** |

*Table 6.5. CP completion time results in the gamified CP*

| TIME | |
|---|---|
| **NON GAMIFIED** | **Total time (h)** |
| User 15 | – |
| User 16 | 74 |
| User 17 | 167,3 |
| User 18 | 92,9 |
| User 19 | 33,9 |
| User 20 | 148,3 |
| User 21 | 114,6 |
| User 22 | 48,7 |
| User 23 | 121,5 |
| User 24 | 41,6 |
| User 25 | – |
| **Average** | **93,64** |

*Table 6.6. CP completion time results in the non gamified CP*

| CP COMPLETION TIME | mean | min | max | Sd | rate (%) |
|---|---|---|---|---|---|
| **Gamified** | 84,71 | 16,8 | 173,8 | 64,17 | 44,12 |
| **Non gamified** | 93,64 | 33,9 | 167,3 | 47,84 | 48,77 |

*Table 6.7. CP completion time statistical values for both CP*

In this case, the average results are pretty similar, highlighting the fact that both versions of the CP have been completed, in average, in less than half of the time given for it. As a result of the test, the p-value of 0,7335 indicates that the difference of spent time to complete the CP in both versions is not statistically significant (taking a significance level of 0,05). Once more, the null hypothesis cannot be

rejected, which means the alternative hypothesis cannot be accepted. Statistical values used to perform the test are depicted in Table 6.7.

In conclusion, even if the null hypothesis (i.e. gamified and non gamified version of the CP obtaining the same results) cannot be rejected after taking the previous tests, given that there is no enough evidences, it doesn't mean that it can be accepted either. This means that some more evaluations and research could be done in order to obtain solid results.

 Below, there is a summary of the results for each measure depicted in *Table 6.8*.

| CP | GAMIFIED | NON GAMIFIED |
|---|---|---|
| Participants | 14 | 11 |
| CP Completion number | 11 | 9 |
| CP Completion Rate (%) | 78,57 | 81,82 |
| Task number | 4 | 4 |
| Task Completion number | 3,54 | 3,91 |
| Task Completion Rate (%) | 88,5 | 97,75 |
| CP Time (h) | 192 | 192 |
| CP Completion Time (h) | 84,71 | 93,64 |
| CP Time rate (%) | 44,12 | 48,77 |

*Table 6.8. Summary of results for both CP*

# 7. Conclusions and future work

In this project, a full proposal of a Cultural Probes in the context of energy consumption is presented. The CP has been designed in detail, including gamification, and successfully implemented (as a mobile application) in both versions (gamified and non gamified CP). Specifically, the design of the CP focuses on children, who have to perform different tasks taking several roles (psychologist, detective, electrician and journalist) to gather information about their own and also their families' electric consumption. On the other hand, the gamification design is based on adding some game elements to the CP such as points, badges, missions, an avatar, a leaderboard, a progress bar and a narrative.

It was a strong thought that the gamification of the CP would motivate the users to complete its tasks given that, usually, classical Cultural Probes present a low completion rate. That is why the main hypothesis of this project is placed on the fact that gamification of CP provides better results in quantity and quality. In regards to this, the implemented app has been evaluated with real users (children from two schools in Barcelona) and results have been computed. Even though this hypothesis could not be proved due to a lack of evidences to suggest the differences between both versions of the CP are significant, it cannot be rejected either. Moreover, outcomes could have been conditioned by noise, such as the children's high motivation to participate in extracurricular activities, no matter what they are about, the quantity of recruited users or other external factors. However, in this case, the non gamified version of the CP seems to have obtained better results of overall completion.

Furthermore, it was believed that the realization of the CP might raise awareness on the participants (and maybe their families) about energy and environmental related issues, which is exactly what happened according to the results of the pre and post-test questionnaires the participants of the evaluation filled in (before and after the use of the CP app). Also, it has been possible to gather some valuable insight from the participant families.

Besides the main goals of this project, personal goals have been achieved as well. On top of all, this project has given me the chance to acquire knowledge about HCI methods on users' analysis, more specifically, about Cultural Probes. Also, it has been an opportunity to improve my programming skills and know more about software development, and it has let me apply several learned concepts throughout the degree in different parts of this project. Working with a tutor has been a really useful experience to learn from her knowledge and collaborate by providing my own ideas. Personally, I'm proud of the final result of this project, and I achieved every single goal I proposed in the beginning.

During the project's development and after the evaluation, there were some ideas and improvements that were believed to be interesting to explore as future work:

- The design and inclusion of more tasks to the CP, given that several children complained that they found it too short and would have liked to continue performing other tasks.

- The addition of mini games (educational or purely for fun) in between the realization of tasks or as an achievement to unlock in the gamified version.

- The redesign of the website's prototype (see *Figure 1.1*) made in the first iteration of the development (see *Figure 1.2*).

For example, gathered data made it obvious that the kids and their parents don't have the same interests or concerns. Therefore, it would be interesting to design a platform with two separated sections depending on who is the user (a kid or an adult), but also another section more focused on family as a whole, because analyzed data also claims that inner families interactions have an influence on behaviors and electricity usage.

- The inclusion of tips, recommendations or concepts' definitions through the CP. The last one would help the kids understand some questions or words presented during the CP.

- The improvement of the database design and connection. Some small bugs about the stored data were found during the evaluation.

As a result of this project, two papers have been published: one presented to the womENcourage conference [2], and other one sent to the British HCI conference [3].

Finally, even if this study is based on the SmartGrid and energy consumption context, lessons learned through this project's research and evaluation can also be applied to CP in other family related matters, such as water consumption and waste management. Also, more research could be done in order to obtain more solid results on the hypothesis that gamified CP provide better results than non gamified ones, given that it could not be accepted, but neither rejected.

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## Appendix A. Evaluation material

## A.1. Consent form

**PROJECTE: CULTURAL PROBES EN EL CONTEXT DE L'ENERGIA**

**FULL INFORMATIU PELS PARES**

**Introducció**
- En aquest estudi es demana al seu fill/a de participar voluntàriament en un estudi d'investigació. Ha estat seleccionat com a possible participant perquè té una edat d'entre 12 i 13 anys, té mòbil o tableta pròpia i pertany a una família de com a mínim 4 membres.
- Li demanem que llegeixi aquest document i faci qualsevol pregunta[5] que pugui tenir abans de permetre que el seu fill/a participi en aquest estudi.

**Objectius**
- Aquest estudi té com a objectiu conèixer millor les necessitats que les famílies tenen en relació al consum i gestió de l'energia elèctrica. Per aconseguir aquest objectiu es farà servir un mètode anomenat "Cultural Probes", que consisteix en donar unes activitats als nens i nenes per a fer voluntàriament a casa durant un període limitat de temps.
- La informació obtinguda en aquest temps servirà per al disseny d'aplicacions informàtiques que ajudin a les famílies a gestionar el seu consum elèctric i canviar o adaptar els seus hàbits relacionats amb l'energia.

**Procediment**
- El seu fill/a tindrà instal·lada una aplicació al seu dispositiu (mòbil o tableta amb sistema operatiu Android) durant dues setmanes. Concretament, l'última setmana de maig i la primera de juny de 2017. Després d'aquest període, l'aplicació quedarà inactiva, llista per a ésser eliminada del dispositiu.
- Aquesta aplicació demana fer un seguit d'activitats que requereixen la interacció del seu/seva fill/a amb pares i germans/nes. Aquestes activitats es fan voluntàriament quan es tinguin uns minuts d'esbarjo al llarg durant el dia.

**Confidencialitat**
- Tota la informació serà tractada de forma anònima, cap informació serà retinguda ni utilitzada amb altres finalitats que aquelles d'establir conclusions de recerca i compartir-les amb la comunitat educativa, famílies i altres investigadors.

**Beneficis**
- La participació en aquest estudi pot fer que la seva família sigui més conscient dels bons i mals hàbits de consum elèctric.

**Consentiment**
- La seva firma a sota indica que vostè ha decidit permetre al seu fill/a participar en aquest estudi, i que vostè ha entès la informació proporcionada abans.

---

[5] *Per a qualsevol dubte sobre l'estudi el pares poden contactar per correu amb les investigadores del projecte:* inmarodriguez@ub.edu*,* annapuig@ub.edu*, Departament de Matemàtiques i Informàtica de la Universitat de Barcelona.*

☐   Marcar si vostè autoritza que la imatge del seu fill/a pugui ésser utilitzada en els medis en els quals es difondran els resultats d'aquest estudi.

Pare/Mare (Tutor del menor) Nom i cognoms: _____    Dni: _____

Pare/Mare (Tutor del menor) Signatura: _____    Data: _____

Investigadores de l'estudi:
Dra. Inmaculada Rodríguez Santiago
Dra. Anna Puig Puig
Departament Matemàtiques i Informàtica
Facultat de Matemàtiques i Informàtica
Universitat de Barcelona

## A.2. Pre-test questionnaire

(Questions marked with * mean they are mandatory)

1. **Email address (the one you will use to register into the app)** *

2. **Gender** *

   ○ Boy

   ○ Girl

3. **Age** *

   ○ 10

   ○ 11

   ○ 12

4. **Do you know what energetic efficiency is?** *

   ○ Yes, I know

   ○ No, I've never heard of it

5. **In case you know what it is, explain it with your own words**

6. **Are you concerned about your household energetic consumption?** *

   ○ Yes

   ○ No

7. **Do you know if yours and your family's energy related behavior is respectful with the environment?** *

   ○ Yes

   ○ A little

   ○ No

8. **Are you aware of your household electricity usage?** *

   ○ Yes

   ○ A little

   ○ No

9. **What is your level of interest about knowing how much energy you consume and how much you are capable to save?** *

○ None

○ Little

○ Some

○ Quite

○ Plenty

10. **What is YOUR level of compromise about making a responsible use of energy?** *

○ None

○ Little

○ Some

○ Quite

○ Plenty

11. **What is your FAMILY's level of compromise about making a responsible use of energy?** *

○ None

○ Little

○ Some

○ Quite

○ Plenty

## A.3. Post-test questionnaire

(Questions marked with * mean they are mandatory)

1. **Email address (the one you will use to register into the app)** *

2. **Gender** *

○ Boy

○ Girl

3. **Age** *

    ○ 10

    ○ 11

    ○ 12

4. **After using the app, are you more conscious if yours and your family's energy related behavior is respectful with the environment?** *

    ○ Yes

    ○ A little

    ○ No

5. **After using the app, are you more conscious about your household electricity usage?** *

    ○ Yes

    ○ A little

    ○ No

6. **After using the app, what is your level of interest about knowing how much energy you consume and how much you are capable to save?** *

    ○ None

    ○ Little

    ○ Some

    ○ Quite

    ○ Plenty

7. **After using the app, what is YOUR level of compromise about making a responsible use of energy?** *

    ○ None

    ○ Little

    ○ Some

    ○ Quite

    ○ Plenty

8. **After using the app, what is your FAMILY's level of compromise about making a responsible use of energy?** *

   ○ None

   ○ Little

   ○ Some

   ○ Quite

   ○ Plenty

9. **What motivated you to do the tasks of the app?** *

10. **What task did you like the most?** *

    ○ Psychologist

    ○ Detective

    ○ Electrician

    ○ Journalist

11. **Why?** *

12. **What task did you like the least?** *

    ○ Psychologist

    ○ Detective

    ○ Electrician

    ○ Journalist

13. **Why?** *

14. **What didn't you like about the app?** *

15. **How do you think it could be improved?** *

## A.4. Journalist's mission questionnaire

1. **Do you contribute to the electric household bill payment?**

   ○ Yes

   ○ No

2. **(If "Yes") Do you think that paying the bills motivates you to make a more moderate use of electricity than the rest of the people in your house?**

    ○ Yes

    ○ No

2. **(If "No") Do you think that if you paid the bills, you would change some habits to reduce the electricity consumption?**

    ○ Yes

    ○ No

3. **Have you ever consulted your house's global consumption in some web page or app?**

    ○ Yes

    ○ No

4. **(If "Yes") What web?**

    ○ The energetic company's web/app (Endesa, Iberdrola, etc)

    ○ A general web/app of consumption calculation

    ○ A web/app connected to the house's meter that allows me to see my consumption in real time

4. **(If "No") Why not?**

    ○ I'm not interested in knowing my house's consumption

    ○ I don't understand the information provided by web pages

    ○ Someone else has consulted the house's consumption for me

    ○ I didn't know that I could consult that information

5. **Are you concerned about the price of the electric household bill?**

    ○ Indifferent

    ○ A little

    ○ A lot

6. **Are you concerned about the environmental impact that energy consumption implicates?**

    ○ Indifferent

    ○ A little

    ○ A lot

7. **Do you think you can reduce your household electricity consumption?**

○ Yes, without diminishing my comfort

○ Yes, clearly diminishing my comfort

○ No, I already took steps to reduce it

○ I don't know and I don't care

8. **How do you understand the consumption information better?**

○ In energy (kWh)

○ In Euros (€)

○ In kWh and Euros

○ I don't understand it in any way

9. **Do you like to encourage other people to have a responsible energy related behavior?**

○ Yes

○ No

10. **What kind of tips or recommendations related to energy consumption would you like to receive?**

○ How to reduce the price of the household electricity bill by making small changes of habits

○ How to reduce the price of the household electricity bill by the acquisition of energy efficient electrical appliances

○ Both of them

**Specific questions for adults**

11. **Do you know how much you pay for the power you have hired?**

○ Yes

○ No

12. **How do you know or would try to know if you can lower the power you have hired?**

○ Through the electrical company

○ Searching information in a web page about energy saving

○ Asking to family relatives or friends

○ Asking to Rubí Brilla (Town hall of Rubí)

**13. Do you know how much power you hired and if it is appropriate?**

○ I don't know the power I hired

○ Yes, and it is appropriate

○ Yes, but I think is more than what I need

**14. Do you know about the hourly discrimination tax (known also as night tax)?**

○ Yes, I hired it

○ Yes, but I didn't hire it

○ I don't know about it

**15. Would you be more motivated to save energy if you could compare your household consumption to your nearest neighbors' consumption?**

○ Yes

○ No

**16. Do you think that you could save more energy if you applied the 50/50 project at home, which means, giving your kids the money saved in the bills as a monthly pay?**

○ Yes, I think that would make my kids effort into not wasting energy

○ No, I don't think that would work

**Specific questions for children**

**11. Do you know how much money is spent on the household electrical bill?**

○ Yes

○ No

**12. If saving energy at home had a positive impact on you as a reward, would you apply steps to reduce electricity consumption?**

○ No, I already do my best to save energy

○ Yes, I think I can try harder to save energy

○ It depends on the kind of reward

# Appendix B. Technical manual

This section aims to explain some technical aspects of the project to provide other developers with the necessary information to extend or modify the applications (gamified and non gamified).

The development of the project has been made on Windows using Unity and *bplaced*.

## B.1. Unity

The Unity project has the following folders in Assets:

- **Animations:** contains the buttons' animation.

- **Fonts:** contains font types.

- **PHP-Scripts:** contains the .php scripts to store data in the database.

- **Prefabs:** contains several prefabs of the screens and some elements.

- **Resources:** contains images and icons.

- **Scenes:** contains all the scenes of the app.

- **Scripts:** contains the .cs scripts of the Unity project (see *Table 5.1*).

- **Extras:** contains some prefabs, icons and animations not used in this project.

To generate the executable, every scene that has to be in the app needs to be added, otherwise, interactions won't work correctly. To add them, follow these steps: go to *File -> Build Settings -> Add open scenes* or drag the scenes into the *Scenes In Build* box. Once the scenes are added, it is necessary to choose a platform (in this case, Android) and configure the *Player settings* to specify things as the minimum API level allowed or the screen's orientation. Finally, the executable is generated by clicking "Build" (in this case, an .apk is saved to the computer) and ready to install. It is also possible to debug the app directly on a mobile device by enabling the *Developer Options* and the *USB Debugging* on the specific device.

## B.2. Database

To create and configure the database, the chosen in this project is *bplaced.* The steps to configure the database are:

1. Go to www.bplaced.net and register by filling the following form (username will be the name of the database):

2. Once registered, go to "MySQL database", where you can add and see all the MySQL databases created (in this case, 4 databases were created, one for each school).



3. Go to *phpMyAdmin* and introduce the username and password used to create the *bplaced* database. These will be used later for the remote connection.

4. Import the tables by clicking "Import" and introducing the .sql file with the tables' structure (for this project, they are "TFG_DB.sql" and "TFG_DB_NG.sql", one for the gamified version and one for the non gamified version).
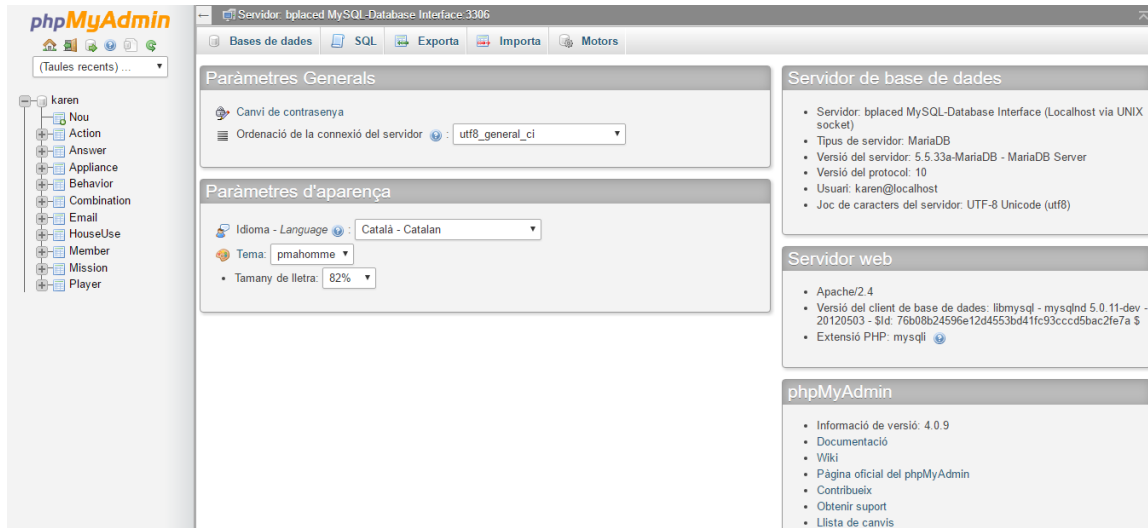


5. Create and configure the .php files. If different database name or password wants to be used, some lines of code need to be modified. These are:

   ➢ *mysql_connect('localhost', 'karen_bcn', '26091994')* -> change *'karen_bcn'* for the new database name and *'26091994'* for the new password.

   ➢ *mysql_select_db('karen_bcn')* -> change *'karen_bcn'* for the new database name.

6. Copy the .php files created to make the connections between the app and the database into the correspondent directory using a FTP application (in this case, FileZilla was used).

## **Appendix C. User manual**

This section briefly explains the requirements and steps to install and run the gamified app[6] and the non gamified app[7] in a mobile device.

Requirements:

- Device must have Android operative system.

- Version must be a version above the 4.1 (Jelly Bean).


Steps to install the app:

- Download the .apk file (it contains the app).

- If a message saying "Blocked installation" pops up, click "Configuration". Look for the option "Unknown sources" and enable it. Finally, click "Accept".

- Click "Install"

- Open the app.

After following these steps, the app is successfully installed and it appears on the Applications panel (its icon is a light bulb in both versions).

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[6] The gamified app is called "Bogeria Energètica" (Energy Madness)

[7] The non gamified app is called "Energia Familiar" (Energetic Family)