





# Redesign and New Evaluation of a Pervasive Game for Older Adults

Alberto Urquía<sup>1</sup>, Jesús Gallardo<sup>2</sup>, Raquel Lacuesta<sup>2</sup>, Joan-Josep Ordóñez-Bonet<sup>3</sup>  
and Silvia Ramis-Guarinos<sup>3</sup>

<sup>1</sup>University of Zaragoza, Zaragoza, Spain

<sup>2</sup>Department of Computing and Systems Engineering, Aragon Institute for Engineering Research (I3A),  
University of Zaragoza, Teruel, Spain

<sup>3</sup>Department of Mathematics and Computing, University of Illes Balears, Palma, Spain

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**Abstract:** Older adults are a growing segment of the population. Many aspects of technology could help this sector improve different facets of their daily lives. One such aspect is video games, something with which older adults are becoming increasingly familiar. Within video games, a field that has grown a lot in recent years is that of pervasive games, those that break some of the classic spatial, temporal or social limits that classic video games have. Following this trend, we developed a pervasive mobile game designed for older adults inspired by Pokémon Go that consisted of players having to move through a physical space to locate real objects that would allow them to unlock memories that were stored in an album. The game had a lot of room for improvement in terms of its visual aspect, and to improve it a redesign and evaluation has been carried out, resulting in a new interface for the application, along with a series of modifications to the game mechanics and introduction of additional ones that allow branching the game experience towards different profiles and needs. In addition, the problems related to its accessibility and usability have been addressed through a series of considerations that can be extrapolated to the design of applications for older adults.


## 1 INTRODUCTION


We are presently witnessing a rise in the demographic segment often referred to as older adults, which includes individuals aged 65 and above. Recognizing the importance of taking advantage of their learning capabilities, it becomes crucial to involve them in initiatives that foster their personal development (Morillas and Martínez, 2013). In Spain, computer games dominate the landscape of digital entertainment, constituting over half of total time spent in leisure activities. It's noteworthy that computer games are no longer restricted to children and young adults; they are now used by various age groups. This shift is attributed, in part, to the rise of the so-called serious games, which are used for purposes beyond mere entertainment, such as socialization and education.


The Spanish Association of Video Games (AEVI) reports that 47% of the global revenue from computer games is generated by mobile games, showing a significant annual growth rate (12.8% more than in 2017) (AEVI, 2019). This trend shows the reality that smartphones have become the primary platform for engaging in computer games.

Additionally, involving older adults in Information and Communication Technologies is crucial for bridging the digital divide, which can otherwise lead to exclusion and dependency for those not integrated into the information society. Once again, computer games play a crucial role. A study (Allaire et al., 2013) involving 140 participants with an average age of 77.5 years revealed that those who played computer games regularly or occasionally exhibited better socio-emotional outcomes than those who had never engaged in such games.

<sup>a</sup> <https://orcid.org/0000-0001-9895-0837>

<sup>b</sup> <https://orcid.org/0000-0002-4773-4904>

<sup>c</sup> <https://orcid.org/0009-0002-7536-1874>

<sup>d</sup> <https://orcid.org/0000-0002-1039-4387>

When developing software tailored for older adults, including computer games, specific requirements must be considered. Given that older adults are now entering the field of computer games, finding appropriate motivation for their participation is essential. Adopting a user-centered approach in the design and implementation of the game proves to be an effective strategy.

The evolution of computer games aligns with technological advancements throughout history. In recent years, a new paradigm, pervasive games, has emerged. Pervasive games (Montola, 2005) transcend traditional boundaries in terms of spatial, temporal, and social dimensions. Popularized by games like Pokémon Go, these experiences use novel technologies such as virtual/augmented reality or geolocation, extending gameplay beyond the confines of traditional computer games.

Taking the aforementioned into account, we have carried out the redesign and a new evaluation for the game EncuentraTe. This is a pervasive game for its use in mobile phones whose initial idea and previous studies were carried out by the AffectiveLab research team at Teruel. The initial design used augmented reality to display different historical and cultural memories, both local and national, appealing to the interest of older adults, when walking throughout a physical space and finding some physical objects. Its users are the people staying at a residential complex in the city of Teruel, Spain. The development of the game was supervised by the therapists of the complex, and older adults themselves participated in the development of the game.

Specifically, the goal of this work is the redesign and evaluation of the mobile application aforementioned, resulting in a new interface for the application, along with a series of modifications in the game mechanics and the introduction of additional ones that allow branching the game experience towards different profiles and needs. In addition, the problems related to accessibility and usability are addressed through a series of considerations that can be extrapolated to the design of applications for older adults.

The first step in our work is a study that makes use of several techniques for the analysis of the game in order to its further redesign. One of the tools used is the Microsoft Inclusive Design Toolkit, which has been analyzed and adapted for use in this context. Different activities of the toolkit have been used to understand the problem, draw conclusions, devise and adapt the final design.

Also, surveys and interviews with the players themselves have been conducted to study in depth

their behavior, their relationship with the application and the various issues that arise in the initial design. Other interviews with workers of this sector, such as therapists and administrative staff, shed light on their experiences, exercises and rehabilitation activities that are exercised to achieve the well-being of the residents.

Heuristics have also been adapted from existing ones (Desurvire and Wiberg, 2009; Pinelle et al., 2008) to be useful for the current working context. These series of points to be reviewed allows to identify the problems to be solved in the redesign phase.

After all this step of analysis, the redesign itself has been carried out. The construction of the prototype is essential to test how users react to the final interface and to resolve certain details of the interface that don't quite work. Then, an attempt was made to adapt the design to as many users as possible, taking into account physical, cognitive, sensory, etc. limitations they may have. This way, it is possible to achieve greater accessibility and avoid the exclusion of certain users.

Finally, a survey similar to the one initially provided has been carried out to the users who have tested the new design, in order to compare both and extract the degree of improvement with respect to key aspects and new functionalities. After this analysis, a series of conclusions of the project are listed, including different observations and final considerations, the difficulties encountered throughout the development, possible avenues for future work and a brief personal assessment.

## **2 COMPUTER GAMES ORIENTED TOWARDS OLDER ADULTS**

In recent years, there has been a notable rise in game development designed for older adults, accompanied by valuable findings guiding the creation of video games for adults. Several noteworthy studies in this field will be outlined below. In (Cota et al., 2015), researchers inquired into factors influencing the engagement of older adults in mobile games. Their approach involved constructing a game catalogue to identify preferred genres among the target population. Subsequently, a game named "Traveling the World" was developed, featuring various mini-games aligned with the genre preferences that were identified. Through this effort, the researchers detailed some motivating elements for older adults, such as the fact

that when players interact with the game, there should be a clear result. Also, the game should get a bit harder over time, and the rules should be simple. It was also noticed that information about why playing is beneficial is essential, and the game should be easy to see and use, with clear images and good color contrast.

Another interesting example is detailed in (Mubin et al., 2008). This mobile game combines a traditional card-matching game with the quest for specific physical locations, thus implying a pervasive aspect. Called "Walk2Win," this collaborative game, following evaluation, led to recommendations such as maximizing audience reach, minimizing rules, incorporating elements from familiar games, eliminating gender distinctions, and allowing for customizable environments.

Another kind of game encourages older people to do exercises using devices like Microsoft Kinect. This could be for rehabilitation or just staying active. An example is in (Gerling et al., 2011), where the authors used Nintendo Wii to create "SilverPromenade", a game which simulates virtual walks with accompanying mini-games. Insights drawn from this experience emphasized the importance of carefully exploring the capabilities of the target audience, choosing metaphors that lead to easy game entry, and designing games to accommodate a diverse range of players and situations.

Finally, another activity for adults, which shares some aspects with the game we have redesigned, involves the use of virtual or augmented reality with the goal of stimulating players' memory, as seen in the Virtual Maze Task (Cárdenas-Delgado et al., 2017). While not explicitly presented as a game by its authors, this activity incorporates gamification elements, requiring users to learn routes in a maze. The study conducted by the authors explored the differences in satisfaction, interaction, and other aspects between an immersive approach and physical activity.

### 3 *EncuentraTe*: A PERVASIVE GAME FOR OLDER ADULTS

In this section we will put into context the game *EncuentraTe* (Pérez et al., 2021), which is the augmented reality-based pervasive game that has been redesigned in this work. We will detail aspects of the analysis, design and implementation of the game.

The goal of the project was to develop a pervasive game to enhance the quality of life for older adults by keeping them active, mentally engaged, and socially connected. The game was designed collaboratively with the input of residents, staff, and the development team of a senior residential complex. The design process involved a user-centered approach, including meetings and observations.

In a first meeting of the analysis phase, staff and developers conceptualized a game where players locate elements in the complex to unlock memories stored in an album, using augmented reality. With the term "memory" we are referring to the description of an old song or movie, a famous person, a legend from long ago, etc. The second meeting was a focus group involving residents. There, the approach was validated and categories for memories were defined. Observations revealed diverse resident profiles, requiring adaptations to meet varying needs.

The game was developed for Android using the Unity engine, with Google Firebase for backend support and Vuforia for augmented reality. The user interface is tailored for older adults, featuring large, clear buttons, simple fonts, and minimal navigation complexity. The gameplay involves locating specific images in the real world, which, when focused on through the device's camera, display virtual buttons. Tapping these buttons unlocks memories categorized into themes (e.g., culture, sports) and provides multimedia content (images, videos, texts, etc.). Players receive encouragement and medals for progress, with the option to view unlocked memories in an album or compare scores via a ranking system. The visual design mimics an old album with paper and leather textures, offering a traditional aesthetic aligned with the app's theme of memories. A fully functional version of the application was obtained, which was tested with older adults, obtaining valuable feedback for its subsequent improvement.

## 4 ANALYSIS STAGE

In this section of the paper we will explain the different activities that have been carried out to perform the analysis prior to the redesign of the application.

### 4.1 Context Analysis

Firstly, the sequence of use that a player follows has been detailed. This has been achieved dividing in key tasks the different screens and actions that must be followed to perform the registration, the main game

mechanics and the complementary elements such as ranking and collectibles. An example of this can be seen in Figure 1. It has been necessary to make explicit the information displayed on each screen in order to, subsequently, correctly analyze and understand the stimuli perceived by the user, while listing them sequentially.

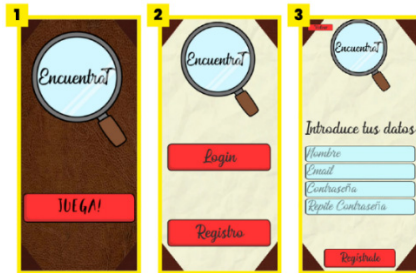


Figure 1: Analysis of the sequence of use of the registration task.

Next, an investigation has been carried out on the applications that are focused on older adults and that allow them to adapt the functionalities of their phone to their needs, provide them with entertainment, a real benefit or an improvement in their daily life. They have been classified into different sections: adaptation of the mobile device, health, entertainment and mental exercise, intergenerational connection, Augmented Reality and AR aimed exclusively at seniors.

## 4.2 Inclusive Design

Once the context in which this game experience is framed has been studied, it is necessary to find the key aspects to take into account to focus on the player and the accessibility of the application, for which we have based on the Inclusive design framework by Microsoft.

There is a wide spectrum in terms of the degree of limitation experienced by users of the range of age that qualifies them as older adults. As for the context of use of the game we are dealing with -a residential complex-, it will be a controlled space most of the time, whose environmental conditions can be regulated to provide an optimal context for play: good lighting, ample space, low noise, etc. In any case, a design focused on the physical limitations of its users will allow the experience to be adapted to other less favorable environmental contexts.

Having listed the physical and cultural limitations suffered by these users, as well as the benefits that this technology can bring them, which should be pursued with this design, it is necessary to analyze the

activities and dynamics proposed by this toolkit. First of all, a description of each one of them and how they would fit within our interests has been made, to later choose the most relevant ones to be applied. As a result of this study, four activities have been chosen from among those proposed by the toolkit and have been rethought for their adaptation to the design for older adults.

Specifically, the activities chosen are the following:

1. Trust in technology. It is necessary to identify what actions they would not trust a machine to perform, focusing on whether they see themselves capable of transmitting the command or that the program is capable of executing it correctly. It is necessary to know to what extent older adults are willing to give leisure time to a new device and how they react to the commands or suggestions it throws at them.

2. Network of people. This activity deals with knowledge about the design challenges in the personal ecosystem of an elder. This should list the interactions between these people during the game and how they relate to each other. It is important that the game experience is not solitary and that it allows them to interact both socially and to encourage curiosity and learning.

3. Disagreement with the solution. Here, the activity proposes to list specific problems associated with one or more elders to improve and adapt their experience in the application and then note and discuss possible solutions to them. From the problems that will be encountered first hand and through the experience of the players themselves, it is possible to collect ideas or functions that solve and enhance the satisfaction produced by the game.

4. Situational adaptation. The idea here is to look for other contexts and constraints encountered by older adults and compare the experience they would have using the designed application. Subsequently, this will continue by adapting and redesigning the interactions with these cases in mind.

## 4.3 Design Principles for Older Adults

From the study of the context and the design process behind these user-centered experiences, different specific characteristics have been crossed from an analysis between different applications and video games aimed at an older audience. The goal is to extract a series of common principles that, when applied during the design of an application targeting this type of users, will improve and facilitate their introduction and understanding of both the medium

and the interaction with the mobile device. Exemplified through their inclusion and design philosophy in different specific titles, added to other information gathered from previous studies, they have been divided among the different sections that make up the gaming experience. These categories and some of the points defined in each category are listed below.

- a. General attributes.
  - Simple.
  - Accessible.
  - Guided.
  - It provides a benefit.
  - Progress can be made mechanically (not introducing new complex mechanics).
  - It does not depend on quick reflexes or coordination of actions.
  - Clear, simple and concise idea or premise.
- b. In-game development.
  - The same basic mechanics with which the tutorial is made are maintained.
  - Difficulty can be increased by increasing the number of elements on the screen or the number of similar actions to be performed, but the learning curve should be very gentle.
- c. Game mechanics
  - Few and intuitive controls. On the case of mobile devices: one or two movements (swipe finger on screen, tilt via gyroscope, search via camera) instead of simulating physical buttons on the screen.
  - Do not overlap different gestures to control the game. If you choose to use swiping, you would only need to use this gesture in the 4 directions throughout the game. The same would be true if you choose to tilt the device.
- d. Menu
  - Immediacy to start playing. Avoid registrations and data entry as much as possible, make it easy to enter as a guest or without a profile.
  - Clearly highlight the main option "Play" or start the game directly when it is opened for the first time.
- e. Interface
  - Properly distinguish each section of the application to avoid mistakes.
  - Use as few simultaneous lines of text as possible, divide the text into simple sentences that the user can move forward and accompany them with voice narration.

## 4.4 Use Analysis

Once the design process to be followed has been defined, it is necessary to study the players and their

needs based on their relationships and interaction with both the application and their environment, discovering the key aspects to be taken into account in the redesign. This step has implied: (i) carrying out surveys and interviews, (ii) the study of therapeutic and learning activities, (iii) the activity about confidence in technology proposed by the Inclusive toolkit, and (iv) the network of people, also from the toolkit. All these activities will be explained in the following subsections.

### 4.4.1 Survey and Interviews

Based on a series of surveys already submitted after the first experience in the context of the residential complex, another one of similar format was designed with the objective of evaluating and finding different functionality problems in the current interface of the application.

When examining the results, some problems were clearly identified: problems in the registration section, some functions that were not clear, or that lack interest for the players. There were also some problems with the visual section and the visualization and interaction with some buttons. Similarly, it was identified some confusion when it came to easily identify the icons with the section of the application they represent. The first attempt often leads to error, having to discard the other options to reach the desired section.

These observations were relevant in order to raise the questions and experiences that we were interested in unraveling in the interview with the players and therapists to make a correct evaluation of the application, delving more deeply into the conflictive points to be corrected and the positive points to be strengthened.

In the management and preparation of the game by the workers, the following considerations stand out:

- Each image to be captured is printed twice. There are two variants of this game: one is assisted (those who use wheelchairs and have physical limitations), where the photos are projected in a room, and the second is for players with greater autonomy, for whom the photos are placed in a corridor where they usually walk, in elevators, halls and multipurpose rooms.

- In order to incentivize the game and encourage older adults to try it, meetings are held with the self-employed, explaining that it is an experience created for them and urging them to investigate it.

Some of the most important points commented by players regarding their experience with the game and the use of new technology:

- Overall, it is fun and entertaining. It is very stimulating to discuss with other players the different

memories and where to find them, although they have difficulty retrieving them and finding where they are stored.

- When starting to play and during most of the games, they have to turn to one of the therapists to solve their doubts (login, screen blocking, exiting a section they have accessed unintentionally, etc.). They also often ask each other many of these difficulties.

Finally, some of the usability issues encountered by seniors during their gaming sessions are as follows:

- During registration, problems with the email, as it does not remember it when the user logs out. This, added to the lack of password confirmation, leads to the creation of new profiles by mistake. In addition, the use of English terms (login, password) confuses them.

- The photos do not correspond to the memories, which generates confusion for them, although it is really designed that way, playing with the surprise factor, but the result is not satisfactory. The first one could be directly related.

By cross-referencing the results between surveys and interviews, it is possible to determine the causes of some of these drawbacks. For instance, although the application remembers the account and the player can enter without having to log in, having to change device at each game session forces the player to have to enter it. In addition, it is not possible to log out of the account created within the app. This forces players to have to create new accounts.

Due to the problem with registrations, loss of accounts and other access-related problems, the ranking is completely unusable. In addition, the interest of players is more in collaboration than in competition, so this method does not result in incentive or motivation to play.

#### 4.4.2 Therapeutic and Learning Activities

Thanks to the collaboration of occupational therapists of a nursing home, we have investigated some of the adapted activities that they present to their residents with therapeutic and rehabilitation objectives. Some of them are aligned with the interests and needs that the developed application tries to cover. Listed below are some of these dynamics and how it would be possible to adapt the design to offer a useful tool, in addition to the segment of users present in each of them:

- Reminiscence: Activity aimed at cognitively impaired older adults with Alzheimer, dementia or other cognitive impairment. It consists of evoking

memories or personal experiences of the person from different objects (photographs, trophies, perfume, toys) that represent their personal tastes or relevant anecdotes with which they have an emotional connection. This activity relates to the basics of the play experience, i.e., finding photographs of their environment and history with which they may be familiar, evoking a memory or experience. For the purpose of including the conversational part of the activity, the inclusion of being able to leave comments and interactions between players about what each memory evokes can be a positive exercise that emotionally connects some of them.

- Montessori method: Initially developed as an educational method for children, many elder care centers adapt these activities for use with their residents who suffer from various physical or mental limitations. The goal is to give older adults a sense of success by completing tasks through small steps that improve their memory and self-esteem. In the EncuentraTe application, this is related to the relationship of each of the memories in its category, distinguished by colors, in addition to teamwork to carry out a clear task.

- Digital education activities: In these day centers, various recreational activities, workshops and classes are held for older adults. One of these workshops consists of computer workshops, where older adults are taught the multimedia center offered by a PC and its recreational possibilities.

- Architecture and space for dementia patients: The ideal architecture, which presents an innovation that has already been incorporated by nursing homes in other countries such as Germany, would be that of a common, central, circular ramp, where older adults can wander freely, and are presented with different plates with stimuli that they can touch, pick up and play with through the sense of touch and hearing.

#### 4.4.3 Confidence in Technology

In this activity, corresponding to one of the activities in the Inclusive Toolkit by Microsoft, an older adult, who owns a personal mobile device, was interviewed. After identifying the actions that he relegates to technology in his daily life and listing the observations and difficulties that arise around this relationship, it is possible to draw a series of conclusions in order to overcome this lack of confidence and incorporate them into the new design. The conclusions are the following:

- To enhance physicality with gestures, vibrations and stimuli that bring tactile interaction with their physical counterparts closer.

- To adapt symbols and language that it is assumed that the user knows (e.g., play, power, source, e-mail) to something more intuitive. It is possible to use similes in a context with which they are familiar.

- To associate the position of the button with its function rather than the symbol that represents it.

- To introduce a tool with which they can communicate and have something similar to a conversation in order to become familiar with a device or function they are unfamiliar with.

#### 4.4.4 People Network

Following another activity adapted from the Inclusive Toolkit, the relationships that exist in the game context and the player's social ecosystem have been graphically represented. This is shown in Figure 2.

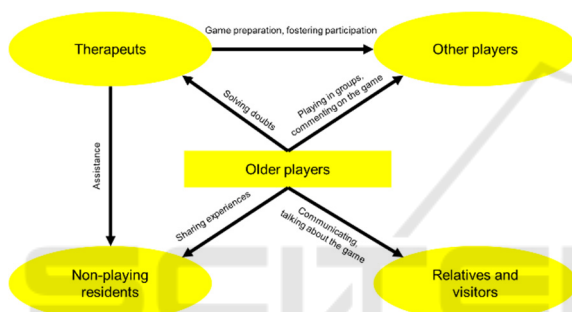


Figure 2: Diagram representing the agents involved and the relationship between them.

In this ecosystem of interactions between different individuals, it is possible to observe the following:

- Willingness to cooperate and develop social skills with other players.

- To strengthen family relationships through knowledge of the possibilities of the mobile device as a recreational and communication tool.

- Exclusion of certain residents who have not been introduced in the game during sessions or in conversation topics. Tools should be included to share the experience, even if they are not directly playing.

#### 4.5 Heuristic Evaluation

In parallel to the analysis of the use and the user, an adapted set of heuristics has been developed based on the heuristics described in the related work section and the design principles previously compiled. Due to comprehension problems, each section has been adapted to the questions asked verbally and in the

questionnaire itself. Then, these experiences and problems have been transferred to the heuristics to evaluate the current design of the application, as the different sections are fulfilled to obtain an optimal, usable and adaptable design for older players.

The heuristics are divided into several sections, with their corresponding subsections: gameplay, emotional immersion and usability and game mechanics. In each one, it is represented by a color if it is fulfilled, it can be improved or it is not fulfilled, accompanied by a comment that highlights the strong point to enhance or the problematic to correct.

#### 4.6 Conclusions of the Process

After carrying out the full study, following the methodologies and activities described in the previous subsections, some of the conclusions drawn in each of the fields are listed below:

a. In terms of gameplay, game progress, challenges to overcome and goals to achieve:

- The tasks to be performed are entertaining for players in the medium-short term, as they are a stimulating novelty, being the arrangement of the photographs what determines the difficulty and variety.

- There are no failure or defeat states, no time or skill pressure to frustrate players, and the feedback is always positive (medals, achievements and score).

b. In the field of emotional immersion we find the following observations:

- The game does not use humor, nor sympathetic elements with which the player feels in a comfortable, informal and playful space. Its only contact with these elements are the memories and the own anecdotes that the user gets to remember by knowing these items, appealing to nostalgia, although the interest of the players is also to be able to access more current events.

- Audio, text and images are present in these memories, but perhaps it would be necessary to have more support in audiovisual content to achieve better immersion and attention.

c. In the area of usability and the game mechanics themselves, we conclude the following points:

- The entry barrier is very high for an older adult, who does not know the necessary steps to enter a digital application. This, together with the lack of tutorial and guidance of the player throughout the course of the game, makes external assistance strictly necessary both for registration, something that causes frustration in them and that must be remembered in each game session, and to start playing. Including an avatar/pet for users to empathize with and serve as an

assistant during the game experience could be a solution for them to become self-sufficient with the use of the application.

- Once the mechanics have been internalized, the player may be able to play independently, although they will continually need the assistance of personnel external to the game, such as for screens they have inadvertently entered, remembering the user they entered with, etc.

- d. As final considerations, some of the small interface details to be modified that would significantly improve usability would be the following:

- Correct the consistency with the names. The medals section is named as badges when getting a souvenir.

- Correct the consistency with the icons. The album is represented with different images.

- Correct the consistency with the typography and its sizes, in addition to using a more legible one for the titles.

## 5 REDESIGN STAGE

Taking the conclusions gathered in the study phase as a basis, it is possible to focus the application redesign process to solve the problems detected and enhance its strengths, improving its accessibility and adaptability, with the aim of defining the concept to be prototyped. In the following subsections we are going to detail the phases of the redesign of the application.

### 5.1 Ideation

Following the activity "Discordance with the solution", adapted from the Inclusive Toolkit by Microsoft, the most important problems or aspects to be improved and the solution chosen for each one of them, which has been selected through the generation of ideas, are listed below.

- a. Need for constant assistance from therapists, both to start playing for the first time or in a session and during the game.

- Inclusion of an avatar or mascot that the player empathizes with and "trusts" to guide him/her through the application and motivate him/her to continue playing.

- b. To promote team play and socialization.

- Creation of clans where collaboration is needed to unlock certain memories.

- Obtaining medals/achievements by adding up the progress of several players.

- c. Problems with the register, its understanding and reminder of the accounts.

- Use a physical item that can be scanned.

- d. Lack of motivation and knowledge of the objectives and achievements offered by the game.

- Focus on the progress bar and the amount of memories that remain to be discovered.

### 5.2 Assistant

In order to guide, assist and motivate the player to continue playing and complete their objectives, a mascot has been created to appear in the game space and in the different menus. It is the representation of a photograph (souvenir), which holds a magnifying glass, which is the characteristic element of the videogame. The graphical appearance of the assistant can be seen in Figure 3.

The first time the user enters the application, this mascot will guide him/her through the tutorial, then show what his next goal is (capturing memories and completing categories) and congratulate the player on each of his progress. It is important to talk to him and use a colloquial tone with which the player feels comfortable and empathizes, establishing a link with the video game itself.

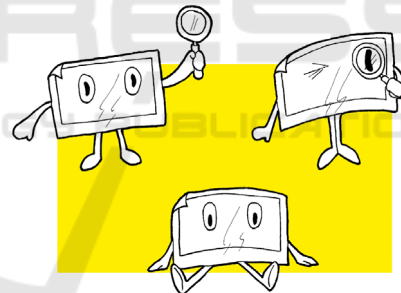


Figure 3: Design of the new assistant mascot.

### 5.3 Content Structure

Figure 4 shows the entire content of the application and how the different sections are structured. The wizard balloon is introduced in the sections where the player needs some context and additional information about its function. It is also present in the play area (real space) contextualized within the Augmented Reality environment. It is possible for the player to click on it to get more help when needed. With respect to the initial design, the team and profile functions have also been introduced, in addition to the unification of the medal section and the album section.



Figure 4: Structural diagram of the application's content.

## 5.4 Wireframes

The sequence of use that players must follow to complete each of the tasks has been defined in a series of wireframes. Every screen that will be displayed in the application is represented in a schematic way. An example of this is shown in Figure 5.

The main tasks that the players will have to perform and that should be optimized to the maximum are:

- Profile creation.
- Memory capture.
- Open a memory from the album.
- To be part of a group.



Figure 5. Fragment of the sequence of use of a task.

## 5.5 Additional Functionality

Next, and as a complement to these tasks described from the sketches of the screens and interfaces through which the user will navigate, we list some of the additional (secondary) functionalities that would further improve the players' experience, trying to adapt the game to the different profiles and conceptualized from sketches. These are:

- Capture of memory fragments. split some memories into different fragments. Each fragment can be captured by a different member of the same group, to increase the collaboration and interaction of the players outside the game, communicating with each other to capture the missing memory.

- Collaborative competition. By joining a team in the same way as they would get a souvenir, they start sharing the scrapbook. In the social tab it is possible to see the album of the other teams and who is the player who has contributed the most within each team, as well as the completed categories.

- Assisted mode. It is intended to cover the need for assisted play that is practiced in the residence for those with mobility limitations. This is achieved by adapting the game so that the memories appear in AR (generated by the application itself) in front of the user without the need to move to scan it, just by clicking on it.

- Quick access. To avoid the problem of lost accounts due to forgotten passwords, this system based on user cards would allow users to quickly access their progress without having to re-enter their credentials. This code can be printed in card format.

## 5.6 Adaption of the Level of Difficulty

The current design of the application allows it to be adapted to different user segments, either by modifying the difficulty or by including other functionalities that serve as digital learning or have a therapeutic sense. In this sense, we have ordered the contents aimed at each target through the increase in complexity and functionalities of the application.

The type of content that is classified in the application as "Memories" is also important for targeting different segments of players, as it is necessary to appeal to their interests to motivate play. It is possible to tailor this content in different ways:

- Personal and player-adapted reminiscence: exercises for reminiscence in players with cognitive limitations and dementia.

- Memories of the locality, events and culture common to a specific and limited group: This is the case of the current application, focused on Aragon and Teruel in particular, with most of the cultural events that had an impact on past generations.

- Thematic memories focused on other places and cultures: With an educational objective, the player can visit and learn about other locations in the country or other cultures, and can identify specific experiences if he/she has been in contact with any of them.

- Current memories: This is a way of knowing what is going on around them, news or events that have happened recently that may capture the interest of some players who do not have the means or motivation to keep up to date. This alternative can reduce their exclusion on certain topics if approached and explained in the right way, facilitating their understanding.

## 6 PROTOTYPE

With the information gathered and the redesigned structure of the application, we have created the different screens of the new prototype that the player would see at the highest level of difficulty, with all the available functionalities. Screenshots of this prototype are depicted in Figure 6.



Figure 6. Screenshots of the prototype corresponding to the memory capture task.

## 7 EVALUATION

In order to ensure the correct fulfillment of the proposed objectives for the improvement of the initial design, different methodologies have been proposed to evaluate its functionality, user satisfaction and iterate the prototype design. In this section we are going to detail them all.

### 7.1 Situational Adaptation

One of the activities that have been adapted consists of reviewing the proposed design based on the supporting drawings of the different limitations of the users, and what possible problems each individual may encounter, or if, on the contrary, the experience is already adapted. The result of this review is partially shown in Figure 7.






|  | Adaptado     | No adaptado |
|--|--------------|-------------|
| <br>Asignaciones                     | Green square |             |
| <br>Difer de entendidos y entendidos |              | Red square  |
| <br>Apoyos con ayuda                 | Green square |             |
| <br>Organos                          |              | Red square  |
| <br>Hábito de vida                   | Green square |             |

Figure 7. Fragment of the table for adapting the design to the different limitations.

### 7.2 User Testing and Design Review

In order to improve some specific details about the prototype interface, its functionality has been tested with the following older adults' profiles by performing the following tasks: profile creation, memory capture, opening a memory from the album and joining a team. The main feedback has been collected from users over 65 years old. In addition, other profiles of different ages were also taken into account in order to find the differences in behavior derived from the technological knowledge acquired, as well as to check their correct functionality.

The test has been performed on both mobile and tablet, with the aim of testing the compatibility of the interface with the different formats. This has required an additional screen to display the photos that the player simulated scanning, in addition to reading aloud the texts displayed by the game that simulate the audio track that supports them.

Some elements finally modified taking into account this information are the following:

With the addition of dialogue balloons to expose memories, users are confused by the use of the "start over" and "pause" buttons. The audio accompanies the text automatically and the user does not have to press play to start the narration. The "start over" button returns to the beginning of the text, but may confuse the player if he/she expects to hear the current text balloon again. Also, it is only possible to advance to the next balloon and not go back if not to the beginning. These confusions are due to the fact that the uses of these buttons to control playback become meaningless when the text is presented in this way, so it would be more convenient for the player to have buttons to advance and rewind the dialogue balloons, while the dialogue is automatically narrated. When incorporating this function, and supporting the sense of advancement, it would be interesting to incorporate

a series of supporting images as slides for each block of text.

Also, in the memory selection menu within a specific category, users have trouble distinguishing the photo and, therefore, the memory they wish to access. It is necessary to place the titles of the unlocked memories legibly and color-coded according to the corresponding category, reducing the number of them on a page. The modification of the album screen taking this into account is in Figure 8.



Figure 8. Modification of the album screen.

### 7.3 Final Survey

Although many of the new functionalities included in the application have their origin in the needs and requests for improving the game experience communicated by the players themselves, it is necessary to evaluate these changes through a second survey. Similar in format and questions to the initial survey, a numerical evaluation is requested based on a score from 1 to 5 of the functions and new elements, as well as other improved functionalities, in order to compare the degree to which the new design adapts and improves the gaming experience of older adults.

In the same way as in the initial survey, the results have been graphically represented in comparison with the initial data and, in this way, to check if there is a perceptible improvement for the players in the different sections.

Regarding registration process, by guiding the registration step by step, using understandable language and dispensing with external accounts (e-mail, Google) for this purpose, confusion among players has been reduced. The results of the question about whether users find hard to understand what data has to be entered for starting playing give are that the average initial score was 3.20, and the final average score is 1.20, so this point has been clearly improved.

Regarding the album, now players can quickly see the list of the memories they have collected and which ones they have not. In addition, the game guides them to this section after getting a souvenir so that they can

see their collection. As a result, player comprehension has increased considerably. The average initial score of this question is 2.20, and the average final score is 4.60, so users now understand quite better this feature of the game.

## 8 CONCLUSIONS AND FUTURE WORK

After knowing the functionalities of the application and, subsequently, having studied both the context in which it is located and its users, as well as different design considerations to create a satisfactory gaming experience, a new prototype of the application has been made as a result of the work. In this prototype, some of the problems found in the initial design of the application are solved, and other functionalities are added to improve and complete the game experience. Some of the most relevant observations extracted throughout the project are going to be mentioned now.

Firstly, it is very complicated to design and evaluate a digital prototype or a game experience focused on the use of a mobile device for users who initially have no prior interest or knowledge of the field. The design consists of meeting the needs of a specific user and, through this experience, we try to create a playful activity that stimulates curiosity and memory, connects with other people and improves their social-affective environment, not only through the game, but also by learning how to use the mobile device as a communication tool.

Because it is difficult to introduce all these values and relate them to the game to an older adult who rejects technology, some social pressure from other individuals in his environment is necessary, as well as support and motivation from experts (therapists and monitors). From that first push and through repetition over several sessions, we would try to gradually replace human assistance with virtual assistance, with the aim that the user would gain independence and self-sufficiency with the use of the mobile device, increasing self-confidence and capabilities.

We have also observed that the contents of the album (memories) cannot be static either, as players get bored after a while and play several game sessions with the same themes. It is necessary to update the contents from time to time and vary the theme as mentioned above to appeal to the curiosity of the players in different fields: current affairs, nature, science, cultures, countries or cities. In this way, the activity would last over time, and the dynamics would

be educational, simulating the experience of being in an interactive museum.

Moreover, it is necessary to highlight the difficulties when running user tests, due to the limitations of the prototype shown to the players. Focused on interfaces and only being able to create static screens, this representation of the application does not match the interaction and stimuli that the user receives in the real application (audio tracks, camera, interactive assistant, etc.), so it is difficult to explain to the user what exactly happens without having played the initial design of the game. This act of imagination on the part of the user hinders his/her conception of the game.

Despite these difficulties, players have noticed an improvement over the previous design in several key areas, such as the use of a mascot as a virtual assistant, a clearer album listing and more user-friendly navigation through memories. Regarding other more complex features, designed for more experienced players, such as the team system and commenting memories, it has been found that players are open to them and consider that they complement their gaming experience, although a real gaming environment over several sessions would be necessary to evaluate them rigorously.

The next step to take this project to a real application, which provides the benefits described in the previous sections and meets the needs of a segment of vulnerable users and at risk of exclusion due to their physical limitations and low technological knowledge, is the translation of the interfaces and game systems defined to a real application. Even the modification of the original design and implementation of the new functionalities would be interesting, since a large part of the contents are already implemented. In this way, it would be possible to count on the opinion of the original players, who are in their usual game environment, already familiar with the mechanics of memory capture. Ensuring that seniors are truly connecting with the attendant and growing interest in the game in the community is data that can provide valuable information for ensuring the mental, emotional and physical health well-being of older adults over time. As for future evaluations of the redesign and its possible implementations, these will be carried out in such a way that quantitative information can be gathered to allow a data analysis from which valuable conclusions can be drawn.

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