



University of Castilla-La Mancha
School of Computer Science and Engineering

Undergraduate Dissertation
Bachelor's Degree in Computing Science and Engineering
Major in
Software Engineering

**Serious Games to Facilitate Social
Integration for Children with Autism
Spectrum Disorder**

Marius Daniel Caleala Iorgu

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*This was all possible to my family
support, specially to my mother,
who has been a great pillar for me.*

Authorship Statement

I, the undersigned, Marius Daniel Caleala Iorgu, with ID number 55493466-D, declare that I am the sole author of the Undergraduate Dissertation titled “Serious Games to Facilitate Social Integration for Children with Autism Spectrum Disorder” and that this work does not break the current intellectual property law and that all the non-original material contained in this work is properly attributed to their legitimate authors.

Albacete, date 14th July 2022

Signed by: Marius Daniel Caleala Iorgu

Abstract

Education is very important nowadays. It determines the future of the children and prepares us to live in society. Sometimes we associate education with a boring activity, but it doesn't have to be true. There are several ways of make education entertaining, and even funny, through gamification and "serious-games" techniques.

The education is universal, the same for everyone, but the way it is taught differs from one person or group to another, which require custom and individual education. There are also some aspects of the education, usually taught more at home than at school, which includes social integration aspects. People with ASD (Autism Spectrum Disorder) require special educational techniques to optimize their learning and specially integrate better into society in a world, sometimes, difficult and strange for them.

This Undergraduate Dissertation is focused on explain the used methodology and techniques to make a game, which contains several "serious games" minigames with the objective of teaching ASD children to integrate better into society.

Resumen

La educación es muy importante hoy en día. Determina el futuro de los niños y nos prepara para vivir en sociedad. A veces asociamos la educación con una actividad aburrida, pero no tiene por qué ser cierto. Hay varias formas de hacer que la educación sea entretenida, e incluso divertida, a través de técnicas de gamificación y juegos serios.

La educación es universal, igual para todos, pero la forma en que se enseña difiere de una persona o grupo a otro, lo que requiere una costumbre y una educación individual. También hay algunos aspectos de la educación, que suelen impartirse más en casa que en la escuela, que incluyen aspectos de integración social. Las personas con TEA (Trastorno del Espectro Autista) requieren técnicas educativas especiales para optimizar su aprendizaje y sobre todo integrarse mejor en la sociedad en un mundo, a veces, difícil y extraño para ellas.

Este trabajo de fin de grado está enfocada en explicar la metodología y técnicas utilizadas para realizar un juego, el cual contiene varios mini juegos serios con el objetivo de enseñar a los niños con TEA a integrarse mejor en la sociedad.

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I must show my gratitude to my family, for giving me the possibility to study, and all the economic help that I needed.

And finally, but not less important, I must thank my friends, which gave me a purpose to fight for. We are told that studies and work is the most important in this life, but without loved ones, the rest of the life makes no sense.

Dedications

I would like to dedicate this project to all the people with autism spectrum disorder around the world, to all their families, tutors, and friends, and to all their caregivers.

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Y finalmente, pero no menos importante, debo agradecer a mis amigos, que me dieron un propósito por el cual luchar. Se nos dice que los estudios y el trabajo es lo más importante en esta vida, pero sin los seres queridos, el resto de la vida no tiene sentido.

Dedicatorias

Me gustaría dedicar este proyecto a todas las personas con trastorno del espectro autista en todo el mundo, a todas sus familias, tutores y amigos, y a todos sus cuidadores.

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Chapter 1

Introduction

1.1 Motivation and context

In Spain there are more than 450.000 people with ASD (1 of each 100 births), and approximately 1,5 million people associated with those people with ASD (*Confederación Autismo España 2018*).

In the public services (education and health fields specially), there are not enough unities specialized in ASD, ant the existent ones are overflowed due to the excessive demand.

A big problem is the lack of public information about this disorder, making it more difficult to develop specialized strategies to provide an earlier detection and developed custom education.

Related to the health context, nowadays the people with ASD in Spain are not considered yet a priority for the public healthcare system, as happens in other countries.

1.2 Objectives

The main objective of this Dissertation is the design of a game using “serious games” principles to facilitate ASD children integration into society in a funny way. To reach this global objective, the following steps are required:

- Analysis of possible serious games that can be adapted to reach the main objective.
- Study the market and existent related work to discover weak points and use them to improve this project.
- From the previous points conclusion, design several serious games adapted to the global objective.
- Implementation of a prototype or alpha version which applies those serious games to reach the global objective.
- Evaluation of the developed prototype in a real environment.

1.3 Structure of the document

The Undergraduate Dissertation is divided into 6 chapters:

- **CHAPTER 1. Introduction.** Introduces the context of the situation, explains the motivations of this Undergraduate Dissertation, and describes the objectives to be reached.
- **CHAPTER 2. Background and Current Status.** Gives a more detailed information about the ASD, the serious games, and how to relate each other to accomplish the main goal of this Undergraduate Dissertation. Also, a description of related work will be given to analyse the strong points and weaknesses of other applications related to this topic.
- **CHAPTER 3. Methodology and development.** There will be exposed the solution proposal, feedback about several software development methodologies, the decision of the methodology chosen, along with the adaptations made to fit with this project, and all the employed tools used during this project.
- **CHAPTER 4. Project development.** Once the methodology has been chosen, in this chapter will be documented in detail the evolution of the project, from the start to the end, along with all the defined tasks and taken decisions that affected the project.
- **CHAPTER 5. Application description.** After obtaining a solid and functional solution, it is time to describe it. The solution architecture, functionality, use recommendations, and other technic issues are defined here.
- **CHAPTER 6. Evaluation.** An evaluation of a prototype of the solution must be conducted. The quality in use will be measured to ensure that all the functionality

fits the final users' needs, and to determine if the system is acceptable, that is, the system is comfortable for the users when using it.

- **CHAPTER 7. Conclusions and future work.** The conclusions obtained from the development process, evaluation and final product will be exposed here. Also, all the tasks and recommendations that could not be integrated during this project are going to be marked as future work.

Chapter 2

Background and Current Status

2.1 Introduction

To understand the relationship between serious games and ASD, first we must analyse and understand first the ASD, then the serious game concept, and finally how to apply this concept to the ASD field to facilitate, in this case, the social integration of the children with ASD.

2.2 Autism Spectrum Disorder (ASD)

2.2.1 What is the ASD?

First, we must know that the autism spectrum disorder is not a disease. It is a child development disorder which manifests itself in diverse ways depending on each person, and we must not generalize.

Sometimes, the ASD can come along with other pathologies: metabolic pathologies, motor problems, hyperactivity, OCD, anxiety or even depression.

There are several alert signs to consider detecting this disorder on children:

- Does not respond to his name after 12 months.
- Does not point objects to show interest.
- Does not play role games after 18 months.

- Avoids the eye contact and prefer to be alone.
- Has difficulties understanding self-feelings or other people's feelings.
- Speech and language skills delay.
- Repeats words and sentences commonly.
- Provides answers not related to the questions.
- Present sensibility to minor changes.
- Does have obsessive interests.
- Shakes the hands or spins around.
- Has unusual reactions to noise, smells, flavours, or feelings.

The ASD manifests into several areas:

- Social interaction and communication
- Behaviour patterns, interests, and activities area.

2.2.2 Social interaction and communication area

Regarding to the social interaction, children with ASD has many limitations and characteristics:

- Limited visual contact, expressions, and gestures
- Lack of interest in being helped
- Lack of ability to start or participate into games with other children
- Prefer to play alone.
- Inappropriate response to formal social relationships
- Limited use of nonverbal behaviours.
- Limited integration of the gaze with other behaviours (words, vocalizations, gestures) to communicate social intention.

Now, talking about a more specific field of the social interaction, the communication present three main levels:

- Children who do not develop any type of oral language.
- Children who present delay at acquiring oral language, and/or comprehension.
- Children with acquired oral language, but with presence of anomalies (echolalia, pragmatic disorders, prosody alterations, etc.).

2.2.3 Behaviour patterns, interests, and activities area

Regarding to the flexibility and imagination, children with ASD present several restrictions and characteristics:

- Restricted behaviours, interests, or activities. The interests use to be perceptive and consists of visual stimuli (watching TV, spinning toys, or bouncing a ball). When they grow up, the sensorial experiences tend to be replaced by more complex interests, but they are still concrete interests and lack socio-emotional content (flags, animals, letters, numbers, ...).
- Exaggerated insistence on the same activity, routine or specific ritual, and low tolerance to changes in these routines.
- They tend to acquire stereotyped and repetitive motor mannerisms such as shaking or turning their hands or fingers, or complex movements of the whole body (clapping or turning objects).
- Binding to certain objects (dice, balls, or ropes).
- Verbal stereotypies, like words repetition.
- Fantasy lack, and poor-content, repetitive games, with a possible presence of stereotypies.
- Lack of symbolic games, and those in which an adult role is simulated.

Apart of the previous characteristics, there are others that are common on children with ASD, but not necessarily associated to this disorder, such as motor clumsiness, sensory hypersensitivity, mental retardation, attention deficit and/or hyperactivity, phobias, or lack of fear in the presence of real dangers, sleep disturbances, special abilities in concrete areas (Curso voluntariado, 2016).

2.3 Introduction to Serious Games

The combination between the words “serious” and “games” looks like it is impossible to match, but it is not. In the last years, serious games have demonstrated that it is possible to learn playing.

Then in the related work section we are going to analyse existing work and examples (applications and concepts) related to the topic of this Undergraduate Dissertation.

To conclude, we must specify that this Undergraduate Dissertation is focused on the application of the serious games' concepts, along with the ASD ones, into a videogame.

2.3.1 Definition of serious game

A serious game is a game which main goal is not the player's entertainment, but the learn and practice of a new activity. Its use has grown in fields like education, defence, aeronautics, science, or health.

2.3.2 Elements of a serious game

Making a serious game is not an easy task. It involves lots of time and task to design and adapt it to the destined public. Even though it exists a wide variety of formats and objectives, most serious games are composed of five elements which ensure their correct functionality:

1. **First element – A story.** Even it is not strictly necessary, usually the videogames have a main story: a nurse that must save a patient, a soldier that must defend his country, or a person that must face its own fears and weaknesses. The more sophisticated is the story plot, the more immersive and greater will be the player's experience and motivation.
2. **Second element – Gamification.** The second basic element of a serious game is the game dynamics, which include rankings, rewards, badges, or a score system. This gamification usually keeps the player's motivation on the minimum necessary level to keep playing it. Related to this, a healthy competition is a particularly useful characteristic to be implemented in our game to get the player motivated.
3. **Third element – Immediate and individualized feedback.** The player directly interacts with the game and instantly obtains a reward (positive or negative) or feedback of its actions and decisions.
4. **Fourth element – Simulation.** Usually, the serious games reproduce a real situation through fictional characters and environments. The player is immersed into a world like the real one, where can train skills or learn concepts.
5. **Fifth element (and the most important) – Learning.** The main objective of a serious game is to teach us something. All previous elements can also be property

of any commercial videogames, but that does not turn them necessary into serious games. Apart from the four previous elements, a serious game must have a purpose which is not only the player entertainment, but the player's education or training (Game-Learn Team, 2020).

2.3.3 Advantages of a serious game

The first image it arrives to our head when we think about games is a group of teenagers playing to a video console from a couch, losing their time. Nevertheless, there are many reasons to embrace videogames as a serious way to gain new skills. Indeed, today, serious games are rapidly becoming one of the most powerful tools for training purposes (Etherington, 2022).

Once all the previous elements are combined, a game has an enormous potential so bring us multiple advantages related to the learning. We can enclose them into five main advantages, which are the following:

1. **Increases engagement and motivation.** Traditional education is boring and usually very inefficient. Students' lack of motivation and engagement is one of the greatest concerns of the professors and human Resources workers (in the business field).
2. **Facilitate the deep thinking.** Usually, specially at the working place, we work in a rutinary and repetitive environment. This makes harder for us the long term planification about the challenges we face. The serious games, thanks to their capacity to immerse into other worlds and abstract us from the reality, can help us to improve the deep-thinking skill.
3. **Allow the real and safe practice.** The learning based on games is characterized by being a practice-based learning. Thanks to the simulators, the players can interact with other characters and use the obtained knowledge from the start of the game. Additionally, the serious games offer us the best from both worlds: on the one hand, simulators reproduce the reality in a remarkably comparable way; on the other hand, the fact that the serious game is implemented into a videogame allows us to practice skills safely and without causing personal or material damages. This is especially important on surgical, driving or military-based games (GameLearn, 2022).

4. **Collaboration.** Another particularly important characteristic of the serious games is their collaborative nature. They can be adapted to teach players how to work in team (Etherington, 2022).
5. **Improves the memory capacity.** One advantage of the serious games is the fact that, as we increase the engagement and motivation of the players, also increases the information memorization. If we apply it to a real and direct practice, the result is that the players learn better and in a deeper way (Etherington, 2022).
6. **Offer immediate feedback.** An ideal serious game offers to the player feedback during all the game session, showing if he/she is winning or losing. This could be a powerful feature to keep the motivation of the player.
7. **Makes the world a better place.** It may look too ambitious, but serious games have the potential to change the world. We can use them as a tool to reach and promote empathy and peace, defend human's rights, and spread civic values. Contrary to the stereotype that video games cause violent or anti-social behaviour, the truth is that game-based learning can foster pro-social and positive attitudes for the society (GameLearn, 2022).

2.4 Serious Games in Autism Spectrum Disorder (ASD)

Now that we know the basic concepts of the ASD and the serious games, let us put them together. We can relate them to make serious games with the main objective of teaching values, emotion control, or even social skills to the children with ASD.

We must implement into the game the skills we want to improve for those children. For that, we can consider several minigames which trains those skills:

- Staring contest: Many children have trouble maintaining eye contact in conversation. A staring contest or a similar application can help them to make and keep the eye contact in a way that allows them to focus on that task.
 - An application of this skill for the game may be to maintain the sight on the eyes of other person or character on the screen.
- Emotional charades: This activity consists of writing different emotions on strips of paper. The children take each one a strip, and then, they must try to act out that emotion.

-
- Applied to the game, this can be applied in other ways. For example, showing several gestures on the screen representing a particular emotion, and then guess that gesture with the correct emotion.
 - Expression mimicking games: Mimicking facial and corporal expressions allows the child to understand what certain expressions mean and recognize them when others make them in real conversations.
 - Simulating conversations or reactions between people can help them get familiar with those expressions and their meaning in a real environment. In the video world, this could be accomplished with face recognition tools, where the player must imitate the shown face or expression on the screen.
 - Topic game: Several variations of the topic game can be recreated, but the most common one involves choosing a topic and naming things that fit into that category using each letter of the alphabet. For example, if you choose animals as the topic, you might come up with:
 - A: Aardvark
 - B: Baboon
 - C: Camel

The topic game teaches kids to stick to one subject and follow directions until they complete the activity. It also helps them make connections and get creative with letters that have fewer options.

- Complete sentences: Examples of real conversations can be given, and the child must fill the gap with the correct word depending on the context. This game helps children by giving structure to conversations to develop the social skills necessary to manage different situations in their daily life. This can also be used to help them learn other languages.
 - This could be represented as a conversation between two characters, or a conversation with yourself, and the player can choose the missing group of words from the conversation from a selection of answers.

- Improvisational stories: Many children tell stories even outside of intentional social skills activities. With improvisational stories, you add another challenge that requires them to collaborate and create a narrative without thinking about it beforehand.
 - To implement this activity into our game, we can place cards with pictures or words face down. The child picks three of these cards, and they must include these objects or topics in the story they tell. The game ends when all the cards are gone, or the kids reach the end of their story. This can be also used in a multiplayer environment.
- Name game: Kids roll or toss a ball to someone after they call out their name. Social skills activities like this one work well for helping even toddlers learn their peer's names. It shows that they are attentive to others, and it is a step toward getting to know other people.
 - This can be applied as a turn-based game with many players, where the kid that has the turn must choose the name of another participant, and a question from a selection provided by the game, and the kid with the name the player has chosen should try answering that question. This can also be played in a random way.
- Rhythm Games: Those games may be incorporated as a social skills activity both at home and in the classroom. These music-making games let children be creative while following directions and recognizing patterns.
 - For this application, sounds are required, so an example would be a game which gives the player several buttons, each one reproducing a sound when pressed, and a pattern of sounds given by the game. The player must match the sounds from the pattern in a way like the *Guitar Hero* videogame.
- Playing with characters: These social skills activities involve tapping into your child's natural tendency to play. Using animal toys or dolls, you can interact with your child through the toys. Having conversations through toys teaches children to recognize behaviours and communicate their feelings.
 - This can be applied to all games by characters integration, where they star the games.

-
- Play pretend: Kids will create a scenario in which they pretend to be someone or something else. For example, they might take on the roles of parents, become a doctor, veterinarian, or even a teacher. Each of these situations allows them to explore different social skills activities. As they pretend to parent another child, for instance, they must learn to recognize and respond to emotions, and adapt to new situations.
 - For a game with this feature, the player may choose a role, and take decisions that correspond to that role.
 - Token stack: You can adapt token stack from board games like checkers to create social skills activities that teach children how to maintain a regular conversation. Every time the child speaks and responds in an appropriate way, they add another token to their stack. They face the challenge of trying to stack their tokens as high as possible while taking turns speaking. This makes children focus on having a calm conversation and giving thoughtful responses to questions and statements.
 - For this application, a moderator would be necessary. The player with has the turn must answer the question asked by the moderator. If he/she asks correctly, they get a reward.
 - Decision-making games: Social skills activities like those decision-making games come in many representations. By using strategy games or activities as simple as sorting and matching, children learn persistence, and cooperation with others. These games help children with indecision, as they ask them to make a choice, even if it is not right the first time. It demonstrates low-risk consequences and encourages them to try again if they make a mistake.
 - Applied to a videogame, there can be a situation description, and several decisions, each one with its consequences. The player must choose one, obtaining feedback about that decision.
 - Building Game: A cooperative game can also be implemented by means of building structures or objects, like a tower using blocks. This helps them learn to try again if the building falls and celebrate each other's unique abilities when they finish the project successfully.

- This can be played on turns, where players dispose of a selection of pieces, and they must create a building. If one fails, both fails, so this will enhance collaboration skills (Evidence Based Social-Skills Activities, 2018).

2.5 Related Applications

There exist several applications focused on improve ASD people skills through several activities and games. We are going to list and describe some of the most important applications that are related to this project's objectives:

2.5.1 Proloquo2Go

This is one of the top communication apps for children with autism. Proloquo2Go is one of the best apps to assist nonverbal children with autism. This ACC (Augmentative and Alternative Communication) app can be used as a daily communication tool, supporting the development of key language skills. As it is a symbol-based app, users learn to express themselves using innovative features backed by clinical knowledge and user research.

One of its stronger points is the fact that the app is completely customizable, allowing you to alter everything from vocabulary to the appearance of the app itself (Figure 1).



Figure 1: Proloquo2Go interface

2.5.2 I Create... Social Skills Stories

It is a concept based on the need for children with ASD to learn how to interact in social situations using a combination of visual, audio, and text to describe an event or skill, stories provide examples of how the user would interact with the others in an appropriate manner.

The goal is to help users enhance key social skills so that they can apply what they learn to develop new routines. All steps and storylines are customizable, allowing you to import personal photos and unlimited pages to your stories. This can be seen on Figure 2 (Game-Learn Team, 2020).



Figure 2: I Create... Social Skills Stories interface

2.5.3 Avokiddo Emotions

It is a creative play app that encourages kids to get goofy with props and then tune in to the animal character's emotions in response to the props. With three adorable characters and more than 100 props, kids can interact in several ways to the animals and understand characters' expressions and reactions to help them, grow in emotional cues and empathic awareness (Figure 3).



Figure 3: Avokiddo Emotions interface

2.5.4 Speech Blubs 2

It is a speech learning game approved by therapists which allows children with autism to activate language with fun speech-based activities. While this app is not strictly designed for children with autism, it is intended for any child that is a late talker (Figure 4).



Figure 4: Speech Blubs 2

2.6 Conclusions

Once we got clear the general concepts, we can conclude with several points:

We must apply the general ideas and characteristics of the children with ASD to the serious games concept to create the application that accomplish with the project objectives.

If we look at the applications from the related work section, we can find several components that we can take and adjust to implement into our application, especially those related to emotion control, speech, context understanding, etc.

Chapter 3

Methodology and Development

In this chapter will be explained the methodologies, tools, and solutions to develop the project.

3.1 Solution proposal

To meet this Undergraduate Dissertation theme, and to put in practice everything I learnt during those four years studying this career, I decided to create a system composed of two applications: a mobile game made with Unity, and an administrative web client created with Angular which allows users to manage the exercises from the mobile game.

Unity game

The game is going to work on mobile devices as an application, or on desktop computers, and it is going to be composed by several minigames, and each minigame is focused to solve or improve a typical social difficulty which is common to children with ASD. Each minigame is going to have a main character which is the one who has the problem, and the problem must solve it.

The game is going to have a main menu with three buttons:

- The play button, which drives to the minigames selection where the player can choose the desired minigame to play.

- The options button, where the player can modify general options, or other options which are concrete to a specific minigame, such as background colour or audio.
- The quit button, which close the game.

As the game will be fully implemented with Unity and C#, it will be composed by scenes. A scene is, for example, the main menu, and each minigame is another scene, so the game is going to be based on navigation through scenes.

Now let's talk about the specific minigames that are proposed now for this game:

- Quiz game: several sentences, classified by difficulty, are given to the player, with one missing part, and a selection of words so that the player must choose the set of words that better fits to the sentence. At the end of each sentence, the game will tell the player if the selected option was correct or not.
- Guess the emotion: several faces representing an emotion are given to the player, along with a selection of emotions, so that the player must match them in a correct way. Even if this game is focused on working with emotions, it can work with other fields.
- Order sequences: figures of steps of daily activities such as brush your teeth are given to the player. The figures must be ordered in the correct way.

Angular web client

This second application will have one main objective: to customize the minigames' exercises from the previous minigames of the Unity game. The user will be able to create, edit, and delete new exercises in an easy way.

3.2 Work plan and Methodology

3.2.1 Work plan

To allow the development of this project, the following workflow must be followed:

- First, we have studied the main concepts related to the ASD and serious games.

-
- Then, the application of the ASD children characteristics to the serious game model were explained by giving several examples, by means of several possible minigames that we can apply to our game.

3.2.2 Methodology

Several methodologies were thought to be followed at the starting point of this project, so we first had to choose between a plan-driven or change-driven methodology:

3.2.2.1 Development methodologies

There are two types of methodologies: plan-driven methodologies, which are those that follows a plan and are more restrictive to changes, and change-driven methodologies, which embraces the changes taking advantages from them to create value.

Plan-driven methodologies

Plan-driven or traditional methodologies are focused on minimizing the risks and give more stability to the project. Breaks up projects into phases and the solution is implemented from a technical perspective, creating a high-level design of modular components and their interactions, and setting standards for how common technical issues should be resolved.

The development consists of producing code in an environment specific to the culture of the project, where tasks are assigned according to individual skills, and development continues until goals are reached.

Related to the testing, delivery, and feedback, testing of individual components should be ongoing, with application-level testing towards to the end of the project. Ideally, feedback from the client must be considered to confirm that requirements have been met, or to identify if there are changes that must be made.

Plan driven methodologies work well for small, well-defined projects with a limited scope of work and few variables.

There are several examples of this traditional methodologies group, but the most known (and the ones we had studied) are the waterfall and RUP ones:

- Waterfall, in which has eight phases (conception, initiation, analysis, design, construction, testing, production/implementation and maintenance) are carried out to completion in successive, cascading manner.
- Rational Unified Process (RUP), also phase-oriented, but iterative. RUP outlines are detailed set of practices for even the most minute elements of a project. Consequently, RUP is intricate, overly detailed, and difficult to apply.

Change-driven methodologies

Change-driven or agile methodologies give the solution to many critics of traditional methods emerged within the software development community.

The conclusion obtained from employing both methodologies was that the traditional ones were not working. They tended to deliver late, poor, and low-quality products. In 2001 a team of 17 software developers published *The Manifesto for Agile Software Development*, which gave the guiding principles for Agile development (Manifesto for Agile Software Development, 2001):

- ✓ Individuals and interactions over processes and tools.
- ✓ Working software over comprehensive documentation.
- ✓ Customer collaboration over contract negotiation.
- ✓ Responding to change over following a plan.

There are several methodologies within this group, where the ones we studied are the following:

- **Extreme Programming (XP)**, which focuses on tactical best-practices for building software rather than the best ways to get the overall project to the release on time and on budget. It describes a specific set of development practices, like test-driven development, pair programming, and continuous integration.
- **Lean**, a generic agile methodology, applicable to the software development process. Its pillars are continuous improvement (focused on value creation), and respect for the people, so that everyone's voice is heard, and everyone is responsible for the final product (PlanView, 2022).

-
- **Scrum**, another generic process framework, not limited to software development. It is cyclic and iterative, so planning and implementation are concurrent. This is the one we have chosen for this project (Cprime, 2022).

Now, once the most known methodologies we studied were exposed, and the one for this project were chosen, let's explain scrum in more detail.

3.2.2.2 Project methodology: Scrum

Scrum is a framework within people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value. It is a lightweight framework that helps people, teams and organizations generate value through adaptive solutions for vary complex problems (Scrum.org, 2022).

Scrum framework is carried out two types of roles, central and non-central roles:

Central roles are those whose participation is very important to the project development. They are committed to the project and are the responsible for the success of each sprint and the general project. Those are the product owner (PO), the scrum master (SC), and the scrum team (ST).

Non-central roles are those whose participation within the project is important but are not crucial for the project success or failure. Those are the stakeholders (clients, users, and sponsors) and the vendors (Lizeth, 2017).

Artifacts

The artifacts represent work or value to provide transparency and opportunities for inspection and adaptation. There are three main artifacts:

- Product Backlog is an emergent, ordered list of what is needed to improve the product, created, and ordered by the product owner. It is the single source of work undertaken by the Scrum Team. The Product Backlog items that can be Done by the Scrum Team within one Sprint are deemed ready for selection in a Sprint Planning event. About the sizing of the items, the responsible are the developers

- Sprint Backlog is a list composed of the Sprint Goal (why), the set of Product Backlog items selected for the Sprint (what), as well as an actionable plan for delivering the increment (how).
- Increment of functionality is the new functionality that is created during a sprint. It must be usable, and it provides value. However, an increment may be delivered to stakeholders before the end of the Sprint (Scrum.org, 2022).

Values

Scrum includes five values to consider:

1. Courage: Team members have courage to do the right thing and work on tough problems.
2. Focus: Everyone focuses on the goals of the scrum team and on the sprint.
3. Commitment: People personally commit to achieving the goals of the scrum team.
4. Respect: Scrum team members respect each other to be capable, independent people.
5. Openness: Scrum Team and its stakeholders agree to be open about all the work (Scrum.org).

Events

Scrum has several events:

- Sprint, which is a fixed length event of one month or less to create consistency. All the work necessary to achieve the Product Goal happen within Sprints.
- Sprint Planning initiates the Sprint by laying out the work to be performed for the Sprint. The resulting plan is created by the entire Scrum Team.
- Daily Scrum is a 15-minute event for the Developers of the Scrum Team. It is used by the developers to inspect progress toward the sprint Goal and to inspect how progress is trending toward completing the work in the Sprint Backlog. Those

short meetings improve communications, identify impediments, promote quick decision-making, and consequently eliminate the need for other meetings.

- Sprint Review is a meeting focused to inspect the outcome of the Sprint and determine future adaptations. The Scrum Team presents the results of their work to key stakeholders and progress toward the Product Goal is discussed.
- Sprint Retrospective is another meeting focused to plan ways to increase quality and effectiveness for future sprints and projects. The Scrum Team inspects how the last Sprint went with regards to individuals, interactions, processes, tools, and their Definition of Done (Scrum.org, 2022).

In the figure 5 we can see the process of the scrum framework, including the different artifacts:

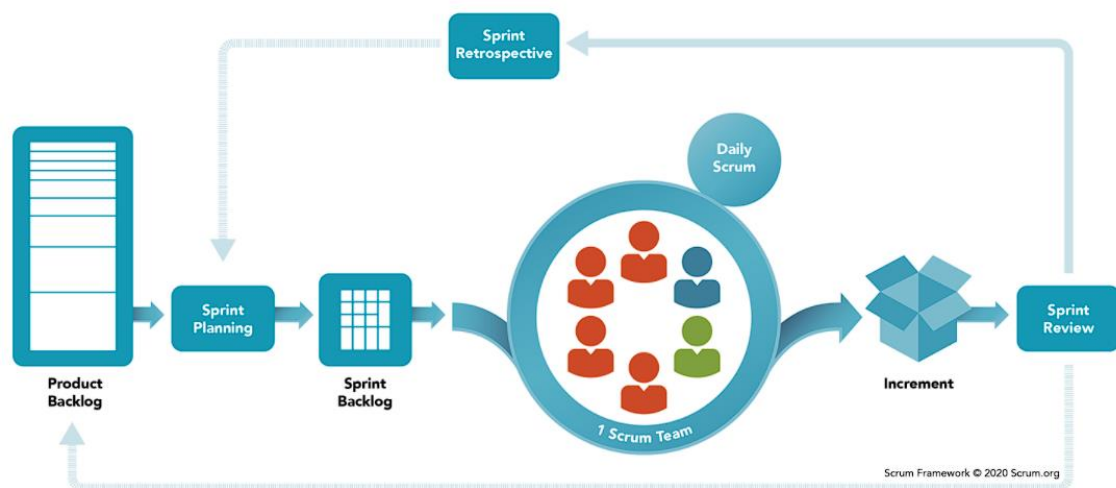


Figure 5: Scrum framework process

SCRUM Adaptation for this Undergraduate Dissertation

Once an explanation of what is SCRUM framework and how does it work, now let's talk about the Scrum adaptation for this Undergraduate Dissertation, as it was impossible to use the original framework. The main modifications are the following ones:

- The Daily Scrum has no sense in this project since the development team is only composed by one member.

- The duration of each sprint is flexible, but always between 2 and 4 weeks each one. The average sprint duration was 3 weeks.
- The development team is not multidisciplinary since it is composed by only one member.
- For the estimation of the tasks the measurement unit employed were the hours instead of the Story Points unit.
- The roles assignment was the following:
 - The Product Owner is composed by the two tutors that help with this Undergraduate Dissertation.
 - The Scrum Master is not available, but its functions are carried out by both the student and the tutors.
 - The Development Team, as it was told before, it is only composed by the student in charge of this Undergraduate Dissertation.

The requirements were obtained by meetings with the stakeholders, exposing a first prototype of the application, and using their feedback to improve it.

3.3 Technologies and tools

All the tools employed for the development of this project are grouped in the following groups:

Project management tools

To manage this project, several tools have been used related to the task organization and control version:

- Git, which is a version control tool to manage software development through a branch system that allows creation of local branches and the uploading of the code of each branch to the remote branch of an online repository. This tool was used to manage the control version of the unity project.

-
- Jira, a task management software focused on scrum framework that allows the creation of predefined items (user stories, tasks, bugs, etc.), custom item types (created by the users), task status management, and provides all the functionalities to allow us work with scrum.

It was used in this project to create the different sprints, along with their items. The sizing unit used was the Story Points unit (SP).

Documentation tools

- Microsoft Office is the text processor used to write all the documentation, including the bibliography and citations management.
- Microsoft Excel is the spreadsheet employed for generate the output data of the evaluation.

Communication and conference tools

- Microsoft Teams was used to maintain the sprint retrospective and backlog refinement meetings.

Design tools

- Microsoft PowerPoint was used to create the storyboard of the application, and to expose the evolution of the final product to the client.
- Krita (v. 4.4.7) is a drawing software used to draw game sketches.
- Gimp (v. 2.10.30) is the image editor used to design and modify application's images.

Development tools

- Unity (v. 2020.3.27f1) was the environment used to develop the application.
- Visual Studio 2022 is the code editor used to create Unity scripts.
- MongoDB Compass is the interactive tool used to manage the database.

Physical tools, peripherals, and devices

- XP-PEN G640 is the graphical tablet used for design.
- Desktop computer with the following characteristics:
 - CPU: Intel(R) Core (TM) i5-11600KF @ 3.90GHz
 - OS: Windows 11 Pro (64 bits)
 - RAM: 16 GB DDR4
 - GPU: AMD Radeon RX 580 Series
- Samsung Galaxy S10⁺ mobile device (with Android OS), and a computer with Windows 10 were used to test the applications.

Chapter 4

Project development

In this chapter, the followed process to develop this project will be explained. As the chosen development methodology is the Scrum one, the project has been divided into 9 sprints. A detailed explanation of the tasks, artifacts and any complementary event involved into this project will be given. In the [Annex III](#) it will be described each sprint with its Burndown Chart.

4.1 Introduction

Background

The project had started with a general idea provided by the tutors, which is to create an application related to the gamification. Then, the student had a more concrete idea related to that topic: an application to help ASD children with their social skills through gamification techniques, to be more concrete, through serious games.

After that, I decided to create the application with the Unity engine because it is a comfortable tool to create games for different devices, in this case, for mobile devices.

Project planification

The project development has been divided into 9 sprints, as we can see in the following table:

Table 1: Project planning chart

ID	Description	Start/End dates
1	Project Planning	28 January – 9 February
2	Requirements and project start-up I	9 February – 2 March
3	Requirements and project start-up II	2 March – 9 March
4	Planning first minigame	9 March – 30 March
5	Implementation of first game	30 March – 20 April
6	Minigames II and III (first part)	20 April – 11 May
7	Minigames II and III (second part)	11 May – 1 June
8	Evaluation and improvements	1 June – 28 June
9	Improving the system	28 June – 12 July

Stakeholders

The stakeholders (people that is interested in the project), are composed by the following ones:

- **Final users:** Are those that are going to use the final product for their own purposes. There are two final users:
 - Children with ASD: children with common needs, such as to improve communicative skills, but at the same time, each one with individual more specific requirements and considerations to consider.
 - People in charge of the care of children with ASD, that are interested in a tool to facilitate their work.
- **Client:** The client in this case is the *Asociación Desarrollo – Autismo Albacete* personal, that collaborate with us to set the requirements and needs for this project, and later, to test our game.

Initial prototype of the project

A prototype of the game interface was made at the starting of the project development, to expose it later to the client, and obtain its feedback. More information about this prototype is available at the [Annex I – Prototypes](#).

Meetings with the client

Once we have set up the main idea of the project, there will be several meetings with the client (*Asociación Desarrollo – Autismo Albacete*).

The second one will be employed for the game evaluation, testing a functional version of the prototype with real users.

4.2 Sprint documentation structure

As it was told before, the chosen framework to carry this project was the Scrum one. So, all the sprints will be documented individually following the next structure: sprint goal definition, sprint planning, sprint review and sprint retrospective meetings conclusions.

4.2.1 Sprint 1 – Project planning

Sprint Goal

This first sprint is mainly focused on search information regarding ASD, serious games, and gamification, set up a general idea for the application and choose the best technology to start developing the project.

Sprint Planning

This first sprint started on 28 January 2022 and finished on 09 February 2022 (21 days). Initially, the idea was to use gamification techniques for educational purposes. During the first meeting with the tutors, we decided to set up the general goal of the project, choose the mobile device hosting platform of the final prototype, and to start the documentation. It is also important to mark that the chosen technology to program the prototype was the Unity Engine. In the table 2, the different tasks planned for this sprint are shown:

Table 2: Sprint 1 tasks

ID	Task	Estimation
TDAA-1	Search information about apps related to serious games	2 SP
TDAA-2	Get informed and choose the tools, languages, and frameworks for the app	2 SP
TDAA-3	Choose a general idea for the app	3 SP
TDAA-7	Get informed about ASD	2 SP
TOTAL:		9 SP

Sprint Review

The Product Owner reviewed the increment of functionality accomplished so far, which was good enough for this first sprint. After this, new PBIs have been generated.

Sprint Retrospective

The amount of work programmed for this sprint was enough for the available time. All tasks have been completed correctly.

For the next sprints, the team accorded to give more importation to the documentation, and not to put too many images.

4.2.2 Sprint 2 – Requirements and project start-up (I)

Sprint Goal

This second sprint is focused on organizing a meeting with the client, implementing the basic structure of the game in Unity, and continue the documentation.

Sprint Planning

This second sprint started on 9 February 2022 and finishes on 2 March 2022 (21 days). During the meeting with the tutors (Product Owner), we have accorded to finish chapter one and two of the documentation and create a storyboard with a general idea of the final prototype to show it to the client in a meeting proposed for this sprint.

The tool that I initially decided to use for the storyboard was Krita, a drawing software compatible with graphic tablets, but for simplicity, finally I decided to use Microsoft PowerPoint, since it has the capacity to duplicate slides to take advantage of the existing ones. The tasks can be found in the sprint backlog (see Table 3):

Table 3: Sprint 2 tasks

ID	Task	Estimation
TDAA-8	As client I want a prototype for the game to check if it fits on my needs	4 SP
TDAA-9	Complete the chapter 1 of the memory and start working on chapter 2	4 SP
TDAA-15	Implement the basis of the prototype on Unity	4 SP
TDAA-16	As client I want the game to have a main menu	4 SP
TOTAL:		16 SP

Sprint Review

The Product Owner reviewed the increment of functionality, and it decided that it was not enough for this sprint, due to difficulties inside the development team. The storyboard was too basic. As a result of this, the team decided to employ the next sprint (with less duration) to improve the storyboard, and other minor tasks.

Finally, the meeting with the client could not be done during this sprint due to the simplicity of the storyboard.

Sprint Retrospective

In this second sprint, the tasks were finished, but not correctly, due to development team scheduling problems. The number of tasks and their weights were correct for the available time, but the development team did not accomplish the expected increment. The team compromised to do a better work for next sprints, and that's why a new sprint complementary to this one was created.

4.2.3 Sprint 3 – Requirements and project start-up (II)

Sprint Goal

Improve storyboard and search more information related to the game. Refine the obtained requirements.

Sprint Planning

This third complementary sprint started on 02 March 2022 and finished on 09 March 2022 (7 days). The main objective is to finish the storyboard of the prototype to present it to the client in a meeting which will take place during this sprint. The conclusions of that meeting can be observed with more details at the [Annex I – I2. Meetings with the client.](#)

Also, this sprint will be dedicated to search more information to have a clearer idea of the game to be implemented, and finish chapter 2 of the memory document. The sprint backlog can be seen in the Table 4:

Table 4: Sprint 3 tasks

ID	Task	Estimation
TDAA-14	Finish Chapter 2	4 SP
TDAA-20	As a client I want a storyboard that completely describes the main idea of the application	3 SP
TDAA-21	Look up for more information to establish a solid main idea for the project	4 SP
TOTAL:		11 SP

Sprint Review

As expected, the Product Owner made a general revision of the sprint, and the feedback was satisfactory. The proposed tasks were successfully accomplished in time.

Sprint Retrospective

This sprint development was satisfactory, but the tasks estimation was bigger than the real effort, so the team will consider establishing an estimation more likely to the reality for the next sprints.

4.2.4 Sprint 4 – Planning first minigame

Sprint Goal

For this fourth sprint, what is expected from the development team is to continue with the documentation and let the first minigame prepared for implementation.

Sprint Planning

This new sprint started on 09 March 2022 and finished on 30 March 2022 (21 days). From this sprint planning meeting with the tutors (Product Owner), we concluded to finish chapter 3 of the memory documentation, plan the first minigame and start with the implementation.

Also, the estimation method for this sprint has been changed from story points to hours to test the difference.

Table 5: Sprint 4 tasks

ID	Task	Estimation
TDAA-22	As a client I want chapter 3 to be completed	4 hours
TDAA-28	Choose the first minigame and prepare it for implementation	2 hours
TOTAL:		6 hours

Sprint Review

From the sprint review with the Product Owner (PO), we concluded that the task related to complete the chapter 3 of the document has been correctly accomplished, also letting the first minigame prepared for implementation, but could not be possible to start its implementation, because of external problems of the development team.

Sprint Retrospective

First, regarding to the estimation method changed (from SP to hours), I concluded that for the chart's generation was negatively affected by this change, so for next sprints, the story point metric will be used again.

Related to the development team effort, which was lower than expected, the team has promised to try to solve the external problems that affected this sprint development performance.

4.2.5 Sprint 5 – Implementation of first minigame

Sprint Goal

For this sprint, what is expected from the development team is to continue with the documentation and start programming the first minigame.

Sprint Planning

This sprint started on 30 March 2022 and finished on 20 April 2022 (21 days). The expectation for this sprint was to correct several issues related to the previous sprint, such as setting up a better document format and document the Scrum adaptation to the Undergraduate Dissertation.

Also, for this sprint was planned to start chapter 5, describing the background, the project planification and the stakeholders.

Table 6: Sprint 5 tasks

ID	Task	Estimation
TDAA-35	Correct the contents of the memory document related to previous sprint	2 hours
TDAA-36	Document the finished sprints so far	2 hours
TDAA-38	Start developing the "complete the sentences" minigame	6 hours
TDAA-39	Complete chapter 4 of the project document	6 hours
TDAA-32	As a client I want to be able to go to the game from the main menu	1 hour
TOTAL:		17 hours

Sprint Review

The Product Owner (PO) and I concluded that all the previous tasks have been correctly completed within time.

Sprint Retrospective

The proposal for next sprints is to give more work to the development team to have the product created for the delivery date (15 July).

4.2.6 Sprint 6 – Minigames II and III (First part).

Sprint Goal

For this sixth sprint, the development team must get informed and start implementing the second and third minigames, and add some features to the game, such as songs and colour changing.

Sprint Planning

This sprint started on 20 April 2022 and finished on 11 May 2022. Their main tasks programmed for this sprint is to start/continue with the Chapter 5, search for information about the second and third minigames to discover the best way to implement them and start implementing them.

In addition, the development team must implement some features such as allowing the user changing the background colour and toggling on/off the background music.

Table 7: Sprint 6 tasks

ID	Task	Estimation
TDAA-41	Complete chapter 5 according to the minigames development	4 SP
TDAA-42	Document the finished sprints so far as a client I want to know the feedback about if it is possible to implement a Daily Activities minigame.	6 SP
TDAA-43	As I client I want to be able to change the background colour of the game	2 SP
TDAA-44	As I client I want background music for the game, and the option to mute it	2 SP
TOTAL:		17 SP

Sprint Review

During the meeting with the Product Owner (PO), unfortunately, once again due to external problems of the development team, not all the tasks could be accomplished. For that, the next sprint will be dedicated to finish the uncompleted tasks from this sprint (finish the third minigame), in addition to new ones.

Also, the meeting assistants have taken an important decision for the project. Neither the development team and any other company department have enough knowledge about which exercises for the games are the best for the children with ASD, not as much as the workers from the autism association have, so we decided to create an Administrative Web that allow the association collaborators to create, edit and delete new exercises for each one of the three minigames.

Sprint Retrospective

The development team performance for this sprint was lower than expected, but this time they have promised to deliver the next sprints functionality in time.

4.2.7 Sprint 7 – Minigames I and II (Second part).

Sprint Goal

In this sprint, that is expected from the development team is to implement the basic structure of the administrative web, and to finish the third minigame.

Sprint Planning

This sprint started on 11 May 2022 and finished on 1 June 2022. The development team must create the basic structure of the administrative web, allowing users to login, create, edit, and delete all the exercise for the first and second minigames. The third one will be task of next sprint.

Table 8: Sprint 7 tasks

ID	Task	Estimation
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TDAA-45	As a client I want an administrative web to manage the minigames	15 SP
TDAA-47	Finish third minigame (Order de sequences)	5 SP
TDAA-49	Connect the administrative web to MongoDB	2 SP
TDAA-50	Connect the Unity app to MongoDB	2 SP
TDAA-52	As a client I want to be able to login to the administrative web using a unique user.	4 SP
TDAA-55	As a client I want to be able to upload images to firebase	6 SP
TDAA-56	As a client I want to be able to delete images from firebase	4 SP
TDAA-57	As a client I want to get images from firebase to the administrative web for the emotions minigame	2 SP
TDAA-58	As a client I want to get images from firebase to unity for the emotions minigame	3 SP
TOTAL:		43 SP

Sprint Review

Once again, the Product Owner (PO) and the development team met to review the implemented functionality. The development team surprised everyone with a huge amount of delivered functionality, so there were no complains and suggestions about anything.

Sprint Retrospective

The development team performance was very good, delivering all the functionality in time. The only suggestion for next sprints was to subdivide huge tasks into several smaller tasks, so that they can be easily managed by the development team.

4.2.8 Sprint 8 – Evaluation and improvements

Sprint Goal

For this new sprint, the team is going to focus on work mainly on the administrative web, and on preparing the system evaluation. Some improvements related to basic functionality and user interface also are going to be implemented.

Sprint Planning

This sprint started on 1 June and finished on 28 June. The main task for this sprint is to create authentication for the administrative web, change the design of the ordering minigame to make it “drag and drop”, prepare the evaluation, and many other minimal but important improvements of functionality and user interface.

Related to the evaluation, during this sprint, the team and the client have arranged a personal meeting for the system evaluation. This evaluation was carried out on the last days of the sprint, after implementing the expected functionality, and the users tested a prototype of the system.

Table 9: Sprint 8 tasks

ID	Task	Estimation
TDAA-59	As a user I want to login to the administrative web	4 SP
TDAA-60	Set up the favicons and other UI images	2 SP
TDAA-61	As a client I want a public section of the administrative web where I can put information related to the applications	4 SP
TDAA-62	Deploy the administrative web (server) to Heroku	2 SP
TDAA-63	Deploy the administrative web (client) to Heroku	2 SP
TDAA-64	As a client I want the third minigame to be "drag and drop"	6 SP
TDAA-65	In the "guess the images" game, create a restriction for the response to be a word with max. 12 characters	1 SP
TDAA-66	As a client I want a public section where I can find the links to download the app for several platforms	1 SP
TDAA-67	As a client I want to be able to filter the games list	2 SP
TDAA-68	As a client I want to be able to choose a category before starting quiz minigame	4 SP

TDAA-69	As a client I want to get at the end of each game a screen where I can see the results	4 SP
TDAA-70	Add the possibility to introduce to the guess images game an optional sentence.	2 SP
TDAA-71	In the ordering minigame, when a new image is uploaded over an existent one, delete the old one	3 SP
TDAA-72	Prepare the evaluation of the administrative web	5 SP
TDAA-73	Prepare the evaluation of the mobile game	5 SP
TDAA-74	Document the evaluation (chapter 6)	3 SP
TDAA-75	As a client I want to be able to choose from the web which exercises will appear in the game without deleting them	2 SP
TDAA-76	Upload files to firebase with a random name	1 SP
TOTAL:		53 SP

Sprint Review

In the meeting with the Product Owner (PO), the development team has exposed a very important increment of functionality. They were proud of all the work achieved during the three last sprints, being this one the most important so far.

The participants of the meeting concluded that there will be one last sprint dedicated to finish all the documentation and make minor improvements on the system.

Sprint Retrospective

All the expected work for this project is almost done. All tasks of this sprint were completed in time.

4.2.9 Sprint 9 – General improvements

Sprint Goal

The main goal of this sprint is complete all the final documentation and make minor improvements of the system without changing important features.

Sprint Planning

This sprint started on 28 June and finished on 12 July.

Table 10: Sprint 9 tasks

ID	Task	Estimation
TDAA-77	Refine evaluation (chapter 6)	2 SP
TDAA-78	Add hover colour effect to tables' rows	1 SP
TDAA-79	Filter lists of exercises by date (from most recent to older)	1 SP
TDAA-80	Complete point 3.1 (structure of the document)	1 SP
TDAA-81	Finish documenting chapter 4 sprints and add a conclusion	1 SP
TDAA-82	Add progress bar when uploading an image to show the upload progress	1 SP
TOTAL:		7 SP

Sprint Review

During the review meeting, development team has exposed the minor changes done over the UI of the administrative web. With this sprint review, the project has arrived at its end.

Sprint Retrospective

All the tasks have been completed at time. A duration of two weeks was more than enough to accomplish all the objectives of the sprint. As it is the last sprint, there is no need of defining considerations and possible improvements.

4.3 Conclusions

The project duration was from 28 January to 12 July (165 days). In general terms, the project has been completed and delivered to the client with success, but during its development there were some irregularities. The performance of the development team was not the same for all the sprints, so the entire team has taken an important decision for the next projects: split each sprint load evenly between all of them. Anyway, all the members that have participated into this project are proud of the result achieved.

Chapter 5

Application description

This chapter will be dedicated to describing the result, but also the employed architecture, system functionality and use suggestions. Screenshots of the applications user interfaces will be exposed along with the explanation of all the functionalities

5.1 Product architecture

The final product consists of a client – server architecture, establishing the communication between both through HTTP protocol. Each one of the components will be grouped in three categories: server, client, and persistence.

5.1.1 Server

For the server implementation, I employed Node.js, which is a JavaScript multiplatform execution environment oriented to asynchronous events. Node.js is ideal for creating scalable network applications (Node.js Team, 2022).

The hosting provider employed was Heroku, which is a hosting provider for deploying application, and supports several environments such as Node.js, Go and Java (Heroku, 2022).

The main purpose of the server is acting as an intermediary between the client and the database.

5.1.2 Persistence

Each application that pretends to store and get data must implement data persistence through databases. In this case, two database providers were employed: MongoDB and Firebase storage.

MongoDB is a NoSQL provider that allows us to store data represented as JSON documents, employed to store all the minigames exercises data.

Firebase is another multipurpose provide, giving services such as authentication and file storage. Firebase was employed to store the images uploaded by the user via the web client, generating URLs for each image, stored in MongoDB.

5.1.3 Client

There are two clients: the TEA Minigames administrative web for the association collaborators, and the TEA Minigames mobile game for the children with ASD.

The **TEA Minigames administrative web** is a web application fully implemented with Angular 13, which main purpose is to manage CRUD operations over the database via user interface. It directly communicates with the server and with Firebase.

The **TEA Minigames mobile application** is a mobile application fully implemented with Unity engine, which is a development platform oriented to videogames development, making use of C# as native programming language, and providing a very intuitive interface to the developer. The mobile application is directly communicated with the server.

The architectural elements can be seen in the figure 6, along with their data flows:

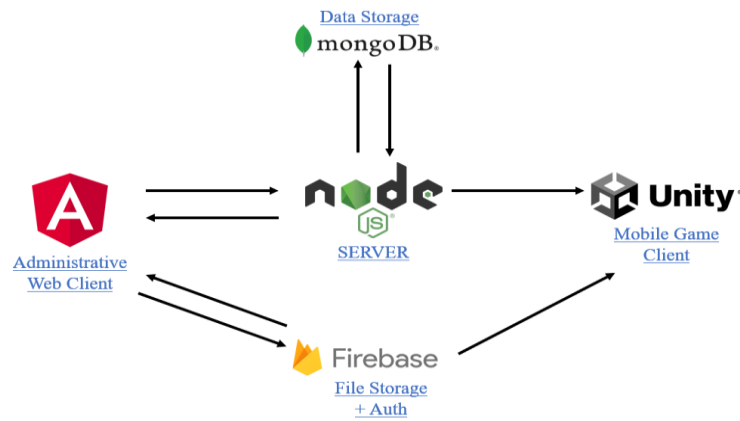


Figure 6: System architecture

A deployment diagram of the system has been created, available at the [Annex II](#).

5.2 System functionality

The administrative web allows users to manage the exercises from each one of the minigames from the mobile game. The user logged in can create, edit, and delete the exercises for each one of the minigames. For those games where it is required, images can be uploaded from the user's device.

On the other hand, the mobile game does not require login, and allows the user to directly play to the minigames. The exercises for each minigame are downloaded from the server and charged in real time.

This product is focused on customization, allowing the users of the administrative web control everything that will be reflected on the mobile game.

For a more technic explanation about system functionality, see [Annex V](#).

5.3 Use recommendations

The idea of programming the administrative web with a framework like Angular came away with one purpose: having only one html document for the entire app, giving user a clean user interface by dynamically showing or hiding the elements. The

application is compatible with most of browsers, it is hosted on Heroku, and accessible by the link available at the [Annex VI – TEA Minigames – Administrative web](#).

Related to the mobile game, Unity has been chosen because of the intuitive interface it provides to the programmer to create games with much less required effort than using other platforms or technologies. In addition, Unity is modular, so in the future many other minigames can be added without affecting the functionality of the existing ones. We can also highlight Unity because of its multi-platform support feature, giving the possibility to build applications for many operative systems. The mobile application can be downloaded for iOS, Android, and Microsoft Windows operative systems from the downloading section of the web client (see [Annex VI – TEA Minigames - Game](#)).

5.4 Description of developed applications

Before start describing the applications, some general considerations must be considered.

On the one hand, although this document is written in English, the applications were developed in Spanish, because as the product is intended for a specific client, in this case the *Asociación Desarrollo – Autismo Albacete*, this is the language they use for communication.

On the other hand, the mobile game can be used by everyone, but the administrative web access is limited to the administrator and client. This is because, in the opposite case, everyone could modify or delete the questions of the mobile game.

5.4.1 TEA Minigames administrative web

Before accessing to the web functionalities, the user must login with a user and password previously created by the development team. Since this system is focused on a concrete client, there is no option for register a new user, because this would be dangerous. Everybody could modify and delete the data, and the idea is that only the association's workers can do that. The user can login through the following view.

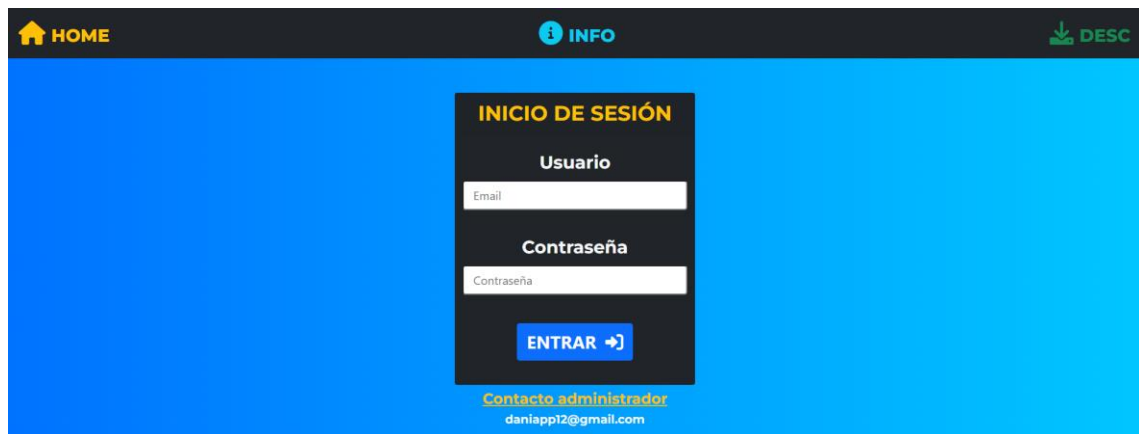


Figure 7: Administrative web – Login

After logging in, the user will be redirected to the game’s menu, with three buttons, one for each game.



Figure 8: Administrative web - Main menu

If the user clicks the “information” button from the navigation bar, a view with some information about the web and the games is shown.



Figure 9: Administrative web – Info

If user click the “download” button from the navigation bar, he/she will be redirected to a view where the mobile game can be downloaded for the following platforms: Android, and Microsoft Windows. The game will not be available for iOS now.

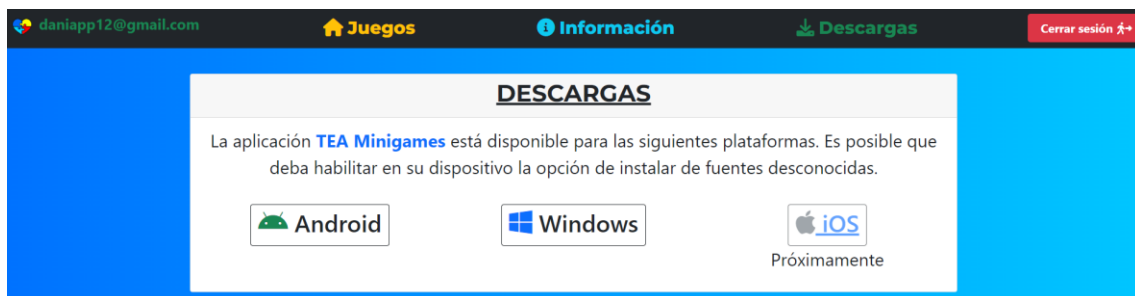


Figure 10: Administrative web – Download

Common game UI elements

If we click on any game button from the game’s menu, user will be redirected to a view which contains a list of exercises. Once there, we must note that all the games have the following common elements:

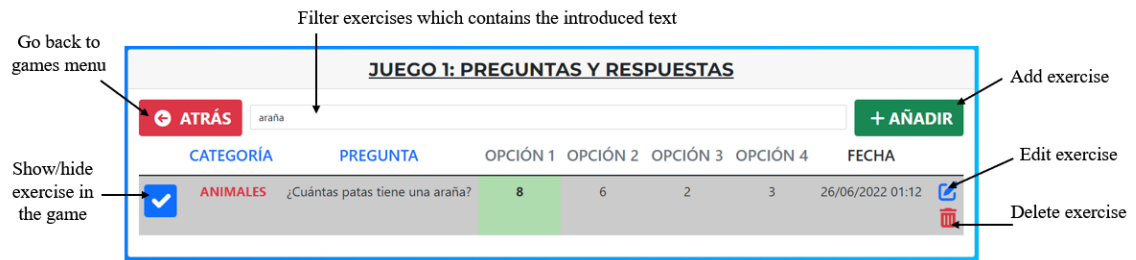


Figure 11: Games UI common elements

In addition, all the exercises from the lists are ordered by date, from newer to older. This date will be updated to the current moment each time the user creates or edit an exercise.

When the user wants to add a new exercise, there is a formulary error handling where forbid user to create the exercise if any of the fields from the form does not match with the required data format. Note that fields marked with an asterisk (*) are required, and the accept button is disabled on the **Figure 12:**

The screenshot shows the 'CREAR PREGUNTA DEL QUIZZ' form. It contains several input fields, each with a red error message below it indicating that the field is required. The fields and their error messages are: 'Pregunta *' with 'La pregunta es obligatoria'; 'Respuesta 1 *' with 'La respuesta 1 es obligatoria'; 'Respuesta 3 *' with 'La respuesta 3 es obligatoria'; 'Respuesta 2 *' with 'La respuesta 2 es obligatoria'; 'Respuesta 4 *' with 'La respuesta 4 es obligatoria'; 'Respuesta correcta *' with 'La respuesta correcta es obligatoria'; and 'Categoría *' with 'La categoría es obligatoria'. At the bottom of the form, there are two buttons: 'ATRÁS' and 'ACEPTAR'.

Figure 12: Form fields error handling

Quiz game management

After pressing the button of the first minigame from the game's menu, the user will be redirected to a list of questions. The user can create, edit, and delete new questions, that will be immediately reflected in the game.

PREGUNTAS Y RESPUESTAS							
← ATRÁS AMIGOS + AÑADIR							
	CATEGORÍA	PREGUNTA	#1	#2	#3	#4	FECHA
☒	AMIGOS	Hay una chica nueva en tu clase. ¿Qué deberías hacer?	Decirle que se vaya	Preguntarle si quiere jugar contigo	Nada, ya tienes amigos	Decirle que no se acerque a tí	21/06/2022 00:18
☐	AMIGOS	¿Quién tiene amigos?	Sólo los niños	Todo el mundo	Sólo los niños y los profesores	Sólo las niñas	27/06/2022 01:22
☒	AMIGOS	¿Qué deberías hacer para ser un buen amigo?	Compartir	Ayudarles	Jugar con ellos	Todas las anteriores	21/06/2022 00:18
☒	AMIGOS	Ya no quieres jugar con tu amiga. ¿Qué le dirías?	Vete de aquí	Dejame en paz	Lo siento, pero me tengo que ir	No me gustas	21/06/2022 00:20
☐	BULLYING	Si alguien se mete contigo sin razón, ¿de quién es la culpa?	Del abusón	Tuya	Del profesor	De tus amigos	22/06/2022 15:02

Figure 13: Quizz game - List

When the user presses the “add” or “edit” button, a new screen is shown where the user can create or update questions (Figure 14). The correct answer index must be a number between 1 and 4, and once introduced, the correct option will be highlighted on green. If we want to add several questions to the same category, the category field must be equal in all of them.

EDITAR PREGUNTA

Pregunta *

Hay una chica nueva en tu clase. ¿Qué deberías hacer?

Respuesta 1 * **Respuesta 3 ***

Decirle que se vaya Nada, ya tienes amigos

Respuesta 2 * **Respuesta 4 ***

Preguntarle si quiere jugar contigo Decirle que no se acerque a tí

Respuesta correcta * **Categoría ***

2 AMIGOS

◀ ATRÁS **✓ ACEPTAR**

Figure 14: Quiz game - Create/Edit

Guess images game

If user press the button of the second minigame, a list with all the data will be shown, as we can see in the **figure 15**.

JUEGO 2: ADIVINA LAS IMÁGENES						
◀ ATRÁS	Qué animal			+ AÑADIR		
ENUNCIADO	IMAGEN 1	IMAGEN 2	RESPUESTA	FECHA		
☒ ¿Qué animal es?			vaca	27/06/2022 02:57		
☒ ¿Qué animales son?			ratones	26/06/2022 21:07		
☒ ¿Qué animal es?			delfin	22/06/2022 15:45		
☐ ¿Qué animal es?			leon	22/06/2022 15:46		
☒ ¿Qué animal es?			loro	20/06/2022 20:22		

Figure 15: Guess the images game – List

When the user presses the create/edit button, he/she can modify the data, upload new images (by clicking the blue cloud button) and delete existing ones (red trash button). The missing answer word must be a single word which contains 12 or less characters, and

numbers and special characters are not allowed; sentence and image descriptions fields are optional. See figure 16:

EDITAR EMOCIÓN

Enunciado (opcional)
¿Cómo están los perritos?

Descripción 1 (opcional)
Primera imagen

Descripción 2 (opcional)
Segunda imagen

Respuesta *
Felices

ATRÁS ACEPTAR

Figure 16: Guess the images game - Create/Edit

Order images

When the user presses the button of the third game, once again, a list with all the data of the activity will be shown. Those empty images will be filled with a black camera image (Figure 17).

LISTADO DE ACTIVIDADES										
		ordena las fcl								+ AÑADIR
ENUNCIADO	1	2	3	4	5	6	7	8	FECHA	
☒ Ordena las fotos									20/06/2022 15:51	
☐ Ordena las fotos									22/06/2022 15:27	
☒ Ordena las fotos									22/06/2022 15:29	
☒ Ordena las fotos									22/06/2022 15:30	

Figure 17: Order images game – List

Order images

When the user presses the create/edit button, he/she can upload new images (blue cloud button) and delete existing ones (red trash button). The orders field must be a

number from 1 to 8 and must be different. To avoid possible problems, try to upload the images in order. See **figure 18**:



Figure 18: Order images game - Create/Edit

5.4.2 TEA Minigames mobile game

Main menu

When the user launches the mobile game, he/she will be redirected to the main menu, with three buttons: play, options, and exit game buttons.



Figure 19: Main menu – Buttons

In the options section, background music can be toggled on/off, and background colour can be switched between six different colours. See figure 20:



Figure 20: Options

When pressing the “play” button, we can see a button for each one of the minigame, which is going to redirect us to that game. See figure 21:



Figure 21: Main menu – Minigames

Quiz game

When pressing the button of the quiz game, a list of categories will be shown. The user can select one specific category, or questions from all categories. See figure 22:

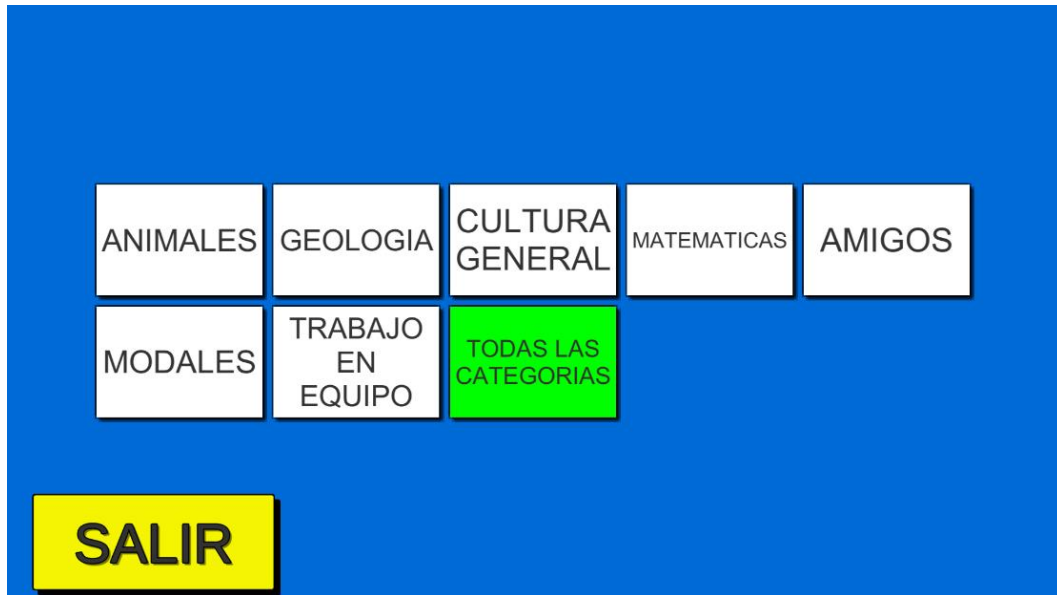


Figure 22: Quiz Game – Categories

When a category is selected, a question will be shown, along with 4 options with only one correct, a button which redirects user back to main menu, and another button that allows player skip current question. See figure 23:

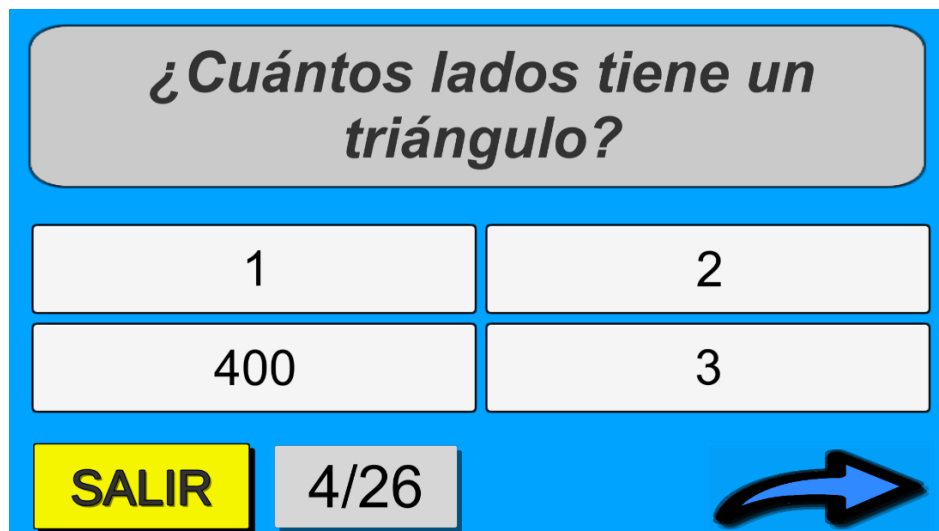


Figure 23: Quiz Games – Gameplay

When the player selects an option, depending on the correctness, feedback is shown happy face if correct, sad face if wrong (Figure 24).



Figure 24: Quiz game - Feedback

When all the questions are answered/skipped, a final screen with three number of correct, wrong, and skipped questions is shown to the player.



Figure 25: Quiz game – Results

Guess the images game

When user press the “guess the images game” button from the main menu, the user goes to the game, where two images, along with their optional descriptions, another optional panel for the question, the unknown word and a selection of characters which contains the letters of the missing word (Figure 26). Also, there are five buttons:

- Reset: clean the missing word.
- Delete: delete the last character added to the missing word.
- Skip: go to the next exercise.
- Tip: highlight the characters of the missing word (figure 27).
- Exit: go to the main menu.

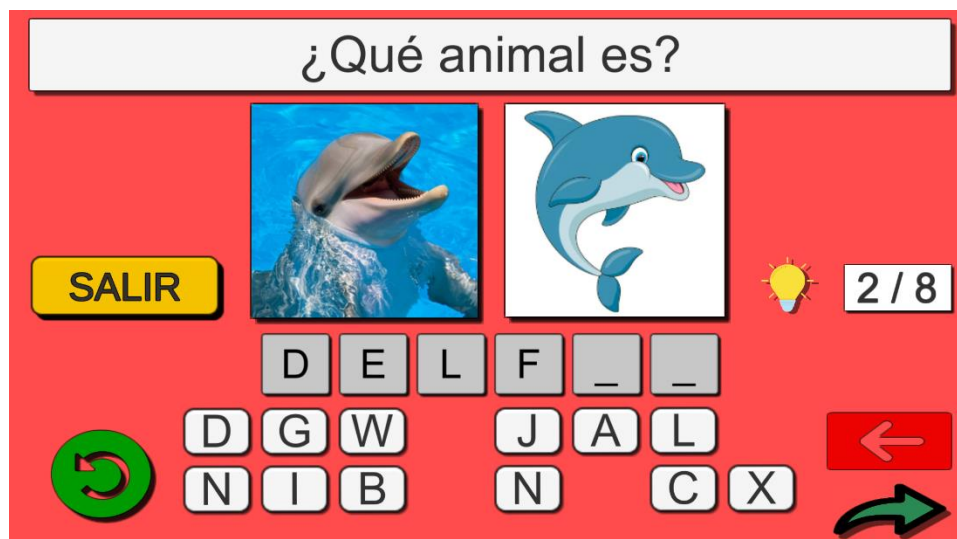


Figure 26: Guess images game – Gameplay



Figure 27: Guess image game - Gameplay with tips

If descriptions were added to the images, two panels will be shown on the right and the left, as we can see in the figure 28:



Figure 28: Guess images game - Gameplay with descriptions

Whether if the player fills the missing word in a correct or wrong way, feedback will be shown to the screen with a happy or sad face (figure 29):

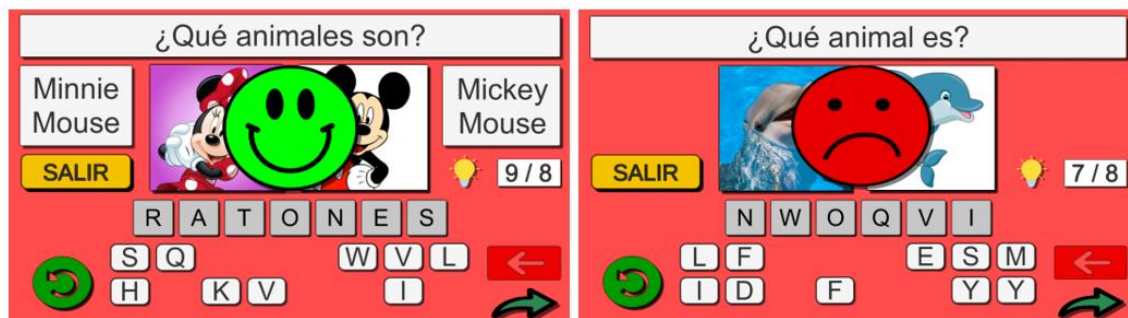


Figure 29: Guessing images game - Feedback

Order images game

In this game we can see a sentence describing a situation, and up to eight gaps, along with the same number of images representing the described situation. The player must reorder the pictures in the correct order by drag-and-dropping them. When all the pictures are correctly ordered, the game load next exercise (figures 30 and 31). The user interface has three buttons:

- Exit: go to the main menu
- Reset: put the pictures at their original position and start again.
- Skip: go to the next exercise.



Figure 30: Order images game - Gameplay (I)

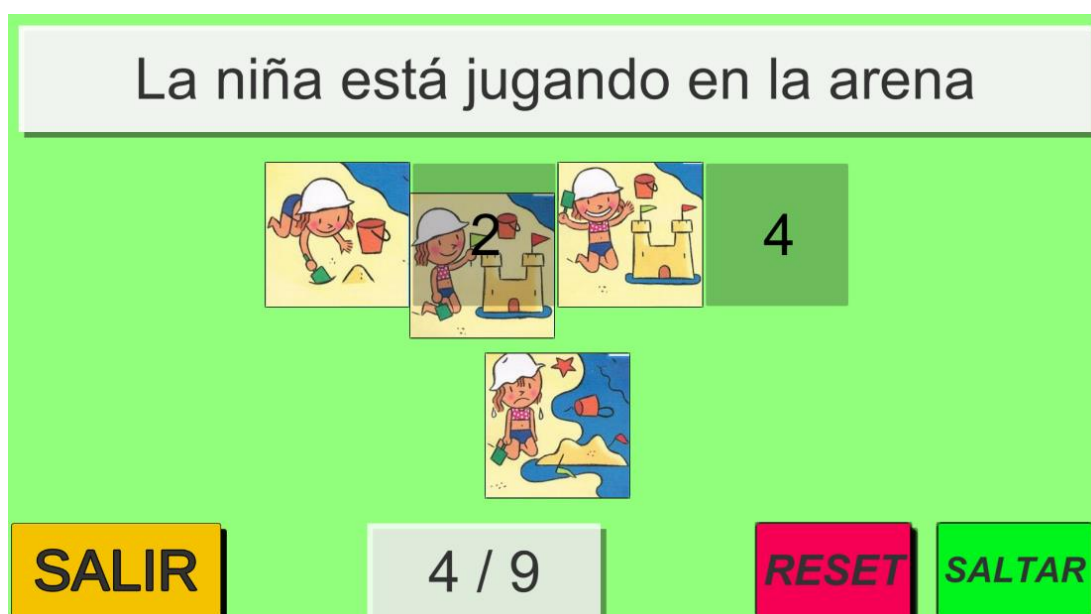


Figure 31: Order images game - Gameplay (II)

Whether if player fills the slots in a correct or incorrect way, a feedback like in the previous games will be shown to the screen, as we can see in the figure 32:



Figure 32: Ordering sequences game - Feedback

Chapter 6

Evaluation

In this chapter it is going to be exposed the quality in use of both administrative web and mobile game applications. The evaluation was made in a real environment, with real users, very similar to those that are going to use the system. After the evaluation, its results are going to be presented.

6.1 Introduction

The evaluation was carried out for both applications: the administrative web, evaluated on a computer, and the mobile game, evaluated on a computer using a digital board.

For the evaluation, there was taken as reference the ISO/IEC 25062 standard, and a SUS questionnaire to evaluate the satisfaction of the users at using both applications.

6.1.1 Product description

TEA Minigames is a project motivated to facilitate children with ASD their integration in our society. The project is composed by two different applications: one for the children with ASD which contains the games, and another one for the people in care of these children, or monitors, who can fully manage the games' exercises.

This project is motivated by a single purpose, but it is destined for both the children with ASD and their caregivers.

6.1.2 Evaluation objectives

As told before, the evaluation is carried out to measure the quality in use of both developed applications. Several quality characteristics were selected, and the evaluation will be carried out around them:

- **Functionality:** The degree to which the users find the features complete, and the degree to which the system reacts as expected to user behaviors.
- **Utility:** The degree to which application features are useful for the final users.
- **Easy to use:** The degree to which the user knows how to use the provided features with or without help, even if they have not previous knowledge about the system.

6.2 Method

The followed method to carry out this evaluation will be shown in this section. For that, it is useful to have information about the participants, context, test design and employed usability metrics.

6.2.1 Participants

As told before, the final product will have two very different users' groups: children with ASD, that we are going to call children group, and people in care of the previous ones, the adults group. The number of participants of each group are 3 children and 6 adults.

On the one hand, the adult group will be shown in the [table 7](#). The collected data was their age range, and their IT use level.

Table 7: Adult participants

Adult	Age range	Sex (M/F)	IT use level (1-10)
1	20-29	F	7
2	30-39	F	6
3	40-49	F	4
4	20-29	M	8
5	20-29	F	8
6	20-29	M	7

On the other hand, the other group related to the children is shown in the [table 8](#). All the participants of this group are from the *Asociación Desarrollo – Autismo Albacete*, and we will collect almost the same data as for the previous group, because the IT use level was limited to three levels: good, medium, and bad.

Table 8: Children participants

Child	Age range	Sex (M/F)	IT use level (good/medium/bad)
1	10-16	M	Good
2	10-16	M	Good
3	10-16	M	Medium

6.3 Context of product use

6.3.1 Tasks

The tasks that will be carried out depends on the group to be evaluated. Those tasks were given to the participants, who must carry them out in a normal context of use, that is, using a computer for the web, and another computer with a digital board for the game.

Administrative web

For the administrative web, the participants must follow the same process for the three minigames: add an exercise, edit, and then, delete it. For the two last games, as images are required, they will dispose of some pictures on their computer previously provided by the evaluator, so they can easily upload them. These tasks are shown with more details in [Annex IV – Evaluation tasks](#).

Mobile game

For the mobile game, the participants must play each one of the three minigames until they complete 5 exercises. The initial idea was to test it on a mobile device like a smartphone or a tablet, but the client had a digital board where participants could play to the game such as a mobile device. The specific tasks to be carried out by the participants of the second group are detailed in the [Annex IV – Evaluation tasks](#).

Previous tasks were selected because are considered as basic tasks that cover all the functionality of the system. Instructions of those tasks will be given to the participants.

Each task will be considered successfully passed if the participants cover all the required steps.

6.3.2 Test context

The context is composed of the place where the test is carried out, the devices used, and any other consideration that affects the evaluation process.

TEA Minigames administrative web is intended to be used on any modern browser such as Google Chrome, Firefox, Microsoft Edge, or Opera. This means that it can be used also on mobile devices' browser, but it is optimized for computers with a resolution of 1080p. The test of the web will be carried out on a computer.

TEA Minigames mobile game can be used on Microsoft Windows, and Android, but for the evaluation, a tablet will be used. The size of the game is 26 MB for Android, and 142 MB for Microsoft Windows.

6.3.3 Experimental design

The following data have been obtained from the evaluation: time lasted on each task, errors, assists, and assisted/non-assisted completion rates. Also, a SUS questionnaire has been provided to the participants.

The language used for the evaluation was the Spanish since it was easier and more effective to communicate.

The evaluation of children was based on observation, since the number of participants from this group could not be greater than 3, so I have opted for qualitative instead of quantitative data. We had the luck that the *Asociación Desarrollo – Autismo Albacete* provided us with an interactive digital board, where participants could play the games in a large display.

The evaluation of the adults was performed online, since the evaluator decided to take advantages to the evaluation meeting to evaluate only the children. This is because there were no more time and opportunities to arrange another meeting.

6.3.4 Process

The evaluation administrator arrived to the *Asociación Desarrollo – Autismo Albacete*, with all the needed material, and carried out the evaluation of the participants.

While the participants were using the applications, the administrator has observed them, taking notes about the evaluation data, along with personal data of each one of the participants as we have seen in the tables 7 and 8.

6.3.5 Usability metrics

There are three characteristics employed to carry out the evaluation, along with their metrics: effectiveness, efficiency, and satisfaction. These belongs to the ISO/IEC 25022.

- The **effectiveness**' metrics are the unassisted and assisted completion rates, the number of errors at performing the tasks and the number of assists from the evaluator.
- The **efficiency** is measured by the time to complete each task.
- The **satisfaction** is measured by the SUS (System Usability Scale) questionnaire provided to the participants after performing the tasks. Unfortunately, there is not a version of the SUS questionnaire for children, so an adaptation of the original one will be done. See the SUS questionnaires from [Annex IV – SUS questionnaires](#).

6.4 Results

6.4.1 Data analysis

The participants' behaviour has been catalogued into groups of time required to carry the evaluation, number of errors, number of assists, and assisted/unassisted completion rates. In addition, as the employed method was observation, evaluator paid attention to every commentary and possible unusual behaviour that could be useful for system analysis. To facilitate this work, evaluator came to the evaluation place with a companion, which helped him with the observation, to not miss any detail.

The mean, the minimum and maximum values, and the standard deviation were employed to help analysing the results. Also, the obtained SUS score has been considered.

6.4.2 Adults result

Adults' performance results

The results for the previously defined tasks that adult's group must perform (see [Annex IV – Evaluation tasks](#)) are the following ones:

Task A1: Create, edit, and delete a question for the quiz game. See tables 9 and 10.

Table 9: Evaluation results - Adults group - Task A1

Participant	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
1	100	0	00:52	0	0
2	100	0	00:46	0	0
3	100	0	00:59	0	0
4	100	0	00:53	0	0
5	100	0	01:07	0	0
6	100	0	00:43	0	0

Table 10: Evaluation statistics - Adults group - Task A1

	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
Mean	100	0	00:53	0	0
Min.	100	0	00:43	0	0
Max.	100	0	01:07	0	0
Standard deviation (σ)	0	0	00:09	0	0

Task A2: Create, edit, and delete an exercise for the guessing game. See tables 11 and 12.

Table 11: Evaluation results - Adults group - Task A2

Participant	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
1	100	0	00:44	0	0
2	100	0	00:32	0	0
3	75	25	01:02	0	1
4	100	0	00:41	0	0
5	100	0	00:59	0	0
6	100	0	00:55	0	0

Table 12: Evaluation statistics - Adults group - Task A2

	Unassisted rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
Mean	95,83	4,17	00:49	0	0,16
Min.	75	0	00:32	0	0
Max.	100	25	01:02	0	1
Standard dev. (σ)	10,21	10,21	00:12	0	0,4

Task A3: Create, edit, and delete an activity for the ordering game. See tables 13 and 14.

Table 13: Evaluation results - Adults group - Task A3

Participant	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
1	100	0	00:54	0	0
2	50	50	01:13	0	2
3	75	25	01:04	0	0
4	100	0	00:49	0	0
5	100	0	01:00	0	0
6	100	0	00:57	0	0

Table 14: Evaluation statistics - Adults group - Task A3

	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
Mean	91,67	8,33	01:00	0	0,33
Min.	50	20,41	00:49	0	0
Max.	100	0	01:13	0	2
Standard dev. (σ)	20,41	50	00:08	0	0,82

Adults' satisfaction results

The obtained SUS individual and total scores are present in the table 15.

Table 15: SUS score for adults' group

Participant	Score
1	85
2	92.5
3	95
4	77.5
5	80
6	95

MEAN	87.5
-------------	------

6.4.3 Children result

Children performance results

The results for the previously defined tasks that children group must perform (see [Annex IV – Evaluation tasks](#)) are the following ones:

Task B1: Play to the quiz game and complete first 5 exercises (first game). See tables 17 and 18.

Table 16: Evaluation results - Children group - Task B1

Participant	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
1	60	40	00:45	0	2
2	100	0	01:03	0	0
3	100	0	00:56	0	0

Table 17: Evaluation statistics - Children group - Task B1

	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
Mean	86,67	13,33	00:55	0	0,66
Min.	60	0	00:45	0	0
Max.	100	40	01:03	0	2
Standard deviation (σ)	23,09	23,09	00:09	0	1,15

Task B2: Play to the guessing game and complete first 5 exercises (second game). See tables 18 and 19.

Table 18: Evaluation results - Children group - Task B2

Participant	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
--------------------	-----------------------------------	---------------------------------	---------------------	---------------	----------------

Evaluation

1	80	20	01:01	0	1
2	100	0	00:57	0	0
3	100	0	01:49	0	0

Table 19: Evaluation statistics - Children group - Task B2

	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
Mean	93,33	6,67	01:16	0	0,33
Min.	80	0	00:57	0	0
Max.	100	20	01:49	0	1
Standard deviation (σ)	11,55	11,55	00:29	0	0,58

Task B3: Play to the ordering game and complete first 5 exercises (third game). See tables 20 and 21.

Table 20: Evaluation results - Children group - Task B3

Participant	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
1	80	20	01:12	1	1
2	100	0	01:35	0	0
3	100	0	01:20	1	0

Table 21: Evaluation statistics - Children group - Task B3

	Unassisted completion rate	Assisted completion rate	Time (mm:ss)	Errors	Assists
Mean	93,33	6,67	01:22	0,66	0,33
Min.	80	0	01:12	0	0
Max.	100	20	0:35	1	1
Standard deviation (σ)	11,55	11,55	00:12	0,58	0,58

Children satisfaction results

The individual and total SUS scores are the following ones from the table 22.

Table 22: SUS score for children group

Participant	Score
1	72.5
2	67.5
3	90
MEAN	76.66

6.5 Results discussion

After evaluation has finished and results have been obtained, there are some points we must discuss from analysing those results and participants behaviour.

First, because it is difficult to find users with the searched profile, in this case children with ASD, we had to settle for 3 participants. For that, evaluator has opted for a qualitative test approach. Children were observed during all the test by the evaluator and its companion. The monitors helped us by giving tips of how to interact with the kids.

Second, since the number of adult participants were limited at the testing site, the evaluation was complemented with other participants like the previous ones.

Adults' evaluation discussion

As we can see in the previous tables related to this group's evaluation, there were no errors committed by the participants at using the administrative web, since the development team have implemented a simple user interface and a good error handling, such as forbidding at the formularies non-compatible characters, words length, number ranges, etc.

The number of assists was very small, due to the simplicity of the user interface and the use of metaphors. The task completion times are quite similar between participants, since they didn't need to think much about the functionality.

We can see more standard deviation in the last two tasks than in the first one, specially at the task times, and this is because the number of steps were higher, and they had to upload images.

Finally, the SUS score obtained for adults' group was 87.7, which is bigger than 68, so observing the SUS scale from the [Annex IV – SUS questionnaires](#), we can ensure that the administrative web is more than acceptable.

Children evaluation discussion

The children enjoyed playing the games. They found them interesting, specially the first one, the quiz game. They got more assists and errors than the adults, but we must split them into two categories: errors and assists due to the user interface, and those due to the exercises difficulty, which were not considered in the evaluation, since only system functionality issues must be considered.

On the one hand, due to game functionality and user interface, we could observe the following issues:

- Some buttons colour didn't contrast well with the text colour inside them, so they could not be read well.
- In the ordering sequences game, for some reason, once all the figures were positioned inside the slots, if the kids wanted to put any figure back to its initial position, they couldn't. For that, they may have pressed the "reset" button to reload the exercise.

On the other hand, due to exercises' difficulty that the evaluator prepared, we figured out, with the help of monitors observations, the following issues:

-
- Some questions from the quiz game were too difficult, or they had too much text. Children with ASD feel overwhelmed with an interface with too many words. In the evaluation, the usual response of the kids was to rapidly choose an answer, independently if it was correct or not.
 - Some images from the guessing the images game were not too appropriate for children with ASD. There were two images of a scared dog, and this kind of images could have a negative impact on the children.
 - Additionally, in the guessing the images game, we figured out that sometimes the missing word was too long, and there were too many possible letters. Anyway, the kids also enjoyed this game, and there were no complains about.
 - In the ordering sequences game, some activities got too many figures. This is not a problem, because the monitors can create shorter activities from the administrative web, with up to 8 images.

Finally, the SUS score obtained for children group was 76,66. Since it is bigger than 68, we can call the game, from the point of view of usability, acceptable.

Other considerations and improvements

Apart of the analysed data, the monitors give us some commentaries during and after the children evaluation. Those suggestion can be seen with more details at the [Annex I – Meetings with the client](#).

Chapter 7

Conclusions and future work

In this final chapter, the extracted conclusions from the project development will be exposed, along with the grade of achievement of the objectives proposed for this project during its initial stages. In addition, it is also important to highlight all the tasks that could not be carried out during this project, but are thought for the future, and define the outcome of this solution.

7.1 Conclusions

The completion of this Undergraduate Dissertation has achieved the main objective proposed for this project, *the development of a system in charge of helping social integration of children with autism spectrum disorder*.

Once setting up the idea of how the system should be adapted for the final users, having previously studied those users' characteristics, and gamification models and examples, the development of the final solution had started. Initially, the idea of how the system should be was too general, and it has been refined during first steps of the development process, until the result was a solid enough idea to work with.

The initial idea was to create only a game composed three minigames, animations, lots of sounds, colours, etc., with some fixed exercises, only upgradeable by the developers, but the team considered this last issue a huge limitation. During the game development, the team decided to sacrifice some of the previous features related to animations or sounds to create another application that allows the completely management of the game exercises, making it as customizable as possible. So, the final

system is a set of two different applications with different architectures, but totally dependent on each other. One important capacity of this system is that it is fully modular, so new minigames can be added without having to modify the other ones.

The first application, planned for mobile devices, would be used for the children with ASD, containing three minigames, and some customization options, such as changing background colour and toggling on/off music.

The second application is a web application that allows users to create/edit/delete the exercises from all the minigames.

Finally, to evaluate the system mainly composed of the two previous elements, the ISO 25062 was employed. The quality in use will be measured with real users, very close to those who the system is destined to.

To conclude, this project development has helped the author to show the acquired knowledges during the career, being more specific, the knowledges related to software engineering.

7.2 Future work

Once the product was finished and delivered to the client, the team detected some improvements during the development that could enhance the final product. The future improvements will be split between the administrative web and game improvements:

TEA Minigames – Administrative web

The following improvements related to the game's exercises management were detected for future development:

- Quiz game: give the option to the user to add an image along with the sentence. Right now, the minigame only allows creating exercises with sentence and four possible answers.
- Statistics panel: In this section would appear the statistics of all the previously played games at the mobile game, with data such as hits, misses, unanswered questions, the name of the player, game session duration, and date.

-
- Better UI on mobile devices: Make the UI more compatible with mobile devices. For now, the UI is optimized for using it on computers.
 - Categories: For the guessing and ordering sequences minigames, give the possibility to the user to group the exercises inside a custom category.

TEA Minigames – The Game

For the mobile game, the following improvements should be considered for the future:

- Story: It would be nice to add story elements to the game, to give it a purpose and make it more enjoyable.
- Reward system: Add rewards and penalties to keep the players motivated.
- Sounds: Add sounds when some events happen, such as pressing buttons, or hit/miss a question, and give the player the possibility to toggle on/off them, as happens with the background music.
- Username: take the username as input for statistics analysis, and for a more customizable experience.

To sum up, as it was told before, one of the strong points of this system is the modularity, so one of the best improvements would be adding more minigames and game modes, like the following:

- Turn-based games, which allows two or more players play at the same time.
- Quiz with images: another quiz modality, where the possible answers are not text, but images.
- Quiz with feedback: in this modality of the original quiz, there could be several correct answers, but the most important characteristic will be the fact that, no matters which answer the player chooses, feedback will be shown with the explanation or the consequences of that decision.

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Annex I. SUPPLEMENTARY DOCUMENTS

I.1 Prototypes

Initial system prototype

Before starting the implementation of the system, a sketchy prototype of how the future system could be was made for the client. This prototype can be found in the Microsoft PowerPoint file attached to this one (see “*Storyboard.ppx*”). The prototype will show the interface of a mobile device, starting from the main menu of the game with three buttons: minigames, characters and settings.

As we will see later, the system will suffer great changes regarding to the prototype, but this initial sketch was very useful to obtain a general idea of how the final product should be.

I.2 Meetings with the client

Two meetings have been arranged with the clients during all the system development, in this case, with the *Asociación Desarrollo – Autismo Albacete*.

First meeting: Requirements

The first meeting, carried out during Sprint 2 on 9th March, was employed to show the client an early prototype of the future appearance and functionality of the system, at that moment, only composed by the mobile game, and later also including an administrative web to manage the game exercises.

This first meeting was also dedicated to obtaining the initial requirements from the client's feedback related to the prototype. Some conclusions were obtained, formed in the following groups:

From the meeting with the client, several conclusions were obtained, classified in different types:

- **Configuration:** the more configurable and customizable, the better the game is. The user must have the option to change the colours (background colours, buttons, text, etc.) and to modify or toggle on/off the game sounds.
- **Minigames themes.** There are several examples of games we could implement for our application, thanks to the client recommendations:
 - Complete sentences with one or several words.
 - Take decisions, where several problems of daily situations are exposed, and the child must choose the most likely solution of each problem.
 - DLA (Daily Life Activities), which consists of adding images of different daily processes and the child must order them in the correct way (for example, washing the teeth activity).
 - Calculation, such as simple logical-mathematic games, always through images if possible.
 - Comprehensive reading: describe a simple action or activity, put several images, and associate each image with its description.
- **Each minigame configuration.** Each minigame (if possible) should have different levels of difficulty, have the option to interact with other players locally (to train waiting times or turns). Also, the text shown in the screen must be the shorter and clearer possible.

Second meeting: Evaluation

The second meeting, carried out during Sprint 8 on 21st June, has been entirely dedicated to show to the client a solid solution of the system, to perform the evaluation, and to obtain the last details that development team should take into account for further improvements, which in this case were minor.

After performing the evaluation, the monitors informed about possible improvements for the system.

- On the one hand, for the administrative web, to be more specific, for the quiz game, they suggested the following improvements:
 - Add a button in the “create question” panel which opens a modal that allows creating or deleting a category, and then select it from a dropdown.
 - Add a section where statistics regarding to the games can be consulted.
 - The possibility to add a complementary image to the quiz questions.
- On the other hand, for the mobile game, they suggested the following possible improvements:
 - Add feedback (smile or sad face) to all games, depending on if the player hit or miss an exercise.
 - Add a category selector to all the games, to play the exercises belonging to one specific category.
 - Add a final panel showing the hits and misses, and send this data to the administrative web, so that the monitors can analyse them.
 - Add the possibility to introduce a username at starting the application.

As general feedback, they really liked product, and they have especially appreciated the possibility to modify exercises data from the administrative web. A copy of the product status at that moment has been provided to the client, so they can use it.

Annex II. SYSTEM DIAGRAMS

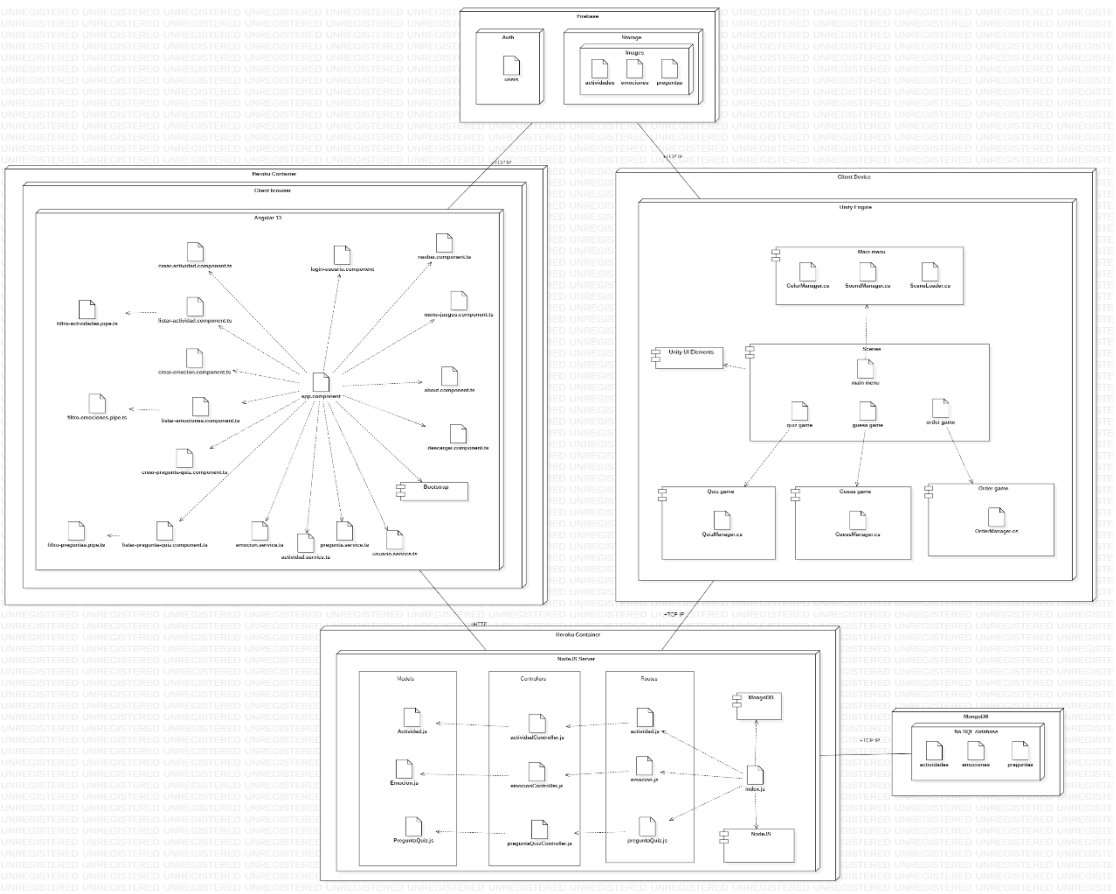


Figure 33: System deployment diagram

Annex III. PROJECT

DEVELOPMENT ARTIFACTS

The Sprint Burndown charts generated by Jira Software (Jira Software, 2022) reflects the evolution of each one of the sprints.

III.1 Sprint 1 – Project planning

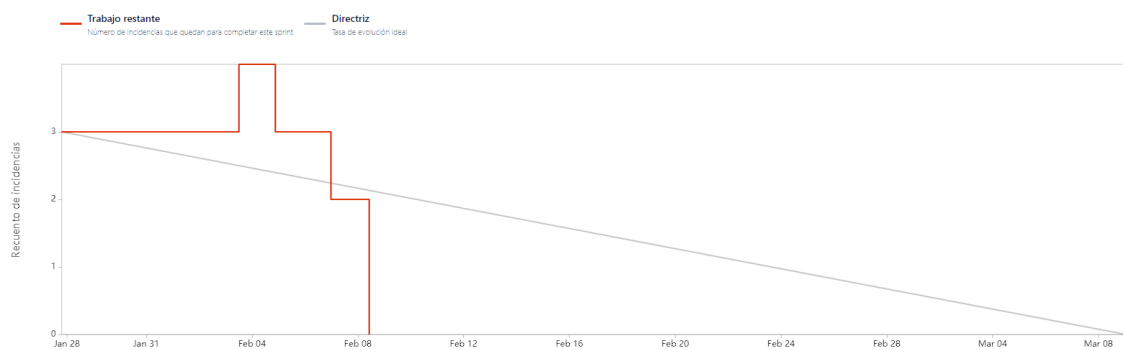


Figura 1: Sprint 1 Burndown Chart

III.2 Sprint 2 – Requirements and project start-up (I)

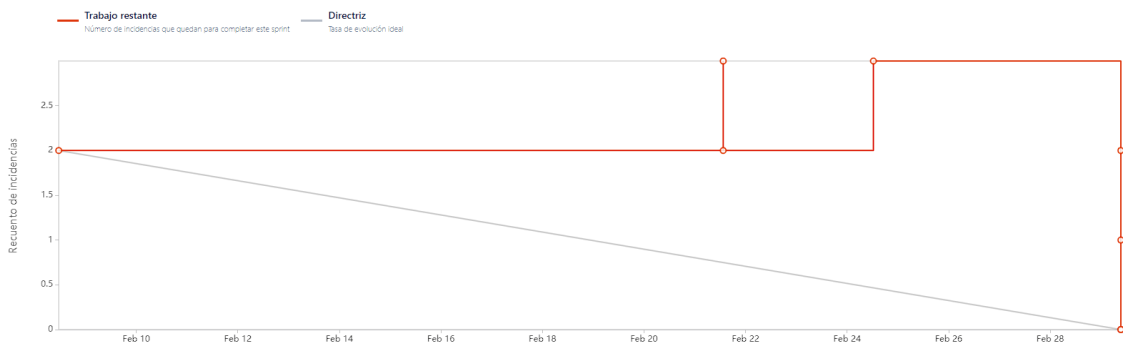


Figure 34: Sprint 2 Burndown Chart

III.3 Sprint 3 – Requirements and project start-up (I)

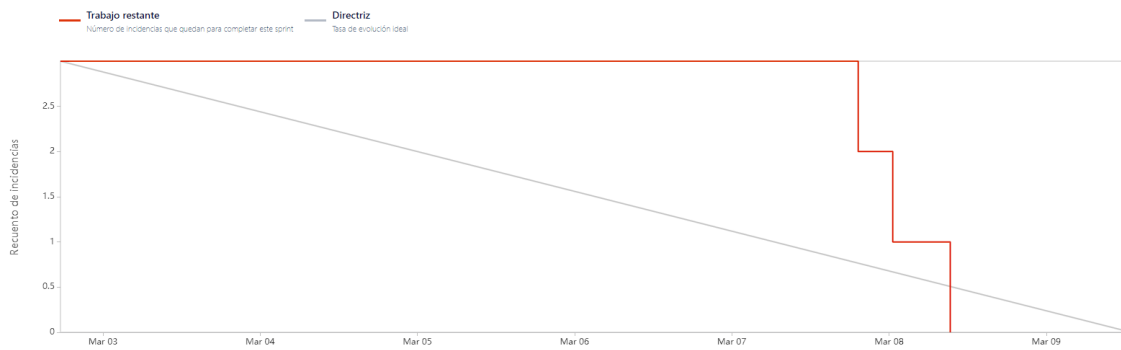


Figure 35: Sprint 3 Burndown Chart

III.4 Sprint 4 – Plan minigame I



Figure 36: Sprint 4 Burndown Chart

III.5 Sprint 5 – Implement minigame I

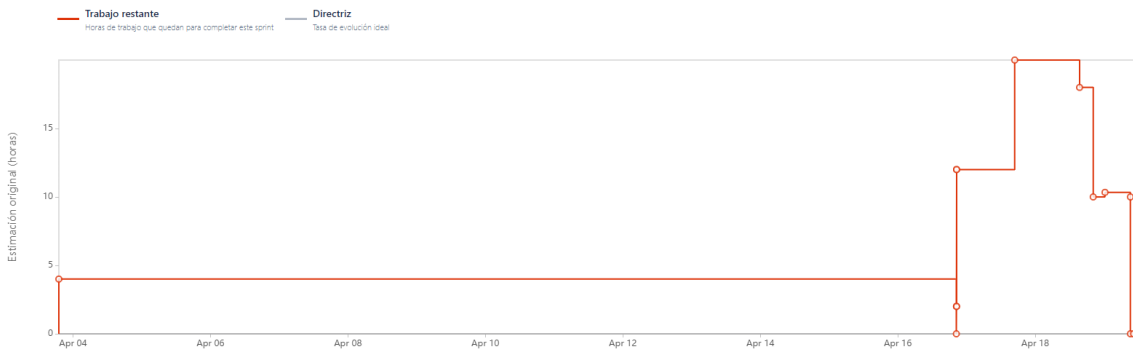


Figure 37: Sprint 5 Burndown Chart

III.6 Sprint 6 – Plan minigames II and III

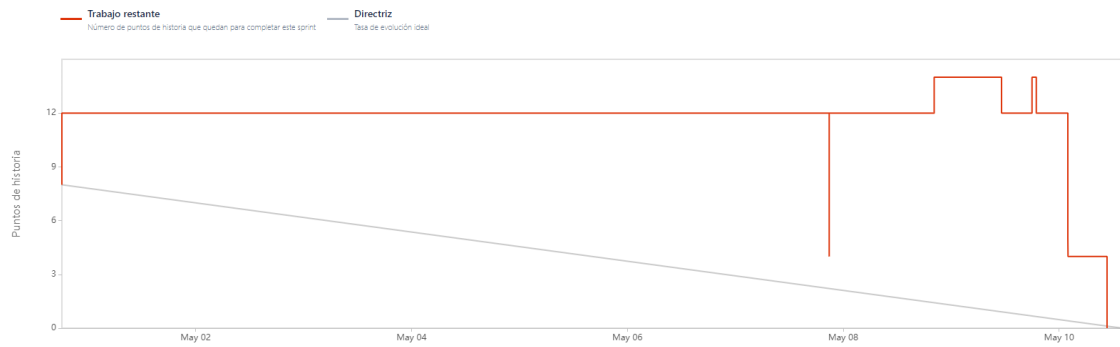


Figure 38: Sprint 6 Burndown Chart

III.7 Sprint 7 – Implement minigames II and III

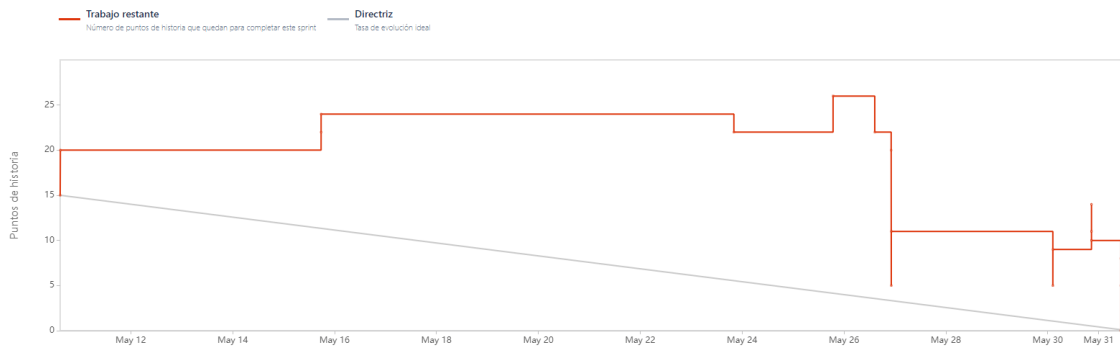


Figure 39: Sprint 7 Burndown Chart

III.8 Sprint 8 – Evaluation and improvements



Figure 40: Sprint 8 Burndown Chart

III.9 Sprint 9 – General improvements

Annex IV. Evaluation complements

IV.1 Evaluation tasks

Adults' tasks

- Initial requirements: Login with the credentials provided by the administrator.
- Task A1: Create and delete an exercise for the quiz game.
 1. Go to the quiz game exercises list (first button).
 2. Add a new question.
 3. Edit the created question (blue pencil button) and change one or more fields.
 4. Delete the question (red trash button).
- Task A2: Create and delete an exercise for the guessing game.
 1. Go to the guessing game exercises list (second button).
 2. Add a new exercise.
 3. Upload the two images provided by the evaluator and add the response word.
 4. Edit the created exercise (blue pencil button), and add a sentence and the descriptions of the images, and save the changes.
 5. Delete the exercise (red trash button).
- Task A3: Create and delete an activity for the ordering game.
 1. Go to the guessing game exercises list (second button).
 2. Add a new activity.

3. Add a sentence and upload the four images provided by the evaluator and assign them the order.
4. Edit the created activity (blue pencil button), and then add a description for each one of the uploaded images.
5. Delete the activity (red trash button).

Children tasks

- Initial requirements: Having the game installed and launched.
- Task B1: Play the quiz game.
 1. Press the play button from the main menu.
 2. Press the button of the first game.
 3. Select the desired category.
 4. Answer/skip the questions till the end.
- Task B2: Play the guessing game.
 1. Press the play button from the main menu.
 2. Press the button of the second game.
 3. Answer/skip the exercises till the end. Use the tip button if desired.
- Task B3: Play the ordering game.
 1. Press the play button from the main menu.
 2. Press the button of the third game.
 3. Order/skip the activities.
- Task B4 (optional): Change the colour of the background and/or toggle on/off the music.
 1. Press the options button from the main menu.
 2. Toggle on/off the music.
 3. Change the background colour.

IV.2 SUS questionnaires

Since there are not versions of SUS questionnaire for children, questions must be the same, but in the case of children, they have been slightly modified for a better understanding without altering the original meaning.

For adults

Marcar con una X donde procede:		TOTALMENTE EN DESACUERDO	EN DESACUERDO	NEUTRO	DE ACUERDO	TOTALMENTE DE ACUERDO
1	<i>Me gustaría volver a usar la web</i>					
2	<i>La web es demasiado compleja</i>					
3	<i>La web es fácil de usar</i>					
4	<i>Necesito ayuda para usar esta web</i>					
5	<i>La interfaz de usuario es intuitiva</i>					
6	<i>Pensé que había demasiada inconsistencia en este sistema</i>					
7	<i>La mayoría de las personas aprenderían a usar esta web rápidamente</i>					
8	<i>La web es muy complicada de usar</i>					
9	<i>Me sentí muy seguro usando la web</i>					
10	<i>Necesitaba aprender muchas cosas antes de empezar a usar la aplicación</i>					

Figure 41: SUS questionnaire for adults

For children

“Marca con una X”						
1	<i>Quiero volver a jugar</i>					
2	<i>El juego ha sido muy complejo</i>					
3	<i>El juego es fácil de jugar</i>					
4	<i>Me han ayudado a jugar</i>					
5	<i>La interfaz del juego es intuitiva</i>					
6	<i>En el juego hay mucha inconsistencia</i>					
7	<i>Creo que casi todos aprenderán rápido a jugar a este juego</i>					
8	<i>El juego es muy difícil de usar</i>					
9	<i>Me sentí muy seguro jugando</i>					
10	<i>Me han tenido que enseñar a cómo jugar antes</i>					

Figure 42: SUS questionnaire for children

For both SUS score analysis in both groups, the following scale was employed (Figure 43). The system must obtain a score equal or higher than 68 to be considered acceptable.



Figure 43: SUS scoring scale

Annex V. System functionality

This project is based on a real-time communication between all architectural elements of the system, being those the web and unity clients, the server, firebase, and mongo DB.

V.1 Web client

The web client, created with angular 13, is the user interface from where authenticated users can perform CRUD operations.

Components

In Angular, each component represents a view or a html element, also encapsulating its functionality, implemented on a typescript file per component. Each component follows the same structure: one file for the styles, one for the html view, other for the tests, and another one for the UI backend implementation.

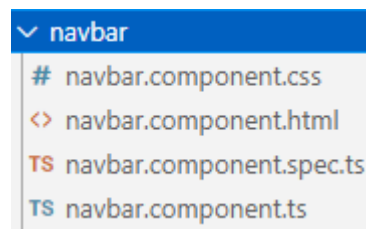


Figure 44: Angular component structure

Models

A model represents the class of an object, defining their attributes types and names. The following is an example of a model in Angular, in this case the *Activity* model.

```
import { Figura } from 'src/app/models/figura';

export class Actividad {
  _id?: number;
  enunciado: string;
  figuras: Figura[];
  fechaCreacion: Date;
  activo: number;

  constructor(enunciado: string, figuras: Figura[], fechaCreacion: Date, activo: number) {
    this.enunciado = enunciado;
    this.figuras = figuras;
    this.fechaCreacion = fechaCreacion;
    this.activo = activo;
  }
}
```

Figure 45: Example of a model in Angular

Services

Services in Angular are objects that get instantiated just once during the lifetime of an application. They contain methods that maintain data throughout the life of an application. In this system, each service represents a one of the three games, and contains the CRUD operations over the database.

Routing

Angular contains a single file which contains all the routes of the application.

```
const routes: Routes = [
  // RUTAS PUBLICAS
  { path: 'login', component: LoginUsuarioComponent },
  { path: 'about', component: AboutComponent },
  { path: 'download', component: DescargarComponent },

  // menu principal
  { path: '', pathMatch: 'full', redirectTo: 'main' },

  { path: 'main', component: ListarJuegosComponent,
    ...canActivate(() => redirectUnauthorizedTo(['/login'])) },

  // quizz
  { path: 'listar-preguntas-quizz', component: ListarPreguntasQuizzComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },
  { path: 'crear-pregunta-quizz', component: CrearPreguntaQuizzComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },
  { path: 'editar-pregunta-quizz/:id', component: CrearPreguntaQuizzComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },

  // emociones
  { path: 'listar-imagenes', component: ListarEmocionesComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },
  { path: 'crear-emocion', component: CrearEmocionComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },
  { path: 'editar-emocion/:id', component: CrearEmocionComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },

  // AVD
  { path: 'listar-actividades', component: ListarActividadesComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },
  { path: 'crear-actividad', component: CrearActividadComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },
  { path: 'editar-actividad/:id', component: CrearActividadComponent, ...canActivate(() => redirectUnauthorizedTo(['/login'])) },

  // Cualquier otra ruta...
  { path: '**', redirectTo: '/main', pathMatch: 'full' },
]
```

Figure 46: Angular routes

Deployment

For the deployment to Heroku, Express was employed, running a server.js file with the following structure:

V.2 Mobile client

The mobile client, that is, the mobile game, was created with the Unity Engine v2020.3.27f1. All Unity projects are composed of three main elements: scenes, game objects and scripts.

Scenes

The scenes are independent contexts, which can represent an entire game, a level, or an independent section of a game. In this project, 4 scenes were used for the following elements: main menu, quiz game, guessing game and ordering game.

Although scenes are independent, they can be linked by sending the active instance of a scene to another scene.

Game objects

Game objects are all the objects that we can find in the game. They can be UI elements (texts, images, buttons, etc.), scripts instances, lights, cameras, etc. The game objects can have a script associated, to link to it all the functionality inside it. The following one is a game object with a script associated, and parameters can be added by drag and dropping other game objects to it:

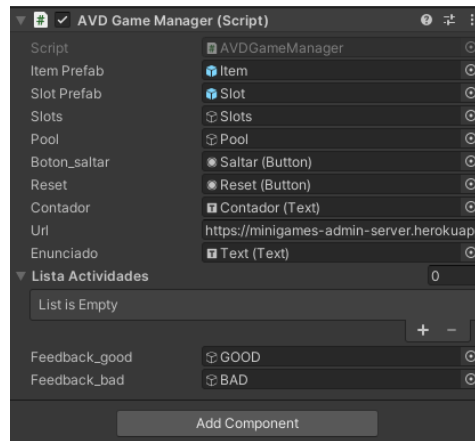


Figure 47: Example of game object with associated script

Scripts

The scripts are the text documents which contains all the code written in C# that makes the game works. They can be linked to game objects to provide them functionality.

V.3 Server

The server is a non-visible app, hosted on Heroku, which is the one in charge of send and receive requests from/to both clients. From those requests, the server modify the data from MongoDB. It contains several element groups:

Config

Contains the database configuration, in this case MongoDB, which basically get the config information from the .env file and create the connection to the database. The employed library to manage the database inside the server is mongoose.

Controllers

Contains the CRUD functions to the database. Those functions are created element, get one element, get all elements, update one element, and delete one element.

Models

Contains the attributes names and types of the main classes and must be equal to the models defined on the administrative web client. An example is the following one:

```
const ActividadSchema = mongoose.Schema({
  enunciado: {
    type: String,
    required: true
  },
  figuras: {
    type: [FiguraSchema],
    required: true,
  },
  fechaCreacion: {
    type: Date,
    default: Date.now()
  },
  activo: {
    type: Number,
    required: true,
  }
});
```

Figure 48: Server model example

V.4 MongoDB

It is the non-SQL database employed to store information regarding to the minigames. To manage the database for development purposes, the employed manager was MongoDB compass, which is a GUI which allows developers analyse and modify the data.

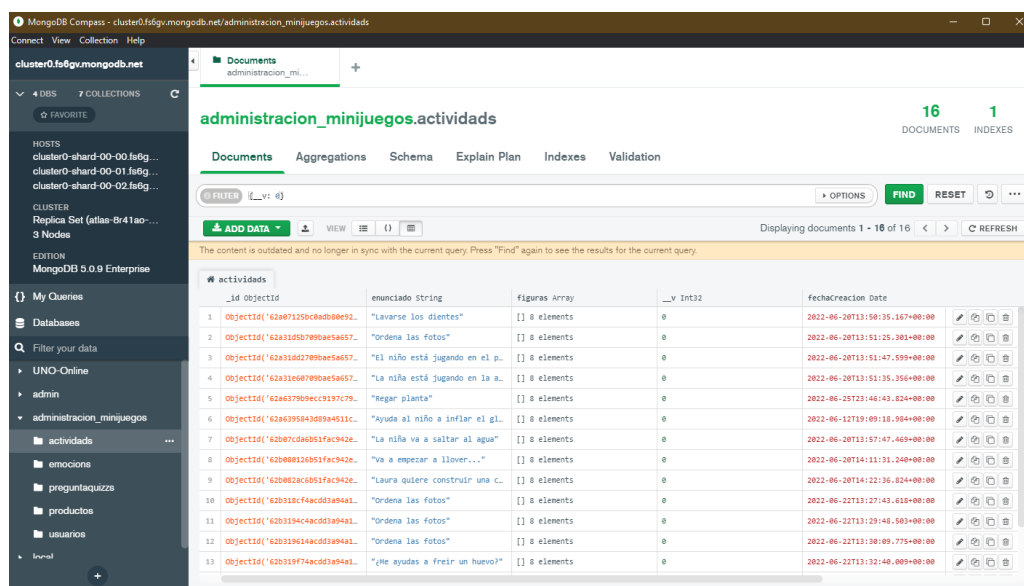


Figure 49: MongoDB Compass GUI

V.5 Firebase

Firebase is the app development provider which was employed in this project for storing images and auth purposes. Firebase acts as a complementary database to mongo and contains the users registered in the administrative web, and the images uploaded by

these users. The web contains upload and delete operations for the images, and login function for the users. Each time an image is uploaded, Firebase returns a download link which is stored in mongo database.

Annex VI. Access to the system

VI.1 TEA Minigames - Administrative web

The web is accessible through the following link:

- <https://minigames-admin-client.herokuapp.com/login>

Login with the following credentials:

- E-mail: admin@admin.es
- Password: admin123

IMPORTANT: The previous credentials will not be available after the tribunal evaluates this project.

VI.2 TEA Minigames – Game

The game can be downloaded from the “**downloads**” section of the administrative web.

Microsoft Windows

Launch the app by executing *TEA Minigames.exe* file:

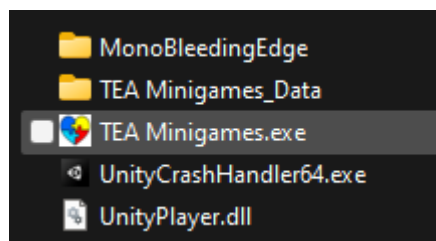


Figure 50: Windows game executable

Android

Install the *TEA Minigames.apk* file. You may need to toggle on a feature to allow your device to install applications from unknown origins.

IOS

Unfortunately, the game is not yet available for iOS.