LINA: A Serious Game To Help Children Improve Social Relations With Their Peers

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Abstract

Children that have problems in developing socialization skills before their teens can become socially isolated, leading to low self-esteem and social alienation, and possibly snowballing into more serious psychological problems further into adulthood. In this thesis we present a the implementation for a Serious Game, LINA, that uses Contact Theory to help pre-adolescent children improving the relations with their peers. In LINA, the players, children from 10 to 12 years old, will try to find out what happened to a missing colleague - Lina - and her story through the discovery of augmented reality clues and overcoming challenges cooperatively. This document specifies the game concept, methodology and implementation of a digital prototype for demonstration. Also evaluates said prototype regarding its usability, enjoyment and interest for the players. Conducted evaluation determined that the players find the gameplay and story fun and are keen on playing more of the game. Future work involves revising this first prototype with the feedback from the evaluation session, coming up with new challenges and exploring technical limitations of Augmented Reality in the game context.

Keywords

Augmented Reality; Contact Theory; Serious Game; User-Centered Design; Socialization Skills.
Resumo

Crianças com problemas no desenvolvimento da socialização antes de sua adolescência podem se tornar socialmente isoladas, levando à baixa auto-estima e à alienação social, que possivelmente se podem transformar em problemas psicológicos mais sérios na vida adulta. Neste documento apresentamos a implementação de um Jogo Sérico, LINA, que utiliza a Teoria de Contacto para ajudar crianças pré-adolescentes a melhorar as relações com os seus pares. Em LINA, os jogadores, crianças de 10 a 12 anos, tentarão descobrir o que é que aconteceu à sua colega desaparecida - a Lina - e a sua história através da descoberta de pistas de realidade aumentada e da superação cooperativa de desafios apresentados. Este documento especifica o conceito do jogo, a metodologia e a implementação de um protótipo digital para demonstração. Também avalia o protótipo quanto à sua usabilidade, prazer e interesse pelos jogadores. A avaliação conduzida determinou que os jogadores acham a jogabilidade e a história divertidas e estão interessados em jogar mais do jogo. O trabalho futuro envolve a revisão deste primeiro protótipo com o feedback da sessão de avaliação, o desenvolvimento de novos desafios, e explorar as limitações técnicas da Realidade Aumentada no contexto do jogo.

Palavras Chave

Realidade Aumentada; Jogo Sérico; Teoria de Contacto; Desenvolvimento Centrado no Utilizador; Habilidades de Socialização.
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1 Introduction

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“Man is by nature a social animal; an individual who is unsocial naturally and not accidentally is either beneath our notice or more than human. Society is something that precedes the individual. Anyone who either cannot lead the common life or is so self-sufficient as not to need to, and therefore does not partake of society, is either a beast or a god.”

- Aristotle.

1.1 Motivation

Nowadays, contact between individuals is increasingly made through digital means: Instant messengers, Voice-over-IP and video calls. Technology allows us to be closer to people, even when they are across the globe. People that do not know each other are brought closer and form social relationships thanks to that same technology. One particular situation is the approximation of individuals through video games \cite{8,9}. For example, studies have shown that cooperative video games can bring families closer \cite{10} and improve the social and affective aspects of hospitalized children by having interactions through a video game context with other children in the same condition \cite{11}.

Socialization is a key process in the psychological development of a child. As the child gradually becomes a teen, his/her social cognition mastery starts to expand and his/her awareness towards the social environment around him/her increases steadily. If asked how to describe a friend, that same description changes from physical characteristics and tastes (e.g. “he has brown hair and likes to play football”) to more psychological traits, due to him/her starting to perceive the others’ actions and behaviours. Also, his/her group of friends shifts from a nebulous semi-structured group of children with whom he/she can have fun and play games to a more heterogeneous and closed group of similar-minded teens that share social activities and opinions \cite{12}.

1.2 Problem

As the peer-to-peer relations increase in early pre-adolescence, enthusiast, cooperative and responsive children are usually seen as the more popular in his group of people. However, a child that lacks social interactions, or that feels vulnerable by this psycho-social development and isolates himself, more often will be deem less popular and this can generate anxiety and will diminish the child’s self-esteem \cite{12,13}, creating a snowball into social alienation. So, a child that has isolated himself, either by unconscious self-imposition or due to reasons external to him/her, has diminished social capabilities and lacks will-power and/or opportunities to engage in social activities with others.

How can we help improve pre-adolescents’ abilities to establish successful relations with their peers? To address this issue we explore the use of a Serious Game [Fig.1.1], but given the complexity of the
problem, both in terms of development and evaluation, we will start with a first step in this direction by focusing on how to create such game. \textbf{How can we make such Serious Game fun, enjoyable, and easy to use for children?}

1.3 Hypothesis

In this document we present a proposal and implementation for a serious game, LINA, with a very strong social component that aims to help children improve relations with their peers. In LINA, the players, children from 10 to 12 years old, will try to find out what happened to a missing colleague - Lina - and her story through the discovery of clues and surpassing challenges. These augmented reality clues will only be shown by scanning markers spread throughout the school. Also, sometimes the clues will need to be uncovered by completing challenges in pairs, which will encourage the children to interact among themselves to progress further in the narrative.

There are three concept pillars used to base the design and development of LINA: Contact Theory, Augmented Reality and User-Centered Design. Contact Theory tries to end negative conceptions about intergroup peers. We will be applying Contact Theory when trying to get a group of children to cooperate to achieve a common goal: finding out what happened to Lina. To do so, they will need to complete challenges, by exchanging clues and information about Lina and by collaborating in other type of puzzles. According to Contact Theory, if done in the right conditions, this will improve their relationships, and hopefully creating new ones.

Augmented Reality is not a new technology employed in the videogame industry. Recently, it has
found enormous popularity with the worldwide-phenomenon that was *Pokémon Go*. Tateno et al. have inclusively written about the hypothesis that the videogame could help children and teens with severe social withdrawal, although studies were not made to support the claim. [14, 15]

As this project will be targeting pre-adolescent children, special care must be considered when designing the concept prototype, as one of our objectives is trying to create a game that children will not find difficult to use. A clean, unambiguous interface with established conventions (like using well-know metaphors for buttons) and restricted freedom makes the users’ choice-making clearer and streamlined. However, such concept is bound to iterative revisions to improve the users’ interaction.

The rest of this document is structured as follows: in Section 2 we will present the Theoretical Background behind this work, we will look at the concepts of Contact Theory, Augmented Reality and User-Centered Design; in Section 3 we will see the work that is related to our project; In Section 4, we will show the work done regarding the design of the game concept, the design of the user experience, and the implementation done so far; In Section 5, we will show the evaluation conducted, its methods and analysis; In Section 6, we will conclude this document, assessing what was done and what are the future steps.
2

Theoretical Background

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2.1 Contact Theory

Before Allport hypothesized the “Intergroup Contact Hypothesis” in 1954, it was believed that inter-group contact would inevitably lead to conflict, result from nineteenth century Social Darwinism, where most groups felt superior to others, naturally leading to hostility. However, no studies were conducted at that time and therefore no empirical evidence was found to support the claim.

After the Second World War those suspicions changed. With the desegregation of the United States Merchant Marine in 1948, the relationship between African-American and Caucasian sailors improved with the number of voyages taken together. Likewise, in a 1957 study by Kephart in the Philadelphia police department, the opinion of white officers regarding fellow black colleagues was more positive in subjects that previously had a black partner.

In 1947, Robin Williams Jr., a sociologist in the Cornell University was asked to conduct a review on intergroup relations. On his monograph The Reduction of Intergroup Tensions he states that inter-group contact would optimally reduce prejudice under four conditions:

• The two groups share similar status, interests and tasks;
• The situation fosters personal, intimate intergroup contact;
• The participants do not fit in stereotyped conceptions of their groups;
• The activities cut across the group lines.

Allport, in The Nature of Prejudice (1954), after extensive study, would lately adapt these four conditions into four “positive factors” that need to be present to reduce prejudice:

1. Equal status between groups. This equal status that Allport states refers within the situation, not coming into. Some writers defend that should be of equal status prior to entering the situation, but research has shown that equal status within is enough and even more important than outside status.

2. Common goals. To reduce prejudice, active inter-group contact must share a common goal. By having the same objectives, the team constituents work effectively, harder and unitedly, as the different groups rely on each other, to accomplish it.

3. Inter-group cooperation. To work in unity towards the common goal, logically, there must not be group competition. Cooperation should be independently emphasized to each subject, as the feeling of competition undermines the effort made by the rest of the team.

4. Support of authorities, law or custom. With a climate of support surrounding the contact’s environment, inter-group contact is more readily accepted and has more positive results. Field re-
search in the military, business and religious institutions has emphasized the importance in support by the authority, as it is that authority that establishes the norms of acceptance.

Pettigrew in his revision of the Contact Theory also proposed adding another condition onto the previous set. The condition, friendship potential he called it, was a result of his findings where groups with deep prejudices between them extremely avoid contact with each other, even when under the four conditions mentioned above. This friendship potential condition states that “The contact situation must provide the participants with the opportunity to become friends” [16].

2.2 Augmented Reality

A variation of Virtual Reality, but different enough to warrant a distinction, the term “Augmented Reality” has been around since the early 1990s, but the whole concept dates back to 1901 when L. Frank Baum in his short story The Master Key described a special pair of spectacles that made the person wearing them see a letter on other people’s foreheads indicating their personality (e.g. “G” for “good”, “E” for “evil”, etc). Then in 1968, Sutherland would revolutionize the Virtual Reality topic with the development of a “head-mounted three-dimensional display”, and only twelve years later would the first wearable computer, WireTap, be invented by Mann, where an optical display would overlay information over the image recorded by a camera. This is a natural evolution of the “heads-up display” used by the military after World War II, where HUDs based in optical reflection presented the information necessary to the pilots without blocking their view in the cockpit.

And it is with this last example that the distinction between Virtual Reality and Augmented Reality become clearer. While the former focuses on creating a separate environment from the user point-of-view, isolating him from his “real” environment, either through visual output, sounds, smells, or even tact, the last tries to enhance the current environment where the user is present, usually capturing it with a camera and overlaying it with information (e.g. text, images) but nevertheless still allowing the user to access the original information captured by his bio-sensors, i.e., eyes, ears, hence “augmenting” his senses. Azuma describes Augmented Reality as systems that: combine real and virtual, are interactive in real time, and are registered in three dimensions;

AR has applications in several sectors of society [17, 18]:

1. From a medical point-of-view it is interesting to see and interact with a patient’s MRI or CAT scan in real-time; or during a surgery, the surgeon could be accessing in real-time data about the patient or receive feedback about the procedure without having to look away from the operating table.

2. In engineering, without having to use diagrams nor sketches, if one can see a 3D model of the artifact, the staff training is rendered much easier. In maintenance, a description of the problem
and its solution just from looking to the broken machine would be optimal in keeping minimal
downtime and the costs low.

3. In the military, pilots have already use the precursor of this technology in their aircraft and more
recently have seen it integrated with the helmets and aircraft software, and this also provides a way
to soldiers receive real-time information like satellite feeds or drone reconnaissance which helps
in reducing the fog-of-war.

Augmented Reality has since gained popularity in the game community with the release of PokémonGO.
In their work Das et al. hypothesize that Augmented Reality could have a social impact that is not nor-
mally associated but is inherent to the genre. Das et al. state that “in comparison to traditional video
games, Augmented Reality videogames may be inherently more social. Players are required to interact
with the surroundings and often encounter friends and fellow players. For example, Pokémon GO and
other ARGs have many features that promote social interaction between players. (...) Players on the
same team are encouraged to work together to strengthen their Pokémon and gain or maintain control of
PokéGyms. The team feature further increases the social component of Pokémon GO because players
must work with teammates in order to advance.” [19] This is an important foundation because it comes
close to what we want to do with LINA, not exactly with the gym or Pokémon mechanic, but more on the
part of using Augmented Reality to socialize and advance on the game.

2.3 User-Centered Design

User-Centered Design, is a broad term to describe design processes in which the users affect the
development decisions. There are several ways the users can be involved: from requirements gathering
and usability testing, to being made partners to designers through the design process. [20]

The term User-Centered Design was coined by Donald Norman in his research laboratory in the
University of California San Diego, but the concept was formed in his book The Psychology Of Everyday
Things (1988), where he states four rules for a design to be user-driven:

• Make it easy to determine what actions are possible at any moment.

• Make things visible, including the conceptual model of the system, alternative actions, and the
results of actions.

• Make it easy to evaluate the current state of the system.

• Follow natural mappings between intentions and the required actions; between actions and the
resulting effect; and between the information that is visible and the interpretation of the system
state.
As this project is intended to be used by children from 10 to 12 years old, special care should be put in place to design a simple, intuitive, unambiguous, and relatively fun, interface so that it can be easily engaging for the players. But for Norman just saying a design should be intuitive is not enough, so he states how important it is to consider some additional design principles to facilitate the designer and the user, and which are relevant to this project:

1. Simplify the structure of tasks. Make sure not to overload the users’ short- and long-term memories. On average the user is able to remember five things at a time. For example, making a long sequence of menus would be counter-productive for a given task.

2. Make sure the task is consistent and provide mental aids for easy retrieval of information from long-term memory. Make sure the user has control over the task. In the case of scanning an image and showing a clue the process should be simple and, as it is a frequent action throughout the game, it should not divert from the established loop: scan, reveal the clue, button to the next stage.

3. Make things visible: bridge the gulfs of Execution and Evaluation. The user should be able to figure out the use of an object by seeing the right buttons or devices for executing an operation. Trying to keep the menus as simple as possible while giving the options necessary, and only those, is a correct implementation of this principle.
3

Related Work

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In this chapter we will look into work that has been done and that can be useful to the design and development of LINA. First, we will look into Serious Games related with improving the social interaction among children, then we will analyze augmented reality Serious Games. Splitting the work into these two major focus areas allows us to see the different problems encountered and approaches used, so that we can combine what we have learned when making LINA. For each focus area we start by having an overview of the papers and then a discussion of its contributions for LINA.

3.1 Social Skills Development Serious Games

In this section we will look into the Social Games focused on social skills development: their social components, and what are their techniques and methods used to improve the players’ social engagement.

3.1.1 SIDES: a cooperative tabletop computer game for social skills development

The first paper is "SIDES: a cooperative tabletop computer game for social skills development" [2] The objective of SIDES was to develop a cooperative tabletop computer game that encouraged group work skills like negotiation or perspective-taking for students in social group therapy, while taking into account the cognitive strengths and interests of individuals with Asperger’s Syndrome (ASD). After the interviews made with people suffering from ASD, it was decided to create a puzzle-style game, with a theme of frogs and insects, as its visuals appealed to the interviewed individuals.

The authors went to a middle school social therapy class and discussed topics with students and the therapists, trying to understand teaching methods and to identify potential solutions for teaching group work skills. They have also conducted one-on-one interviews with the disorder-affected students but found that group interviews work better.

In terms of results, the students complained about the current group therapy activities, and also gave the suggestion that the game should not appear too “educational”, as it would make it uninteresting and not fun. With the therapists, they found that tabletop games were already used as tools during the classes, but close supervision was needed from the therapists as arguments and quarrels were frequent among the students.

The game is played by four players. At the beginning of each round, each player is given nine square tiles with arrows (three of each of three arrow types). Unique arrow types (e.g. pointing left, pointing right, around-the-corner, etc.) are distributed among the participants so that a participant cannot have all 12 arrow types in their hand. Students need to work together to build a path with their pieces to allow the frog to travel from the starting lilypad to the finishing lilypad. There is a limited supply of each arrow type, thus students are encouraged to cooperate in building an optimal path to win more points. To gain
points, the path must intersect with the insect pieces on the board, each worth different points. The
group must agree on one path that collects the most points with their given amount of resources. Once
all players agree with the solution, the frog will travel along the path and collect points by eating all the
insects in his way.

A paper prototype was made to finish the rules, check for game balance and whether the prototype
should be turned into a digital game. It was tested with two five-student groups and the feedback was
very positive, both from the students and the therapists. The students liked the theme and the game
flow was suited. Therapists like how they played cooperatively and had more balanced roles instead of
having dominating and least active individuals.

After the paper prototype, a digital version [Fig. 3.1] implemented in Java for the DiamondTouch multi-
user tabletop was made. The players had the same pieces and goal as the paper prototype. Each player
had the arrow pieces plus three more voting buttons: test the path, reset, or quit the game. This voting
system only changes the state of the game if an option is voted unanimously, which gives the players
equal status in the situation and forces the group into engaging in communication and coordination.

The first session evaluated whether a tabletop game was an appropriate tool for facilitating social
skills development and if there was any sensory or motor issues specific to this audience that affected
interaction with tabletop technology. The students found SIDES to be a motivating but challenging
activity. They also thought the interface was appropriate and easy to use, with much of the excitement
revolving around the new technology. There were still some problems regarding the amount of control
each player had, with some children pushing each others’ hands and shouting, trying to dominate and
lead the others.

For the next session, SIDES was revised: turn-taking and controlled access (i.e. only each player
can move their own pieces) were added, to prevent other players from interfering with the move, which
requires players to communicate and coordinate more.

The second session evaluated how students responded to computer- versus human-enforced rules,
how the current design aspects encouraged or discouraged effective group work, and what was the role
of the therapist during a tabletop computer activity. Two groups were made: one group had previously
played the previous iteration of the digital game, and the other had only played the paper prototype.
They played four rounds each: two with no rules, one with human-enforced rules, which meant there
was a therapist facilitator, and one with computer-enforced rules.

In Group 1, there was an increase in positive language as well as a decrease in the amount of
aggressive behaviours over multiple rounds. The computer-enforced scenario was the most well per-
formed, and the no-rules scenario was deemed the worst in terms of team-effort. By the last round,
no student touched other players’ pieces nor played out of order, having adopted the turn-taking rule
naturally.
Contrasting to Group 1, Group 2 found the no-rule scenario the easiest of the four to work as a team. Questionnaire data supported this claim, with the rule enforcing being the most disliked. This was possibly due to a particular individual that would not give up his turn, even when he had no pieces.

3.1.2 Implementation of an chatbot in a serious game associated with the acquisition of social skills and the promotion of collaborative tasks in children

In the paper "Implementation of an chatbot in a serious game associated with the acquisition of social skills and the promotion of collaborative tasks in children” Mansilla et al. propose a serious game as a suplement to therapy in children with emotional disorders [1].

When a child’s character is formed, any situation that affects him emotionally in that period will leave him marked in adulthood, hence it is important to care about the child’s emotions in this phase. A Serious Game provides the appropriate tool for the necessary therapeutic support. With the game the authors expect to help to overcome moods of sadness or depression, using psychological tools like music therapy and appropriate color management.

The prototype will try to counteract the negative emotions present in the child, not engage with the causes responsible for them, through fun and animated scenarios with carefully chosen colors, stimu-
The background music, similarly to colors, will be suited to stimulate the brain through joyful rhythms to lift the spirit. To motivate the child and avoid the feeling of frustration, in case of a low score when finishing the challenge he has the opportunity to repeat it.

There are five scenarios: jungle, sea, desert, polar and forest. First the player registers his name, then selects a difficulty level, from simple to complex. In the simple level the player must choose animals that fit in that scenario and populate it. Every time the player accomplishes an objective triumphant sounds are triggered so that the player’s mood can improve. Medals and trophies are also awarded to help with the sense of achievement.

Challenges have to be specially considered, they need to be balanced to avoid bringing the player into boredom or on the other hand, into frustration. So, to adapt the challenge’s complexity to the player, the combined response of the player’s time with his number of hits is calculated. If the player takes too long to rightly place the animals, aiding tracks will be shown to assist him. If the player is rapidly completing the stage then the difficulty increases in two ways: the game gives less time to populate the scenario, or shows animals that are not obvious or well-known.

### 3.1.3 Development of a Videogame to Improve Communication in Children with Autism

In “Development of a Videogame to Improve Communication in Children with Autism” Bringas et al. refer to the development of a videogame made to improve the communication of children with autism, on the basis that videogames can positively change an ASD-affected child’s social behaviour towards other children. [6]

The authors met with experts on autism to understand what made the children isolate themselves and what techniques and methods were better suited to design an effective tool in complementing the conventional therapy, using the **TEACCH - Treatment and Education of Autistic and Related Communication-Handicapped Children** method.

The objective is to improve social interaction by showing a pictogram with basic activities that can be
performed in school or at home. The game’s complexity can be changed to adapt to the child’s preferences, hence the content shown can change (from a pictogram to images to categories). An important aspect is the positive reinforcement through points and trophies rewarded, promoting motivation to learn and social engagement.

The game design follows the iterative model. Developed in Unity3D for the multi-platform mobile support plus the ability to be played in a webpage through Unity Web Player.

The game takes place in a nature-laden scenery, with the purpose to raise awareness in the child that he is part of an environment and his actions are part of said environment. It focuses on the development of communication and learning abilities through the visual interface and interaction, so that the player feels compelled into finishing all activities within the game.

The game provides a fun and friendly environment to improve the verbal and non-verbal communication. The game is split into two sections: the communication panel and knowing animals, places and ecosystems.

The communication section shows a thematic panel related with the place or activity. The interface is composed of a group of pictograms of basic activities that can be performed at home or in school. The game allows to eliminate or add images to customize the panel to each individual according to his needs. Through this panel the child can associate meanings to each image, allowing him to express his thoughts and emotions. In the bottom portion of the screen there is a board where he can construct a phrase through the combination of pictures.

The knowing animals section is made of two modes: Learn and Play. In Learn Mode several animals are shown through a name, a real-life picture, a caricature, and with the click of a button, the sound they make. In Play Mode [Fig. 3.3] the child demonstrates his knowledge about the animals from the previous mode. The picture and caricature of a randomly selected animal appears, and from three different options its name must be chosen. In case of answering incorrectly the game gives another chance, hence the child always ends up choosing the right answer. Upon choosing the right answer points are awarded [Fig. 3.3].

### 3.1.4 Analysis and Discussion

In SIDES, the students made an effort to collaborate and communicate with their peers, which is remarkable as they promptly disengage when unmotivated or uninterested in a task otherwise. Our vision of LINA aims to the same goal: creating fun social engagement opportunities where the children are interested in participating, instead of isolating themselves. The authors underline that the game works because, not only is educational in terms of group work, but also because it does not appear to be so, which makes it more fun and appealing. Therapists also mentioned how it evens out the class: the more quiet and isolated are “given a louder voice”, while the more outspoken and dominating become more
restrained in their interventions. LINA’s vision also shares the goal: to “even” out the class, actually, it is one of the core bases of this project as Contact Theory explicitly states that all participants must have the same importance to the task at hand.

Both Mansilla et al. and Bringas et al. focus primarily in creating videogames that rely heavily on bright colors (so far as to be considered chromatherapy) that try to uplift the players’ mood. Granted, overcoming depression or sad mood is not LINA’s objective, but the use of bright colors contrasts with LINA’s vision as an immersive realistic game, considering that we are also trying to pass Lina’s point-of-view. But perhaps uplifting the players’ mood makes him more receptive to social interaction. With audio there is the same problem, while joyful rhythms are used by Mansilla et al. these do not always reflect the mood of the game.

Both games also reflect on the use of awards to motivate the player, and this is an approach that we can very much implement on LINA, as it stimulates the player and has the potential to reduce frustration.

3.2 Augmented Reality Serious Games

In this section we will look with more detail to Augmented Reality Serious Games, their concepts and methodologies, how to design and develop them.

3.2.1 Pathomon: A Social Augmented Reality Serious Game

With Pathomon [Fig. 3.4] Rapp et al. take the premise created by the blockbuster Pokémon GO and turn it into a serious game designed to make the players aware of the known viruses and how to eradicate them while being a social experience.

Players have to find QR codes, corresponding to antidote ingredients or viruses, in an area. By collecting the ingredients, they can craft antidotes, which then can be used to attack viruses. These actions give the player experience points. Some viruses need to be attacked by more than one player. This, along with having to share the QR codes’ locations and the right combination of ingredients to make the antidotes with the other players, gives the game a strong social component.

The player creates a personal account, and then is given a profile of an expert on a certain virus. This means that they can “contaminate” certain QR codes the player has interacted with. This profile also records the player level, his achievements and the global score ladder. The players can level up with the earned experience points, unlocking new viruses and antidotes. The Pathodex and Inventory records the fought viruses and stores the antidotes, respectively.

Throughout the game, facts about the viruses are unlocked, like size, lethality, symptoms, incubation time, method of transmission, etc. Some “fun facts” are also stated. Realistic shapes are used for the viruses’ appearance in the AR part of the game.
Figure 3.4: a) Login, b) Pathodex, c) AR view, d) Profile, e) Inventory, and f) Crafting, in Pathomon. [3]
The game was made in Unity3D to achieve multi-platform support. For AR, Kudan platform was used. An Amazon AWS EC2 instance attached to an Amazon RDS database hosts the server-side implementation and API. Pathomon can be played in iOS and Android devices.

A study conducted revealed that sensory immersion and positive affect were praised, but the game flow and challenge were only reasonable, as they felt the game start and progress too difficult. In the social aspect, the interviewed people did not think their actions could affect the actions of the others, maybe be due to focusing on their own progress.

3.2.2 Narrative Design for Rediscovering Daereungwon: A Location-based Augmented Reality Game

In "Narrative Design for Rediscovering Daereungwon: A Location-based Augmented Reality Game" Shin et al. propose an augmented reality Serious Game to show an historical site differently than through conventional means. [7] Daereungwon is a historical place in South Korea where 23 tombs are located beneath large mounds, but it fails to convey the stories and cultural heritage through the conventional way, due to all tombs appear identical, the scenery being the same from the entrance to the exit, and all the important relics with the historical context being moved permanently off-site, leaving the visit with much room for imagination and making invisible the historical backgrounds and details pertaining to each tomb.

The goal of this project is to expand the visitors’ experience by giving them an added dimension where they can enjoy a gamified interactive narrative focused on increasing the awareness and understanding of the history and cultural heritage found on site. With that goal, the game is designed as a first-person Role Playing Game centered around three points-of-interest: the Michuwangreung, Hwangnamdaechong, and Cheonmachong tombs. The game application will run on the visitors’ mobile devices, and said visitors just need to read markers installed through the visit route, and augmented content will appear superimposed over the physical space.

The player takes the role of a scavenger trespassing the forbidden burial grounds of the Silla royalty trying to reach Cheonmachong and steal its treasures. The interface gives a first-person perspective of the objects and difficulty-increasing challenges faced in the three stages corresponding to the three points-of-interest. Along the path players encounter objects and characters that will develop the narrative about the player’s goal and the past and present of the site.

The three different points-of-interest[Fig. 3.5] give different contexts and features in the single game narrative, but their information and related stories can be divided in three categories: if the owner of the tomb has been identified, if the excavation of the tombs and its relics was carried out, and the contextual storytelling elements of each of the tombs.

The game is built around the Memorable Experience Design Framework[Fig. 3.6] (Bulencea & Eg-
ger, 2015), that describes a method of creating concept tourism experiences by combining experience staging devices and game design techniques. According to this framework, positive emotions during an experience are generated when there is a stable oscillation between relaxation and tension. This oscillation is vital for tourists to orient themselves in a ready and receptive mindset. Hence, the game starts with easy challenges and progressively gets more difficult, with smaller, relaxing tasks, and rewards between the main challenges so that players do not lose interest and/or get frustrated.

The Interest Curve (Schell, 2008) is also applied with the MED framework as a tool to create the progression pattern, maintaining the player's interest level by fluctuating the intensity in a regular pattern while simultaneously increasing it slightly, culminating with the most intense moment in the end, creating an upward curve overall.

In the first Point-of-Interest, bamboo leaves start clouding the augmented interface when the markers are detected and the game starts, with the player unable to proceed further. The leaves transform themselves into soldiers, and the player must "push away" all these soldiers out of the augmented screen by hitting them from the biggest to smallest. When the player accomplishes the mission, the screen is cleared of the bamboo soldiers/leaves and a virtual gate augmented over the real gate opens, and he gets a shovel.

In the second Point-of-Interest, an animation showing the once separate tombs joining one another over the real tomb is augmented on the screen once the marker is detected. The challenge here is to shovel in as many of the queen's treasures that are flying out of the tomb with the shovel given in the first stage, hence, it is impossible to play this stage without having played the first. The treasures shoveled are transformed into gold coins and, in the end, a map showing the path to the final destination appears on screen.

In the last Point-of-Interest, a white eight-legged horse appears at the entrance as the player approaches. Then the player needs to win the battle against it within a time limit, to gain the Gold Crown and ancient treasures. The gold coins previously earned can be used to purchase weapons and armor, making it easier to play this stage if played the previous ones. Once the player exits Daereungwon after accomplishing the challenges, all the treasures disappear from the game application.

3.2.3 Analysis and Discussion

There is a strong resemblance between Pathomon and the vision of LINA as far as game mechanics, albeit with different premises, and there are some aspects that can be used as inspiration for our project. The interface is not confusing and useful in demonstrating what interaction patterns work in mobile devices; The way that people contaminate sites may inspire a mechanic in LINA where is shown which colleagues have been in a given place; The inventory, perhaps more so than the crafting mechanic, may also be useful in LINA, where, for example, the child after a stage was given an object necessary to a
Figure 3.5: Features of the 3 points-of-interest. [7]

<table>
<thead>
<tr>
<th>PoI</th>
<th>Owner</th>
<th>Excavation/Relics</th>
<th>Storytelling Elements</th>
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<tbody>
<tr>
<td>#1</td>
<td>Known</td>
<td>Untouched/Remain Intact</td>
<td>Guardian King/ Bamboo Soldiers</td>
</tr>
<tr>
<td>#2</td>
<td>Unknown</td>
<td>Completed/Found</td>
<td>Joint tomb of king and queen</td>
</tr>
<tr>
<td>#3</td>
<td>Unknown</td>
<td>Completed/Found</td>
<td>Inside access to tomb granted</td>
</tr>
</tbody>
</table>

Figure 3.6: The game narrative combining elements of the MED framework and the Interest Curve. [7]
future stage. This would certainly add another dimension (and immersion) to the game. Reflecting on the interviewed users thinking their actions could not affect the actions of others due to being focused on their own progress, in LINA as one’s progress is dependent of the rest of the group, it is possible that this problem is non-existent.

The Daereungwon project uses an interesting method in conveying the cultural and historical heritage that otherwise would not be so thrilling and extensive. The biggest contribution here, that seems interesting and relevant to LINA is the use of Memorable Experience Design framework and Schell’s Interest Curve to create an engaging First-Person Role Playing Game experience for the visitors of Daereungwon, with a single cohesive narrative constructed linking the three points-of-interest that fluctuates its intensity while winding up to the climax. The construction of a similar fluctuating narrative is part of LINA’s vision, and while the use of the MED framework or Schell’s Interest Curve up until this point was not being considered to be used, it is possible we can use it in the future.
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"Lina, your colleague and friend, did not appear today in class and your teacher knows that she will not come to school anymore, but does not know why. Although she sees your messages, does not answer them, she just sends an enigmatic image that appears to be on your desk. What could that mean?"

With the first paragraph as premise, LINA is a mobile Augmented Reality videogame inserted in the D.O.T. - Die Offene Tür [21] project, aiming towards "improving social connectedness through digital experiences". LINA aims to create an immersive experience, where the players take on the role of students in a class and engage with each other, guided by the game. This allows the players to socially connect themselves free of prejudice, acting as a field-levelling tool by providing them with an isolated fictional environment and by portraying (and socializing as those) fictional characters. Having begun focusing on the COPMI - Children of Parents with Mental Illness - the game has now broaden its target group to all children in the middle school ages (10-12 year olds) as they can also benefit from the fictional space that the game creates, as prejudice is not exclusive to children with special needs.

4.1 Game Concept

4.1.1 Concept

The basic concept of LINA is the search for a clue through the use of overlayed augmented reality over a marker. When scanning an image [Fig. 4.2] with the device’s camera, an overlayed clue (usually an object that the player can interact with) is revealed, usually describing an important event involving Lina, followed with instructions to search for another image.

After the player completing 1 or 2 "stages", they must find another player - or group of players, henceforth designated as element - and solve a challenge presented to them. These challenges could be answering questions about the parts of story that only the other player knows about (which forces them into socializing when sharing their parts of the story), or having both elements perform a task together, for example simultaneously scanning a set of markers. This way the game creates an interesting way of socializing while at the same time exploring a narrative that relates to social isolation. This gives us the four "positive factors" mentioned in Contact Theory:

- Equal status between groups - All children will have the same importance in the game, all have important information that need to be shared among the others so that they can all advance in the narrative;

- Common goals - The shared goal is to overcome challenges and finish the game and find what happened to Lina.
• Inter-group cooperation - Only by sharing the information, or completing challenges together can they advance in the narrative, so there must be cooperation among themselves.

• Support of authorities, law or custom - The teacher, being the authority figure in the classroom, has given the explicit approval and is even directly involved in the game.

These “stages” are not the same for all players: different players would get different stages so that they would get different pieces of the puzzle.

As the complexity of the game increases due to the elements scaling, multiple approaches have been discussed regarding the game’s structure. Originally, each student started on his own and slowly paired up with his colleagues until the whole group searched for the final clue as one, like a perfect binary tree, with each node being an element: a leaf node representing a student, a non-leaf node representing a pairing and the root node the whole class. This structure would only work if the number of students in the class was a power of two, or else a student would have to either play alone while others were already paired, or skip stages to pair with a larger group, which would be unbalanced. Plus, the number of stages could be inappropriate to accommodate the number of students in class.

Then it was considered to split the class in smaller groups of students, with each group playing LINA separately instead of being a single class, but that would defeat the purpose of pairing the children with someone that they get along with, plus it doesn’t address the issue with the previous strategy.

Then it was concluded that instead of trying to make the number of stages according to the number of players, it should be the opposite: establish a fixed number of stages and split the class accordingly into groups of a pre-established size. For example, if a certain challenge needs elements of 4 or 5 persons then in a class of 9 it would split into [4,5], in a class of 18: [4,4,5,5], in a class of 23: [4,5,5,5,4]. Then at the end of the challenge the next elements are reshuffled (or perhaps the system could know which colleagues the player hasn’t been paired with - needs further discussion) However it is necessary to first know how many stages LINA has before starting to split the class into groups, and then make the challenges flexible to accommodate groups of N or N+1.

4.1.2 Structure, Challenges & Story

It is necessary to reiterate that this project is still more than a proof-of-concept and that multiple approaches on how the game would be deployed have been considered, so the structure is subject to eventual changes. Presently, it has been discussed splitting LINA in sessions (or “episodes”): The first episode is an introduction, the next three are the story development and the last episode concludes the story with the discovery that Lina has been acting strange due to her parents being affected with a mental illness. Each session is made of: 5-10 minutes for recap in the beginning; 30-35 minutes of gameplay, where the children play some stages, initially by themselves, later in groups; and 10-15
minutes of discussion afterwards.

A stage is the basic gameplay unit, similar to a level. There are 5 core stage archetypes in LINA:

1. A roleplay-style stage, where the players are instructed to say something, or act in a certain way;
2. A narrative-related stage, where the player only needs to pay attention to the narration or to the text presented to him in his screen;
3. A simple find-the-marker stage where the player is tasked to find a marker, then has to interact with an object and finally gets a piece of information that either develops Lina’s character or his character.
4. A find-the-marker stage that differs from the previous archetype when the information or objects gathered in this stage is going to be useful in a cooperation stage later on.
5. And a cooperation stage where the players need to work together to complete a challenge. This relates with Contact Theory, where each player has the same importance in working towards the common goal.

So far there are 7 different stages in the game:

• Stage 1 - Registration and Initial Briefing:
  An example of the first archetype, in this stage the students and the teacher engage in a role-playing scene where the teacher is making the presence list, with each student answering his/her (character’s) name, and by failing to call Lina the class gets intrigued with her absence, moving on to the next stage.

• Stage 2 - Lina’s Message:
  An example of the 2nd archetype, in this scene the player’s character wonders how strange it is that Lina did not show up for class. He thinks to himself whether he should text Lina. After texting Lina asking what happened to her, she only answers back with a mysterious image. “What does that mean?” the player’s character wonders. This prompts the player to search for this picture and thus setting up the premise for the first mission. As each player is going to search for a different image, the received image is going to be different for each player, making the number of different markers varying with the number of students in class.

• Stage 3 - Tutorial:
  Tutorial is an example of the 3rd archetype, the first mission and entry point for the player into the proper game. After receiving the mysterious image from Lina’s message, the player needs to find what it means. The markers will be placed directly on the player’s desk, just to introduce them to the core mechanics of the game, like scanning and tapping the marker.
• Stage 4 - The Party and The Note/The Picture On The Wall:

This stage is another example of the 3rd archetype. In *The Party and The Note* the player finds a crumpled-up paper that unravels a note that reveals that Lina didn’t want to go to a colleague’s birthday party.

While one player is playing *The Party and The Note*, another player is playing *The Picture On The Wall*. In it he finds, upon scanning the marker, that art is Lina’s best subject and that, when asked to draw someone that inspires her, she drew the back of a hoodie.

*The Picture On The Wall* was an idea from the original proof-of-concept where the students would have several drawings shown on a wall in real life, with a marker replacing Lina’s drawing, prompting the students to scan the marker to see the drawing, and make it as seamless as possible.

• Stage 5 - The Broken Screen/The Broken Screen - Lina’s PoV:

Like Stage 4, *The Broken Screen* and *The Broken Screen - Lina’s PoV* are two missions played in parallel by different players, that differ from the previous ones as they are setting up the cooperation stage that follows, falling under the 4th archetype.

In *The Broken Screen* the player finds a folder containing a letter from the teacher, Mr.Gordon, to the headmaster explaining how he found Lina and Ashley standing next to a broken computer. Lina first says that she and Ashley were the culprits but later she confesses to Mr.Gordon to have done it by herself.

In *The Broken Screen - Lina’s PoV* the other player finds a note inside a backpack that reveals that Lina did not break the screen but it was in fact two older kids that bullied her into confessing the misdeed, and that Lina will correct things up, but did not say how.

• Stage 6 - Cooperative Question:

When scanning the marker, the player finds an instruction telling to wait for the other player. When both players are at the marker they are asked to answer a question about the other player’s part of *The Broken Screen* story, which prompts the players into sharing their parts so they can answer the questions. When they correctly answer the question they unlock an instruction to find the next marker. This stage is an example of the 5th archetype.

• Stage 7 - Lina’s Diary and Puzzle:

After unlocking the next marker in the challenge the players must find as a pair. When scanning the marker each player gets a different half of a page of Lina’s diary. They are taken to a screen with four different images. The images are the same for both players, but their order differs. They are then instructed to tap on the images by the order they see on the other player’s device. When they do so correctly both parts of the page unite to become a single page. One of the players
is then asked to read Lina’s diary to the other. This stage is a combination of archetypes 4 and 5 since there is a marker to be found but also a challenge after finding the marker, but does not make sense splitting into two different stages.

4.1.3 User Experience Design

![Figure 4.1: a) Post Processing filters were tested in a previous iteration of Exploration Mode. b) An example of the current iteration of Exploration Mode. Although subtly, it is possible to see the blur effect being applied to the background. c) An example of the current iteration of View Mode. d) An example of the Interface Mode, in this case, the current iteration of the Main Menu. This is also an example of the UI theme.](image)

4.1.3.A Interfaces and Interaction Techniques

In terms of interaction, the game can be also divided in game modes: Exploration Mode, View Mode, and Interface Mode. The player in each stage plays through one or more of these modes.

*Exploration Mode* [Fig.4.7-b] is the main scene in LINA, it is where the core mechanic of searching the world through imaging acquired live from the rear camera occurs. This was also the scene prone to more changes during the development. The recurring mechanic in a archetype 4 stage is: when the player scans a marker an augmented object appears, which the player needs to interact by tapping. Tapping that object usually unveils the real clue, and tapping on the clue usually triggers a narration and sends the player into *View Mode*.

*View Mode* [Fig.4.7-c] is a screen where the players are shown an object relevant to the player. This was born out of the necessity of having a separate screen where the player could read an image containing text without having to keep the device scanning the marker. This screen also proves useful
in presenting new objects that did not necessarily come from scanning a marker, for example, after the question challenge, when the new marker and instruction is unlocked.

**Interface Mode** [Fig.4.7-d] is any other scene where the player interacts with an interface, like when listening to its character narration or a challenge. This usually follows the hand-script text on a notebook-style background, but not always: an example is the SMSApp with its own style.

![Figure 4.2](image1.jpg) **Figure 4.2:** The markers that are recognized and overlayed through Augmented Reality. **a) The old icons.** These icons were chosen for being colorful images of simple objects that the children could easily recognize. Some were important to the story, like the one with the back of a hoodie sweater. **b) The new icons.** These icons replaced the old ones due to being relatively easy to be custom made, are well recognized (even more so than the previous ones) by Vuforia and serve as a plot device due to art being Lina’s best subject.

### 4.1.3.B Aesthetics

In LINA there is a conscious effort to pass an immersive and atmospheric, almost cinematographic, feeling when playing the game. For that we made a number of decisions regarding the aesthetics: **Exploration Mode** includes an atmospheric background music that accompanies the search for the markers, and sound effects when necessary. Also in “Exploration Mode”, several post-processing filters like Grayscale [Fig.4.7-a], Sepia and Gaussian Blur were tested with the purpose of knowing the technical boundaries and what were the different cinematographic feelings conveyed. In particular, the Grayscale filter has been decided to be used in missions that are “flashbacks”, being a typical visual effect used in media for that purpose; and the mixture of a blurred background and the sharp overlayed item provided a good effect aesthetically.

We also strive for realism with the markers and augmented reality clues, by trying to use realistic models. Pairing with the concept that art is Lina’s best subject, the scribbled markers can become part of story, as if they were made by her, adding another layer of depth to the game. The design of the markers was changed in the middle of the development to fit the more realistic style [Fig.4.2]. There is also a recurring art theme in the game [Fig.4.7-d]: the hand-script on a notebook-style paper, as if the
whole game was handwritten by Lina herself. This is further reinforced with an effort to have all interface images and buttons being drawings.

We also relied in established metaphors when designing the interface, not wanting it to be confusing and creating an obstacle that prevented the players from enjoying the experience: the “dented wheel” means settings, an arrow pointing right means “continue” and circular arrows mean “replay” (restarts the narration).

4.2 Implementation

4.2.1 Design Methodology

The game was subject to several revision iterations, being developed first a low-fidelity prototype [Figs. 4.3 and 4.4] from a supplied proof-of-concept document, then it was shown to experts and the playwright responsible for the narrative, iterated again, shown to the experts, and then developed a first version of the digital prototype [Fig. 4.5], and then shown to the experts once more.

When designing the second prototype a design team was assembled, consisting of Adam Barnard (tasked with the creation of the narrative and art design) [22], the author of this document, Diogo Martins (tasked with designing the challenges, designing the user experience and implementing the application), Ina Stacher (a psychologist with expertise on Contact Theory and children in our target group) and João Dias (overseeing the whole project). This team had weekly meetings regarding LINA and its design decisions. Due to time constraints it was not possible to have children testing the several prototype iterations, only the last one.

4.2.1.A Paper prototype

An initial low-fidelity paper prototype [Figs. 4.3, 4.4] was developed to conceptualize the interface and give some rough guidelines to fulfill the given script. A revision was made after presenting it to specialists where some suggestions regarding the presentation of some information texts and buttons.

The interface was chosen to be a simple area of text with some buttons on the bottom of the “screen” (usually “Back” and “Next”), as to keep it simple, so that small children will not be distracted so easily, and to be intuitive, without ambiguities nor entropy.

4.2.1.B First digital prototype

The first digital prototype [Fig. 4.5] was made in the Unity 2018 engine for its multi-platform support, and the Augmented Reality plug-ins that could be used to implement the scanning part. Initially, we thought that the markers could be QR codes to be scanned, however we decided to go directly for printed
Figure 4.3: Low-Fidelity Prototype of the teacher’s screen.

Figure 4.4: Low-Fidelity Prototype of the children’s screen.
pictures instead, as the cost for implementation would be the same and there was not an advantage in starting with QR codes and changing to printed images later on.

For the Augmented Reality part we used Vuforia Augmented Reality SDK 8.3, a plug-in that allows 2D or 3D “markers” to be recognized and overlays an image or object in a position relative to the marker. The game uses a client-server approach to handle communication between the devices [Fig. 4.6], as there must be a server app running as a game controller. This server also handles the synchronized communication used in the introduction, for example, where a dialogue scene must be coordinated between the teacher and his students. Contrary to the client apps, the server will be run in a computer.

4.2.1.C Second digital prototype

A second, and current, digital prototype was developed with the goal of presenting a minimal viable product for user testing. With this iteration we could experiment with the User Interface to see what would convey the feeling of the experience better - as it is supposed to have a realistic feeling, although a bit cartoon-ish, due to Lina’s drawings. Plus, some story was added and the cooperation parts were refined.

For this prototype there was no need for a running server (as it was focused on the gameplay and the atmospheric feeling that was trying to be passed) so it was decided to make this version a local client where the user could choose between two “mock-up” players - Simon and Max - avoiding unnecessary complexity and the faults and could be derived from there.
4.2.2 Prototype Rundown and Implementation Decisions

This subsection presents the specific implementation decisions, first for the Exploration Mode and View Mode, and then for each stage in the same order that are shown in the prototype. The scene names (for example, Opening or Headphones) currently given in this document follow the Unity scene file names given during development.

4.2.2.A Exploration Mode and View Mode

The augmented reality clues presented in Exploration Mode, despite being different for each mission, were subject to several revisions regarding the way they were shown: initially they were just a simple white rectangle with the instruction to find the next marker and the marker image. Then the clues became relevant items for that mission (like a note containing a piece of the narrative), but players had to read it while having to point the device, which proved tiresome while trying to read a long text. Then to mitigate this problem, we made items interactive so that tapping on the note made it expand into fullscreen. But in an effort to discourage the player from reading directly from the augmented image, instead of the fullscreen, the note was represented by a generic document icon. However it was changed back because this went against the realistic feeling. So we tried using the blurred models for the augmented images, but it was still agreed that it was not pleasing. Finally, with the introduction of 3D objects, the overlayed clue is not the clue itself but a third object, that upon tapping shows the real clue in View Mode.

On the superior part of Exploration Mode there’s a header with the “Settings” button, the task at hand
with the corresponding marker, and a custom color with the character’s name in an effort to personalize the User Interface and make the player feel unique. Originally there wasn’t a background for the header, but to continue the metaphor of being Lina giving the instructions, the notebook paper style image became the background.

To help players know what to do when encountering an interactable augmented object, when a player needs to interact with an object a hand tapping icon appears to signal the player that he is before an interactable object.

This also brings up the already discussed idea of using objects in the inventory to interact with other augmented objects, like using a key to open a locker. A very basic Inventory was implemented - in Fig.4.7 there are two yellow buttons that would scroll through the Inventory, selecting the "current" object, and then tapping on the icon would either activate the object or enter View Mode for text-based objects - but since there wasn’t any usefulness for this demo it was decided to shelve this mechanic for now.

Another shelved mechanic was the "Dropbox" or "Mail", where players could send and receive objects by having a marker in their desk that would trigger an augmented cardbox or mailbox, and by tapping on that box they would send the "current" object on the Inventory. However this posed a dilemma: if a player has an advantage (like the key to the locker from the example above) would it be beneficial for the player to hand that advantage to another, or would it be better to use that advantage (instead of giving the key to another player, they would pair and both would physically go the marker and open the locker)? It was then decided that it would be better for the players to pair instead of transferring objects, making this feature shelved until a justifiable use appears.

![Figure 4.7: a) An example of the current iteration of Exploration Mode. b) An example of the current iteration of View Mode. c) An example of a previous iteration of View Mode.](image)
**View Mode** is just composed of a black background and the image in the center. Previously, instead of a solid black background it was a slightly dark transparent panel that was superimposed on the **Exploration Mode** screen, making it possible to see the live camera image. This unnecessarily made the device heat up and use graphical resources when the player is just reading a text. Hence the background was made a solid color and the camera turns off when it enters **View Mode**. Although not an isolated Unity scene in the current build, it can become one in the future if the necessity arises. This is especially true if an Inventory system is added to the game, as the players should have a way to inspect each individual item, a typical mechanic in Role-Playing Games.

### 4.2.2.B First Stage - **Registration/Opening and Headphones**

In the first prototype a server would be running a “ServerGameManager” object, a class responsible for keeping all the information about the players and controlling the pace of the dialogue, giving instructions to the client-side game managers, making it a Master-Slave architecture due to the synchronous nature of the situation, similar to a director giving orders to his actors. This scene (Registration) essentially involves the players pairing with the server, choosing their character’s name and role-playing a scene with their teacher.

As the second prototype doesn’t have a server and was just for showcasing purposes, the initial dialogue is skipped. Instead, there is an introduction video describing the initial exposition by the teacher. This scene will be henceforth called **Opening**. Then the player is given the option of choosing which of the fictional players - Simon and Max - he wants to play as (in **Main Menu**), and is asked to put on their headphones (in **Headphones**).

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**Figure 4.8:**

a) The exposition video in **Opening**.  
b) An initial version of **Main Menu**.  
c) The current **Main Menu**.  
d) The current **Headphones**.
4.2.2.C Second Stage - Narration and SMSApp

Initially, Narration [Fig.4.9-a] did not have a proper background yet, the subtitles button was on the bottom-center part of the screen and the “Done” and “Replay” buttons were just disabled until the narration stopped. This was dropped in later iterations since it was decided that the player could restart the narration without having to wait until for it to end, and there was no point in having the green tick button present at all because it could be confused with an active button.

The design concept in SMSApp was to create a familiar texting application, similar to the messaging app found in all phones or even WhatsApp. This creates the illusion of a real texting app, together with the notification sound played when Lina’s message is received, animations showing the messages being sent and received, and green ticks representing the “seen” status of the message sent. This was an idea that was present in the original proof-of-concept document was complemented by the narrator-character saying “Green ticks... she has seen the messages...”. However, all narration was removed from this scene as it was deemed unnecessary and slowed the pace from the game. When moving forward to the next stage the next scene can take some time to load, so as to not appear that the game froze, a loading pop-up was created, consisting in a small rectangle with the notebook-like background and a hand-script text appropriately saying “Loading...”.

4.2.2.D Third Stage - Tutorial

This stage is the first contact with Exploration Mode. The augmented clue shown is an envelope with the player’s name on it that upon tapping, triggers an animation where the envelope turns and opens.
Tapping again opens View Mode with the next instructions.

4.2.2.E Fourth Stage - The Party and The Note/The Picture On The Wall

In this stage the players start in Exploration Mode. In The Party and The Note the player playing as “Simon” finds a crumpled-up paper that upon tapping shows a note that reveals (through the character’s narration) that Lina did not want to go to a colleague’s birthday party. The original idea was to have an animation where the paper unfolds, but it wasn’t feasible in the current schedule, so it is just the sound of a paper unfolding and opening View Mode.

In The Picture On The Wall. Upon scanning the marker, “Max” finds out that art is Lina’s best subject. As shown in Fig.4.12, originally there were several augmented drawings and the player would have to tap on Lina’s to trigger the narration, but then it was changed to having just Lina’s because it occupied a lot of screen space meaning the players would have to back up from the marker which resulted in Vuforia losing track of the marker thus making the drawings disappear. Unlike the previous missions the player does not need to tap on the drawing as there is no text and, consequently, no need for View Mode, making the narration rightly appear when the marker is scanned.

4.2.2.F Fifth Stage - The Broken Screen/The Broken Screen - Lina’s PoV

In The Broken Screen “Simon” finds a folder containing a letter from a teacher, and in The Broken Screen - Lina’s PoV “Max” finds a note inside a backpack. The mechanic is the same: by tapping their objects, the players enter View Mode and the narrations exposing their parts of the story are triggered.
Figure 4.11: The Party and The Note  

a) A previous version with the model as the augmented image.  
b) A previous version with a generic document icon for the augmented image.  
c) The current version, with a crumpled paper model.  
d) A previous version of View Mode, notice the initial note model.  
e) The current View Mode with the revamped model.

Figure 4.12: The Picture On The Wall  

a) The previous augmented image.  
b) The View Mode has since been removed from this mission.  
c) Currently, the marker only reveals Lina’s drawing.
Figure 4.13: The Broken Screen. a) Initially the note was shown directly over the marker. b) Then it was replaced by a generic icon. c) Currently, a folder model is used that shows the note on tapping. d) Previously, the note was represented as a scrollable text in View Mode. e) Currently, it is shown the note model.

The View Mode was initially different for The Broken Screen: the text on the image was a bit condensed it was hard to read, so a scrollable window with the text was made, but it was preferred to cut some part of the text on the model and use it to read for a better sense of realism.

4.2.2.G Sixth Stage - Cooperation and Question

The third mission presented to the players is Cooperation: it starts in Exploration Mode and the players, when scanning the marker, find an instruction telling them to wait for the other player and upon arrival to tap the instruction. After tapping they are instructed to remove their headphones and answer a question about the other player’s part of the story. If they select the wrong question they’ll be presented with a pop-up suggesting they should talk some more. When they correctly answer the question they unlock an image instructing them to find the next marker.

In order to have both players in the same place two markers are placed side-by-side on wall. This decision (versus having a single marker for both players) goes back to the initial idea in the proof-of-concept document when the reward for correctly answering the question was each player unlocking half of the next marker, which would then become one by having an animation “gluing the pieces”. This would require for the game to know not only that the players were standing beside each other, but and more specifically who is on the left and who is on the right. However, it was decided to use this mechanic later in the game when discovering Lina’s diary page.
Figure 4.14: The Broken Screen - Lina’s PoV  

a) A previous backpack model, changed for its texture not looking realistic enough.  

b) The new backpack model. Tapping triggers an animation and a narration.  

c) Before, the note was shown directly over the marker.  

d) The current version of View Mode.

Figure 4.15:  

a) The text instructing the players to wait for each other.  

b) The screen instructing the players to remove the headphones.  

c) The question presented to one of the players.  

d) The pop-up shown if they answer incorrectly.  

e) The next note "left" by Lina with the instructions to find the next marker.
4.2.2.H Seventh Stage - *Lina’s Diary and Puzzle*

When scanning the marker each player gets a different half of a page of Lina’s diary. Upon tapping they are taken to a screen with four different images. The images are the same for both players, but their order differs. They are then instructed to tap on the images by the order they see on the other player’s device. When they do so correctly it triggers an animation where both halves unite to become a single page. “Simon” is then asked to read Lina’s diary to “Max”.

Interestingly, having both image sequences side-by-side creates the perfect analogy for recreating the page: each player has either the left or right parts of both the puzzle and the page, and by collecting information on the other side of the puzzle he manages to complete the image, making both players with the full puzzle image in their screen, symbolizing the diary page. If instead of the animation being two sides coming together, was the puzzle image morphing (through a fade for example) into Lina’s diary the metaphor would suit perfectly as well.

Also, “Lina’s Diary” previously had the *View Mode* opening upon tapping the augmented image but it was removed so that the players wouldn’t try to read the text before unlocking the full note. And the diary page model was revamped with less text as the old image had the text too condensed which made reading too difficult.

This mission originally consisting in just having both players searching for the marker as a pair, without the puzzle stage, because the puzzle was being used as a way to make sure the players were standing next to each other before being asked to answer the question in the previous stage. The puzzle itself was also different, instead of having both players introducing an image sequence, one player had a six-digit number while the other had to input that number in his device. Thus, one player had an active role while the other had a passive one, and it was decided that it would be better if both had equal roles in a cooperation, at least for now, as it has been discussed characters having particular traits that would give them advantages in certain stages, like a lock-picking ability (for the padlock example previously used). This would create an asymmetrical gameplay that would add another layer of depth into the game, but players’ abilities still requires some discussion, as Contact Theory states that the players should be all in equal footing.

4.2.3 Changes Made for the Evaluation Workshop

Some changes had to be made to the prototype for it to be properly played in the evaluation workshop. For instance, all text was translated to German, for despite being a high-achievement school, it was agreed that their English level would not be sufficient for them to understand the story. The note images that were written in English were left untouched as there was not enough time to replace them for German translated ones and to be ready in time for the workshop.
Figure 4.16: 

- **Lina’s Diary**
  - a) The old page model.
  - b) The View Mode that was removed.
  - c) The half presented to “Max”.
  - d) The other half presented to “Simon”.

Figure 4.17: 

- **Puzzle**
  - a) Half of the puzzle presented to “Simon”.
  - b) The other half of the puzzle presented to “Max”.
  - c) The full image appears to both players when the sequence is correctly inserted.
  - d) The full page of Lina’s diary is revealed to both players.
  - e) “Max” is instructed to listen to “Simon”.
  - f) “Simon” is instructed to read the page to “Max”.
In the last stage, after having united Lina’s diary, the players were prompted to either read the text or listen the text being read. As their English level was deemed not sufficient, and most likely they would not like reading or listening to an English text, to the extent that could impact their perceived enjoyment, it was decided to remove that part, being replaced with a message to give back their devices to the people conducting the workshop.
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5.1 Evaluation Goals & Method

5.1.1 Goals

The purpose of this pilot-test is to assess two things: how the children like the prototype in terms of enjoyment and satisfaction, i.e., whether they like the concept, have fun playing and want to play more; And the usability, whether the virtual and "real life" components of the game - interface and challenges - are adequate, and work well with each other, and individually.

5.1.2 Evaluation Workshop

The evaluation was conducted with children from a high-achieving middle school in Sankt Pölten, Austria, as there was another workshop from the same project already scheduled there, and, due to being close to the end of the classes, it was difficult to schedule a new workshop in Portugal.

To evaluate this, two classes of children aged 10-12, were split in groups of 8. Of course this was not always possible, so if a group was odd-numbered, Ina Stacher (an Austrian psychologist attached to this project) would fill in the role of the missing player. Ideally, each pair would have its own session, but this would make the workshop take much longer. The reason for having groups of 8 is due to logistics, at the time of the evaluation the project only had 8 devices available with which we could perform the workshop. In each session, the group played as 4 different pairs - 4 played as Simon and the other 4 played Max - as if they were part of 4 different classes. To decide who played as Simon and who played as Max, the children were seated in two rows of four: those in front would play as Max and those in the back play as Simon. Previous to the workshop markers were spread around the room. Each session took about 30 minutes, 5 for an introduction, 15 for the actual gameplay, and the remaining 10 to fill a quantitative questionnaire and have a little group discussion with some qualitative questions.

As the workshop was evaluating 4 pairs of players playing at the same time, new markers had to be created so that four players (or in a limit case, the whole group) searching for the same marker would not gather around one place. As Vuforia is effectively colorblind when reading a marker - uses a grayscale image to recognize the pattern - new markers were devised with the same sketch but a different color, and a letter in the corner with the pair that belonged to (pair L, I, N, or A). However, Vuforia didn't properly distinguish the markers with the letters, so they became more indicative for the players than functional, as they can still scan a marker that "belonged" to another pair.

5.1.3 Quantitative and Qualitative Instruments

To evaluate the enjoyment/satisfaction and usability a quantitative questionnaire was constructed based on three scales: GSUS, an adapted version of SUS - System Usability Scale for game context [23], the
Table 5.1: The interview guide with the corresponding target variable for each question.

<table>
<thead>
<tr>
<th>Target Variable</th>
<th>Question</th>
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<tr>
<td>Enjoyment</td>
<td>What was your first impression of this game?</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>What did you like most about this game? Why?</td>
</tr>
<tr>
<td>Enjoyment (and Usability)</td>
<td>If you could only change one thing about this game, what would you change? Why?</td>
</tr>
<tr>
<td>Enjoyment (and Usability)</td>
<td>What didn’t you like about this game? Why?</td>
</tr>
<tr>
<td>Usability (Efficiency)</td>
<td>Does the User Interface look organized?</td>
</tr>
<tr>
<td>Usability (Efficiency)</td>
<td>Is it easy to understand how to use the game?</td>
</tr>
</tbody>
</table>

Enjoyment subscale of GUESS - Game User Experience Satisfaction Scale [24] and the Interest/Enjoyment subscale of IMI - Intrinsic Motivation Inventory [25]. This questionnaire grouped some questions that were transversal to all three, and omitted others because it would take too long for the children to answer all the questions, plus some would not be suited for the children to answer, like the Usefulness subscale of IMI and GUESS. In the end it was composed by the following nine questions:

- 1 - I think I would like to play this game frequently. Derived from GSUS. (Higher score is better)
- 2 - I found the game unnecessarily complex. Derived from GSUS. (Lower score is better)
- 3 - I thought the game was easy to play. Derived from GSUS. (Higher score is better)
- 4 - I would imagine that most people would learn to play this game very quickly. Derived from GSUS. (Higher score is better)
- 5 - I felt very confident playing the game. Derived from GSUS. (Higher score is better)
- 6 - I needed a lot of help before I could get to play this game. Derived from GSUS. (Lower score is better)
- 7 - This game was fun to play. Derived from IMI and GUESS. (Higher score is better)
- 8 - I would describe this game as very interesting. Derived from IMI. (Higher score is better)
- 9 - I enjoyed playing this game very much. Derived from IMI and GUESS. (Higher score is better)

The answers were provided in a 5-point Likert scale with “thumbs up and down” images: “thumbs up” if they agreed with the statement, “thumbs down” if they disagreed. Also collected was their age, gender and class [Fig.5.1].

The discussion/focus interview followed a guide [Tab.5.1] (based on the one from M Steiner et al. 2015) [26].

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5.2 Results

These results were obtained from a population of 31 subjects - 13 males and 18 females, 9 being ten year-olds, 21 eleven year-olds and 1 thirteen year old - split in two classes: class 1A with 22 subjects - 10 males and 12 females - and class 1C with 9 subjects - 3 males and 6 females.

5.2.1 Quantitative Results

These quantitative results come from the questionnaires answered after the play session. Cronbach’s Alpha tests were conducted for each subscale to see if we could find a correlation between the questions that derived from the same subscale: the first six questions (derived from System Usability Scale) and the other three (derived from Intrinsic Motivation Inventory Interest/Enjoyment subscale and Game User
Figure 5.3: The mean results of the questionnaire per gender, with a 95% Confidence Interval.

Figure 5.4: The mean results of the questionnaire per class, with a 95% Confidence Interval.
Experience Satisfaction Scale Enjoyment subscale). For this the results of questions 2 and 6 had to be
inverted to the scale being inverted, i.e., lower score is better, while in the other questions, higher score
is better. The results were 0.308 for the first six questions and 0.935 for the last three, which meant
that questions 7-9 are directly correlated and could be treated as one, while 1-6 are independent. This
could be due to the SUS-based questions assessing several aspects of Usability, from playing difficulty
to wanting to play more, which are not directly related. Henceforth questions 7-9 were grouped under
the label "IMI Enjoyment".

First, from analyzing the given answers for each question [Fig.5.2] the results are positive for both us-
ability and interest/enjoyment, averaging the value of 4 out of 5 (also considering the inverted questions),
which means that the inquired subjects agree with the following:

• They would like to play the game frequently;
• The game is not unnecessarily complex;
• The game was easy to play;
• The game does not have a steep learning curve;
• The players feel confident while playing the game;
• They did not need a lot of help to play the game;
• The game is fun;
• The game is interesting;
• They enjoyed playing the game;

A Chi-Square Test (all questions had p-value <0.05) refuted the hypothesis that the answers were
the result of children randomly answering the questions [Fig.5.5]. Then further checking the answers
by splitting the population by gender [Fig.5.3] and class [Fig.5.4] revealed a notable gap in the mean
values for some questions between the classes. This prompted conducting Mann-Whitney U Tests
(p-value <0.05) to see if there was any relation between the answers and either gender and/or class.
While its results showed no statistically significant difference regarding gender, the same cannot be
said regarding class, for questions 1 (p=0.001), 5(p=0.014), 7(p=0.004), 8(p=0.004) and 9(p=0.004).
This meant that class 1A, in comparison with 1C, enjoyed the game more and felt more confident while
playing it, and subsequently would like more to play again in a frequently manner (although class 1C
only has 9 subjects versus the 22 in 1A). This was first noticed during the feedback discussion at the
workshop, and the collected data seems to confirm that perception. The second class was made up
by "gifted" children, and it is curious to wonder why they enjoyed the game less or why they felt less
confident while playing it. Ina Stacher hypothesizes that, as overachievers, the children in that class were not comfortable with not understanding parts of the game and reacted more adversely than class 1A. Nevertheless, the overall usability and interest/enjoyment results were positive.

5.2.2 Qualitative Results and Discussion

This feedback results from the qualitative focus interview made after the children answered the questionnaire. Overall, the children liked the gameplay and the story. They wanted to play longer, and liked the challenges presented to them, but some did not work out as expected. Also, the interface worked well but there was some confusion regarding the audio and subtitles that the players did not like.

They found the premise of Lina disappearing and leaving clues entertaining and fun; they also liked the question challenge, saying that this forced them to discuss the story. The image puzzle was received less enthusiastically, specially by the class 1C, as they grew frustrated for not being able to finish the puzzle by themselves and had to effectively wait for the other player. Also, one child remarked that did not understand she had to tap on the images to finish the puzzle.

With the first group, as there were several Simons and Maxes, when presented with the question, the players would ask “Who’s Max?” or “Who’s Simon?” among themselves and then start sharing their stories as one group, instead of having four separate subgroups. While interesting, this was mitigated in later groups by emphasizing the four pair teamwork when introducing the game, as they clearly did not understand that aspect of the demo.

Also regarding the characters’ name, they did like the fact they are playing as fictional characters, but almost everyone preferred having the option to choose their character’s name, either from a list or submitting their own. Selecting a name from a list is present in the previous, server-based version.

When asked to wait for the other player and then share their stories, unsurprisingly most would not wait for the player and would just try every answer until he got the right one. This is a byproduct of this demo version as there isn’t a server to check whether the player is really present or not. Afterwards the
children explained that they were confused with the "Wait here for Max" instruction because they did not know if he was a real person or not and got impatient waiting. Those that did wait for the corresponding second player also criticized the waiting period, saying it took too long for the other player to get there. Nonetheless, they praised the cooperation with their colleagues, especially with having to pair with a random person and not only with their best friend.

Another reason given for trying all the answers was not having completely understood the story, or not remembering it well. For the first issue, not surprisingly, the language barrier could not be removed by just having subtitles, especially as unlike Portugal, Austria usually dubs movies and television shows, leaving the children unused to subtitles. All the children agreed that they did not like having English audio and German subtitles, finding the first distracting, so much that they played almost the whole game without their headphones on, preferring to read the latter. The second issue was previously addressed regarding the usefulness of having a recap before the question, or an Inventory where the player could re-read a note.

Regarding the User Interface, there was no confusion with the control buttons but, despite having the task written in the top of "Exploration Mode", some players did not know what they had to do, so in the "Tutorial" mission, instead of scanning the marker right in front of them, they started scanning the whole room to see if something happened. Another issue was when they scanned their first marker and the tapping icon appeared, they tapped the icon instead of the marker, in fact, a few tapped everything on the screen and eventually managed to tap the marker. A few also complained about the size of the interface, saying it was too small and difficult to read. Although the game is thought to be played on a smartphone, one child was playing on a tablet and it was noticed that, visually, the game looks and plays much better, for example, when tapping the augmented objects.

Regarding the User Interface, there was no confusion with the control buttons but, despite having the task written in the top of "Exploration Mode", some players did not know what they had to do, so in the "Tutorial" mission, instead of scanning the marker right in front of them, they started scanning the whole room to see if something happened. Another issue was when they scanned their first marker and the tapping icon appeared, they tapped the icon instead of the marker, in fact, a few tapped everything on the screen and eventually managed to tap the marker. A few also complained about the size of the interface, saying it was too small and difficult to read. Although the game is thought to be played on a smartphone, one child was playing on a tablet and it was noticed that, visually, the game looks and plays much better, for example, when tapping the augmented objects.

While the workshop occurred without any technical mishaps regarding the software, one device’s camera did not focus properly and did not recognize one marker. This made impossible for the player to continue playing past that point, so he had to wait for another player to finish so that he could be given his device. This of course had a significant impact on that player’s opinion of the game, as when asked what would they improve, that child’s answer often remarked fixing up that error.

Concluding, this workshop was positive in two ways: first, it showed that the children are interested and would enjoy playing LINA, and second, it showed that not only the prototype is in the right direction to become totally usable, but also pointed out what aspects to improve for that end. For example, questioning the players poses some challenges regarding to what is asked from them versus what they will actually do: they are asked to talk with the other player and answer the question, but they can simply “brute force” the system and click on all the answers until they find the correct one; or tap on the correct answer on the other player’s device. This unquestionably defeats this stage where the whole purpose is for them to cooperate to overcome the challenge. Another issue is trusting the players’ memory to
recall what happened previously in the game. If they were not paying attention during the storytelling
then they cannot be an effective help and this mitigates the purpose of this stage. Either having an
Inventory mechanic, where the player could access the previous collected notes, or having a journal or
diary that logged the important events regarding the story or the player's actions would help the player
to "remember" what has transpired.
# Conclusion

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6.1 Conclusions

An initial prototype for LINA, a cooperative Augmented Reality mobile game, was presented, with the goal of improving relations between classmates, based on Contact Theory. This game consists in having a sort of interactive theater play, directed by the game, to find what happened to Lina through the search of Augmented Reality clues and challenges to be completed through teamwork. Three iterations were made: a paper prototype, a basic technical proof-of-concept involving a server, and a second prototype, more focused on the User Interaction and the challenges proposed to the players.

A workshop was conducted to evaluate the Usability and Enjoyment of the prototype through a quantitative questionnaire based on the System Usability Scale, Intrinsic Motivation Inventory, and Game User Experience Satisfaction Scale questionnaires, plus an interview for qualitative feedback. This workshop had some interesting findings and, as it was the first time the game was played by the actual target group, was extremely useful for observing their natural reaction to the whole premise, interface, and challenges proposed.

While the overall collected data showed that they indeed liked the premise and enjoyed the game experience, also showing interest in playing the game in weekly sessions, there is still much development regarding the story and challenges to be done. Plus, this first stage of the game still needs to be reworked and their feedback will be taken in consideration.

6.2 System Limitations and Future Work

Obviously, as this is a initial prototype, there is still a considerable amount of work to be done. First, this initial stage must be rework with the children feedback into consideration: While the User Interface generally worked well, the text, and maybe the marker, must be bigger in “Exploration Mode”; Also, before each mission there is the need of a screen clearly instructing them what to search for, which was something the game had in the first prototype; The question needs to have a system that does not allow the players to try each answer, or at least a mechanic that discourages them from to do so; Before the question there needs to be a recap or, like stated previously, an Inventory system that allowed the player to inspect or re-read objects.

On a broader scope, the rest of the narrative still needs to be concluded, obviously taking into account the future challenges that will be devised. This is the main priority in the future development of LINA: the development of interesting and fun challenges that the players need to conclude, and that will be beneficial to their relationships. One thing that was discussed was having an activity (called “Episode 0”) to be played by the children where information about the player’s relationship with each of their colleagues could be extracted from. Then the game would selectively pair them with the ones whose relationships are weaker.
Technically, there is still room for improvement and exploration: whether the game should still be played on a smartphone or on a tablet is a recent topic for discussion; Vuforia supports the recognition of textures like grass or tables, and this is an interesting boundary that should be pushed; The use of geographical points for placement of augmented objects is another addition that could prove useful (for instance an augmented computer could appear on top of a table, or a locker in the school hall, without the need for recognizing markers).

Regarding audio and visuals, the use of post-processing filters and music/sound effects are going to be key when conveying the feeling and atmosphere for special scenes (for example, in a flashback mission, the screen could change to black and white while the sound of rain hitting the window and sad atmospheric music plays, for maximum dramatic effect).

Lastly, we need to translate all the images and recording new narration in German, especially if Austrian children are going to continue testing the game.
Bibliography


1. Ich möchte das Spiel gerne öfters spielen.

2. Ich finde das Spiel unnötig kompliziert.

3. Ich finde das Spiel war einfach zu spielen.

4. Ich denke, dass die meisten Kinder sehr schnell lernen das Spiel zu spielen.

5. Ich wusste genau was zu tun ist im Spiel.

7. Das Spiel war unterhaltsam.

8. Ich fand das Spiel sehr interessant.


Wie alt bist du? _____

Ich bin ein     Bub    Mädchen

Danke für deine Hilfe! ☺