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JAVIER TRESACO VIDALLER

DESIGN AND IMPLEMENTATION OF COOPERATIVE MULTI-PLAYER GAME TO FOSTER SOCIAL INTERACTION

Master of Science thesis

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ABSTRACT

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Nowadays, a high percentage of the population owns a personal device to connect with anyone at any time. Yet, these smartphones affect the face-to-face interaction, prompting individuals' attention to their devices instead. Besides, games have also shifted from tools to communicate through the use of competition and/or collaboration to complex systems with global interconnection, complicated artificial intelligence agents and high definition graphics. Smartphones give the opportunity to play games at any time and location. Nevertheless, the capabilities of personal devices have merely been explored in situations where people are collocated.

The main objective of this thesis is to create an application for smartphones to encourage communication and socialization. *Imaginary* has been developed as a playful experience where players must overcome the lack of shared information to achieve a better outcome than other players or groups. The game shows a picture to only one player which stays unknown by the rest. Players can compete against each other or collaborate as a team to reproduce the picture as similar as possible. Asymmetry and lack of awareness hinder the player's task, making communication an essential tool to success.

A user study was conducted to evaluate the impact of the application in the communication and to detect possible usability problems. It consisted of 6 sessions with 4-5 participants from different nationalities and levels of familiarity with others. The results have defined *Imaginary* as a relaxing, engaging and playful game that facilitates interaction and communication. Participants described the game as a new experience that can be used for team up, learning purposes or just for leisure.

PREFACE

I would particularly like to thank my supervisor Thomas Olsson who has been very patience and has always provided me with valuable feedback. I would also like to mention all the people in IHTE department who have seen evolve my game and gave me the opportunity and the tools to develop something that I like.

This thesis has a special meaning for me because I have the chance to delve into the knowledge of HCI and novelty technologies. Moreover, I have the opportunity to meet new people and make really good friends. I would like to specially thanks to those friends who spend part of their life with me for making me feel like home and helping me through the hard times.

Finally, I cannot forget the unconditional support my family has given to me. I cannot express how important they are for me and I want to thank their patience and motivation.

21.2.2016

Javier Tresaco

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LIST OF ABBREVIATIONS AND SYMBOLS

Alljoyn	An open source framework that makes it easy for devices and apps to discover and securely communicate with each other
Class	Is an extensible program-code-template for creating objects, providing initial values for state and implementations of behavior
COOP	Cooperative Systems
CSCL	Computer Supported Collaboration Learning
CSCW	Computer Supported Collaborative Work
F2F	Face to face communication
D2D	Device to device
HCI	Human-Computer Interaction
PLEX	The Playful Experiences (PLEX) framework is a categorization of playful experiences
Tag	A label attached to someone or something for the purpose of identification or to give other information
SDK	A set of software development tools that enables a programmer to develop applications for a specific platform
UI	User interface
UX	User Experience
Wi-Fi Direct	A standard enabling devices to easily connect with each other without requiring a wireless access point

1. INTRODUCTION

This thesis was written within the scope of the Human-Center Technology Unit (IHTE), at Tampere University of Technology, in 2015. The project was carried out by the research group SocioTech[1] , which aims to enhance social interactions between people in close proximity through the use of mobile or wearable devices, and ubiquitous technology[2].

Games have been widely used to encourage and enhance communication in social gatherings, by introducing motives through competition or collaboration. In the era of computers and electronic gadgets, social games are evolving into popular and easily accessible past time activities within groups of friends or familiar people. The behaviour of people playing digital games in social gatherings will be studied thoroughly, in order to understand how the use of technology can affect the communication and interaction between them.

For the purposes of the thesis, a digital application was developed, subsequently used and evaluated in user trials. The application combines some social aspects of board games with the interaction opportunities that mobile technology has to offer (using personal displays, asymmetry, zooming etc.). It was mainly inspired by drawing games in which players team up to guess what one of them is drawing.

The current chapter describes the groundwork of the thesis, and attempts to specify its objectives. The process that was followed as well as the applied methodologies are mentioned and explained. Finally, the way the current document is structured and organized is described.

1.1 Background and motivation

Nowadays digital electronic devices have grown to be an essential part of our lives, a fact that is amplified by the existence of smartphones and social networks. The opportunities that such a case has to offer have been employed since the beginning,

[1] http://www.tut.fi/en/social-technologies/Agenda/index.htm
[2] http://www.techopedia.com/definition/22702/ubiquitous-computing

in order to apply collaborative interaction between people. It is often pointed out that collaboration in working and educational environments can improve people's attitudes, therefore allowing the tackling of more complex problems[10, 13, 21].

Several different studies and company-related research have explored large common displays which provide collaborative interaction between users, especially for leisure activities such as interactive displays at museums[3], past time activities in train stations[4], digital board games[5] and others.

The use of personal devices for co-located collaborative activities however has not been examined as extensively. Smartphones are mostly perceived as rather private devices, used for individual tasks or to communicate with others remotely. Thus, most mobile games are focused on single-player or multiplayer mode over the internet, but rarely for groups of co-located people.

Board games have been used for a long time between groups of friends as a means of having fun and socializing. Board game players interact face-to-face, in order to achieve the game's objective by cooperating or competing against each other. Many board games have been implemented and can be played via electronic devices, but the essential aspect of face-to-face interaction has been neglected. Video games for consoles and smartphones give players the opportunity to play against artificial intelligence opponents, entirely omitting social interaction. They provide however the interconnection of people around the world, leading to the creation of social communities of players.

In many situations, friends gather together in public spaces such as bars or houses to spend time together. In such occasions, board games are used as social activities between the group members. However, with the spreading of smartphones and gaming consoles, the popularity of board games decreased, giving place to self-indulging games[6]. The objective of this thesis was to use novel techniques to create a game which will encourage people to play with and talk to each other, over just looking at their own smartphone devices. The result was a gave called *Imaginary*, which utilizes the capabilities of modern smartphones and tablets, and can be played in social gatherings. *Imaginary* provides a concept that encourages social interaction and cooperation without the need to have a physical board like most board games.

[3]http://www.formula-d.com/interactive_educational_exhibitions.html
[4]http://www.jcdecaux.co.uk/rail/rail-digital/motionwaterloo
[5]http://epawn.fr/
[6]http://www.pewinternet.org/2009/11/04/social-isolation-and-new-technology/#fn-492-1

1.2 Research objectives and methodology

The main objective is to explore and analyze the ways that technology can lead to face-to-face interaction. In-game interaction and communication between players, as well post-interaction encouraged by the game are considered important aspects. Less attention is given to features such as the final outcome or teamwork efficiency. The thesis attempts to diversify the purpose of mobile devices in order to create a common playful activity for co-located people, discouraging isolation.

In order to utilize the accessibility of open-source software, the application was implemented for mobile devices using the Android operating system. A framework was used to support the interconnection between devices in the same local network. The game uses players' personal mobile devices to provide unique information to each player and bring asymmetry to the game, where information is not shared equally. This fact makes the collaboration essential and boosts the social interaction between players.

For the development of the application, an iterative design was applied, as instructed by the principles of User Centered Design[7]. That included the creation of paper prototypes and storyboards which aimed to improve and simplify the design procedure by encouraging the users to focus on the important aspects of the game. The User Centered Design is a process that emphasizes on the user's needs wants and limitations at all stages of the design and development of the product. Therefore, the game had to be redesigned several times to satisfy to the users' requirements and demands.

An evaluation of the application was carried out with a total of 30 participants, which aimed to allow the gathering of important feedback on the users' experience from playing the game. During this evaluation, the participants' emotions while playing were examined, in order to assess the effectiveness of the game in encouraging communication to overcome information asymmetry.

1.3 Structure of the thesis

This thesis is divided in 7 chapters, starting from a theoretical background on social technologies (Chapter 2) and social games (Chapter 3).

The chapter "social technologies" covers a historical review of the group's formation and team work, describing the user needs that motivate individuals to join

[7]http://www.usabilityfirst.com/about-usability/introduction-to-user-centered-design/

groups. Additionally, Computer Supported Collaborative Work and Learning fields are defined along with relevant study cases.

Chapter 3 covers the social games that have influenced interaction between people, covering both board and digital games. A brief history background of board games and video games is presented to emphasize their influence since their appearance. The term social games is defined and its different forms are presented. Finally, some case studies that have brought co-located games to analyze the interaction is abroad.

Next, the design and implementation methodologies are presented, focusing on the interaction process with the use of paper prototypes and storyboards, as well as the technology used to interconnect the devices and to develop the application. The limitations and problems encountered during implementation are addressed in this chapter.

The evaluation process is described in chapter 5, including the questionnaires used and their objectives of use. The user study session is explained along with the recruitment process and the data collection.

The next chapter presents the results of the study sessions and the interpretations for the video recording.

Finally, the last chapter contains a discussion of the findings and how the application can be used to explore the groups interaction in co-located environments within the use of technology, as well as future work and ideas are presented to improve the game.

2. SOCIAL TECHNOLOGY

Social technology is a simple technology used by group of people. However, the concepts behind this technology are more complex.

The Social Technology is a term associated to social networks such as Facebook, Twitter, LinkedIn, etc. Moreover, there are other technologies which enable to connect people on terms of social technology such as the Internet or mobile devices.

There have been several definitions of the social technology which are not describing the social media accurately. As Fisher notes in his article [9], many definitions define the social media as the tools that allow to share and discuss information among people. Thus, the content of the social media is shared and it creates the interaction required to integrate the technology.

The concept of social media covers different types of technologies and objectives. New relationships and group interactions which are created by the use of new technologies are studied in more details in this thesis.

In this chapter, the elements that cause isolation in a group as well as the features which drive collaborative work into success are described. Moreover, the reasons that drives individuals to socialize, the interactions in social groups, the team work factors and an introduction to computer supported collaborative work (CSCW). CSCW is a branch of HCI which studies the tools and interactions for collaborative work.

2.1 Social groups

When the social groups concept is addressed, the intrinsic understanding tells us that social groups are referred to casual meetings with friends. Also, it can include social gatherings with less known people who share a common interest.

Before getting into the details of the group categories and their needs. It is essential to understand what drives individuals to belong to groups. It is possible to understand the group interactions by studying the different types of relationships and the

individual motivations to interact with each other's. Then it is conceivable to design a technology to support and to facilitate the team work.

2.1.1 Social needs of people

As the HCI field points out, user needs take a crucial role in the users' actions and behavior. Maslow's proposed a theory in the early 50's where he categorized the user's needs into five stages pyramid [29]. He stated in the theory, the lower parts of the pyramid are the needs which the individual will try to fulfil before moving to the next level. Only the need for grouping and belonging will be discussed more in details later in the thesis.

According to Maslow, the biological and physiological needs are the first priority for an individual. Then, the safety needs comes next in order to motivate the person to look for protection and order. After that, the belonging needs take place which are more related to work, family, friends and romantic relationships. Finally the last two steps are based on esteem needs and self-actualization needs. It shows that the lower stages require some sort of group belonging. Based on history references, there is a clear mention about the necessity of group formation due to the need of food and other natural resources. Furthermore, the safety needs established an important base of society. The individuals behavior and motivation differ among people in higher manner more than the safety or the biological needs which are based on primitive and subconscious decisions.

Shibutani describes the social groups as the social worlds who considered each participant seeks to develop its career,to maintain and to enhance its status[37]. He states that an individual creates its own perspective in consonance with their judgments and experience. Whereas, the others with different perspectives define the same situations differently and thus, reacting selectively to the environment. This perspective is a self-validated point of view of what is perceived about objects, events and human nature This has helped to evaluate the environment and the possibilities. It is a stable vision of his/her world that guides and helps to predict what is plausible.

Following the model which Shibutani described. People who share a conventional understanding as premises of action, have a shared perspective which can be define as a culture. Culture is a dynamic process that evolves every day with the renew of its norms by social interaction. These social interactions refer to the exchange and support of its members perspectives by responding to what others expect. Current society stands its base on common perspectives which are fulfill through the

communication.

Modern life has brought multitude of communication channels that overpass the geographical limitations, allow people to interact and communicate in real time and over the distance. Hence, people have the ability to participate in several social groups simultaneously. The individuals' unique perspective combines a large number of unrelated activities with different degrees of participation which form a social world. In order to evaluate how a person behaves, it is required to study the person unique perspective in combination with its social worlds. This perspective does not define how the person will socialize, whereas it defines the person needs for participating in social groups.

2.1.2 Socialization

When interacting with people, the socialization is the joint of experiences. The act of socialize depends on the others. Shibutani [37] categorized two types of interactions, the first type is the primary relations and the second type is emerged from the cultivation of abilities, values and outlook. Primary groups are usually long lasting and contains people who have more influence on the individuals personality.

Hamilton conducted a study to categorize groups in different clusters according to the relationships and interactions with others[23]. As a result, he identified 4 types of groups presented below:

- Intimacy groups: usually consisting on families, friends, romantic relationships.
- Task groups: including groups formed at work
- Social categories: related to culture, gender or similar aspects
- Loose associations: similar hobbies, communities or people that face a common situation

According to Hamilton study, the groups showed different levels of entity and patterns of attributes (e.g., degree of interaction among members, shared goals and outcomes, duration of the group, group size, permeability of group membership). Although family and friends appear in the same group, it is good to clarify that not all relatives or friends belong to the intimacy group. Friends can include different degrees of friendship such as closer friends, friends who share only few common interests or temporary friends.

Moreover, the group formation has several phases, starting from the creation, continuation and termination which varies and depends on the type of the group. Intimacy groups are more lasting and the continuation of the relationship usually falls on the family cohesion and level of friendship. The main objective of this thesis is to focus on the interaction of the people within different group relationships (friends, coworkers or strangers) as well as facing collaborative and competitive tasks.

Znaniecki[31] states that the collective action within a group refers to a consequence of individual actions. An individual action is based on a subjective attitude and an objective social value. Whereas, the social group action is an integration of an ideological model of attitudes and social value. Based on Znaniecki opinion, a social relations can be asymmetrical, where some partners influence more than others.

Interaction between unfamiliar people is frequently a product of task oriented teams or circumstances where people face common situations. This cooperation may demand a common goal or additional motivation in order to be achieved. Svensson defines elements such as shyness, insecurity or isolation as factors that cause the absence of interaction. While, the existence of the interaction is usually forced by external factors where people must put an additional effort to keep the communication alive[40].

Nevertheless, groups among strangers can also be formed intentionally. For example, joining a sport club, a party, shared project or similar hobbies. Some groups can show a higher motivation as individuals choose to join intentionally. However others are done to overcome a situation.

Personal traits like shyness, fearless, laziness and other elements such as lack of trust or common ground, environment, cultural differences, can affect on the group formation and continuation[4]. Furthermore, non-verbal communication and context take an important role in the direct communication. Therefore, the technology that aims to modify or substitute face to face communication needs to be aware of the implicit communication aspects as well as the context and where they are introduced.

2.1.3 Face-to-face interactions

Face-to-Face (F2F) collaboration refers to the type of interaction which is carried out without any mediating technology. In this collaboration, the participants can interact in the same location and with the ability of see each other's. Moreover, the Face-to-Face communication could be verbal and non-verbal.

A study made by McGrath, shows a comparison between face-to-face interactions

and written communication system [30]. Face-to-face interactions have more equal distributed participation with a hierarchical status which is less constraint. Moreover, the source of a contribution is always known by the rest of the members in addition to the absence of delays between the input and the consequent feedback. McGrath also pointed out in his study, the larger the group is, the lower probability all member contribute. Further, the stronger the hierarchy is, the lower the contribution of the low status members.

According to McGrath, face-to-face communication contains implicit rules that vary slightly amongst cultures. Furthermore, only one person can be the speaker at one time and this role is shared among group members, though not necessarily in an egalitarian way.

The technology encounter problems when implementing a new communication system. Thus, it must be taken into account the behavior modification when presenting the new technology. Gallagher[11] concluded that groups whose meet by using technology over the distances, form weaker bonds between members support and spend more time initiating and planning their work in comparison with face-to-face groups. The section 2.2.2 explains in detail face-to-face interactions through the use of technology.

2.1.4 Team work

A description of a team work behavior is presented before addressing collaborative work in teams. The aim is to provide an understanding of the elements and phases which compose communication in task oriented interactions.

Due to the increasing complexity of the tasks and the heavy workload, the division of labour takes a basic role in the modern society. Nowadays, most of the organizations conduct large researches to decode and improve the characteristics of managers. Managers and coordinators should promote and motivate others' collaboration while taking an active part. Team work usually fails on keeping the motivation and participation up by all of its members. The role of a good moderator is to keep track of the interaction while assures that all members collaborate actively in the process. The book *Intellectual Teamwork*[12] presents three dimensions to measure group effectiveness:

- Productivity, the cost of adding cooperation and communication lower than the gain obtained by the division of labour.

- The extent to which it provides individual members with social, material or intellectual rewards.
- Ability to sustain itself as a social unit over time.

On the other hand, division of labor brings factors which counteract the productivity, such as cohesion, conformity of individuals within the team and burdens of communication and coordination. The study of group interactions will help to determinate pitfalls on technology that aims to improve and support social interaction and collaborative work. For instance, technologies such as video-conference support richer communication than existing technologies like messaging or voice, but it has failed to substitute physical meetings. Video-conference eliminates the opportunities for informal interaction which might happen when switching to physical meetings. Rich interaction frameworks provide the base to establish a shared understanding of the problem confronting a group or a team. This will offers a groundwork where individuals can develop the consensus needed to carry out complex projects[22].

McGrath[30] categorized the group activities into four stages. First stage is the acceptance, where the project is approved and the goal is set up. Second stage, it involves in choosing the solution, followed by a third stage where the conflicts are overcome. Last stage refers to the execution of the actions to achieve the goal. Based on McGrath analysis, the first and the last stages are common to any project, whereas, the second and third could either occur or not.

There are several studies on analysing team work and the degree on which the cited dimensions affect the interaction.As well as defining new factors that play a role in the development of working relationships[10].

2.2 Computer Supported Collaborative Work

At the beginning, the studies focused on how a single person interacts with the computer and the development of user interfaces which made this interaction more appealing. Many research fields focused on the cognitive load[1], the usability[2], emotions and other aspects that affect the interaction[32].

A new field started to gain attention in the 80's. In 1984, the acrimonious CSCW (Computer Supported Collaborative Work) appeared in a workshop and intended to understand and to support the collaboration through the technology.

[1]http://www.nngroup.com/articles/minimize-cognitive-load/
[2]http://www.nngroup.com/articles/usability-101-introduction-to-usability/

Figure 2.1 *Close up of Hemidactylus NLS system developed by Engelbart. Copyright SRI International. All Rights Reserved*

Despite the limited networks capabilities and the computer constraints. The first collaborative workstations were developed in 1986 [3].

As it can be seen in the figure 2.1, Engelbart in collaboration with Augmentation Research Center (ARC) at the Stanford Research Institute (SRI), developed a hypertext working system (NLS) which allows to sharing screen collaborative, viewing and editing among others features.

At the beginning, CSCW represented any collaborative work which involved in technology. However, the technology has evolved allowing new types of interaction to go beyond what CSCW covers before. Moreover, CSCW is just a label for the community that focuses on collaborative work. Nevertheless, there were many other similar communities which embrace the collaborative work based on technologies under their name, such as EUSSET (European Society For Socially Embedded Technologies) or COOP (Cooperative Systems) among others.

According to The Encyclopedia of Human-Computer Interaction [5], a categorization of collaborative work can be divided in three categories including: communication, sharing information and coordination. The three different behaviours can happen in real-life, where all the users interact at the same time, or in an asynchronous way.

The desired user experience differs in technologies. For example, a communication without lag and avoiding connection problems is highly more important in video

[3]https://www.interaction-design.org/encyclopedia/cscw_computer_supported_cooperative_work.html

conferencing than it is in shared document repositories. Thus, the user needs must be specific for each collaboration technology and the evaluations should be measured in the appropriated context.

In this thesis, the real time interaction is studied with a special interest in co-located environments. This means that users are located in the same space and have a face-to-face interaction. Therefore, the application does not need to worry about users' location or voice communication among others.

2.2.1 Computer Supported Collaboration Learning benefits

Some cases studies cited below refer to Computer Supported Collaboration Learning[4]. The CSCW aims to design and improve collaborative activities in situations where the technology plays a significant role in shaping the nature of the interactions. Whereas, the CSCL is more focused on the study of collaborative learning, mainly in students, and their benefits. The CSCW shifts to the tools that support collaborative works for organizations. However, many studies can be found under the same collaboration of CSCL and CSCW which exports from learning to work and vice-versa.

CSCL studies the interaction and coordination of people from different ages range when they perform a shared task. It investigates on how this interaction happen and the improvement of the learning process. Moreover, the possibility to obtain new and existent cooperation systems which can boost the communication and increase the motivation.

There are a slight difference in the two concepts of cooperative and collaborative work alternatively. Peter Goodyear[33] defines the co-operative learning concept based on situations where a task is divided and each part is dealt independently. Whereas, the collaborative learning concept provides a framework on how to learn from organization and how to participate with others. Jonhson[20] and Hattie[16] concluded based on the final results and the problem solving strategy analysis, that the outcomes of collaborative work are superior than individualistic and competitive learning. Furthermore, Lou[24] points out in his studies that there are more opportunities for each member of a group to interact and participate than being in a small teams. Lou proclaims in his study on the importance of having a good group moderation and thoughtfully design which are the main key factors to support larger groups in collaboration. Not only the outcome or performance of the group

[4]http://www.isls.org/cscl2015/

can be better in collaborative environments but also the individual can be improve the intrinsic values in social interaction such as collaborative knowledge building [33]. The simple use of collaborative tools do not teach the users how to argue and improve the interaction. Collaborative environment usually boost social interaction, when the tools are provided then it will encourage and stimulate individuals' minds [6, 14]

2.2.2 CSCL in synchronous face-to-face environments

The face-to-face interaction and the computer supporter collaborative learning occurs around a piece of technology that supports the interaction of multiple users in the same location such as mobile devices, interactive whiteboards[21] and interactive tabletop devices.[34]

Kershner[21] found in his research, a positive motivation and a joint understanding of the task are fundamental elements of any collaboration. Kershner evaluated the collaborative tasks by using an interactive whiteboard, while Falcao[34] used interactive tabletop devices. Both Kershner and Falcao agreed on the need of making the collaborative tool engaging and exciting. They suggested that situations such as multiple inputs, multiple resources, dependency of physical resources, dynamic feedback, support spontaneity, productive outcomes and shared visual field are recommended[33].

Figure 2.2 *Tabletop concept mapping, tracking individual participation on the tabletop. Visualisations for longitudinal participation, contribution and progress of a collaborative task at the tabletop. Roberto Martinez [28]*

Collaborative work requires a moderator role which motivates and coordinates the others. Wichman et al.[1] described this role as vital and challenging. In learning

environments, students expect moderators to be involved in the discussion while allowing some degree of freedom in the decision making process.

The ARGUNAUT project leaded by De Groot[15] studied the moderator's role in synchronous, graphical e-discussions and developing tools to arbitrate the interaction. Martinez et al.[28] investigated the challenges which could face the facilitators in collaborative work and the necessity to focus on the process instead of the outcome. Tabletops were used to support the interaction and to gather the data of the collaborative process (see Figure 2.2). The research outcomes showed that the moderators should keep on track of the interaction in order to encourage and facilitate the interaction between participants. In Martinez study case, the tool used has recorded a historical log of the interaction which required a further analysis. Therefore, the moderator role takes an important role in face to face collaboration.

Benford et al.[3] demonstrated in the study with children about the use of a collaborative tool which does not imply a collaboration between all the participants. In this study, the children had to compete and work alone instead of sharing the same ideas that will allows to create a joint story. Some of the children made it difficult to the others to interact or even deleted the efforts which had created by the other kids. The game in this thesis evaluated two different modes. First mode, the players can collaborate to create a shared outcome. The second mode which is a competitive mode where players act individually to create an outcome picture.

Benford et al. stated that the cooperation cannot be forced or omitted. Collaboration must be awarded with new features or outcomes which cannot be achieved by single performance. Although he defined this approach "encouraging collaboration" for WISIWYS (What I See Is What You See) systems, where the outcome is common for all participants. In this game, the coordinator and the painters negotiate about the level of collaboration on a common ground as in order to exchange additional information and to achieve the required outcome.

Lundgren et al.[26] provided a framework on how to design and guide new mobile experiences for face-to-face situations. They identified four relational perspectives for designing the complex interplay between: *the social situation in which it takes place, the technology used and the mechanics inscribed, the physical environment and the temporal elements of design.* The most important dimension in developing a game is the technology perspective. Lundgren et at. divided it into four categories: *information symmetry, interaction abilities, information distribution and event triggers.* In the game developed, the players do not have access to all the information. Thus the information is not symmetrical across users. One player has access to the

main picture to be imitated while the rest can only see their own results. The players must overcome this asymmetry with verbal communication in relation to their drawings. Lundgren et at. emphasized on the importance of having the information symmetrized and distributed as a feature of team work which can affects the users act and interaction.

2.3 Summary

It is a built in skill of the intrinsic human values to associate and belong to groups. The motivation which encourages the group to belong to another one are varied. One of the motivation is seeking a protection and looking for leisure. The interaction will diverge from personal contact to distant relationship.

The nature of these interactions have been studied by psychologists since decades. Nonetheless, not all individuals act in the same way, inherent factors define our personality as we interact with others. Personality traits, culture, the type of relationship with others and the outcome or objective of the collaboration could affect the interaction.

The technology has altered the process in which humans interact. By the use of the new communication systems, the land borders limitations disappeared and the communication among strangers or people from different cultures became more common and easier to access.

If the technology wants to reshape and renovate successfully the human interaction, it must understand and adapt to the human behavior as well as adding new factors that enhance communication and facilitate teamwork.

New study fields have emerged to evaluate interactions when people work together using technology. The nature of these interactions can be both learning and task-oriented. However, these studies not only focus on the outcome but also evaluate the interactions arising in the process.

This thesis focuses on developing a game which allows to evaluate small groups face an informal task and a moderator coordinate the work without having all the information shared among all participants. This chapter covers what drives individuals to collaborate, the factors and context that affect to communication. In addition, the importance of technology to be be redefined in order to support cooperative tasks.

3. GAMES

Games cover a broad variety of types. Bernand[39] defined a game as an engaging activity directed towards a specific state, conducted by specific rules. These rules usually restrict the actions to be taken. By contrast with task oriented activities, the means used do not need to be efficient.

Several games had been discovered in many ancient cultures. Most of these games were based on a board where players moved some figures around it. Yet, other physical activities such as "tug of war", where two teams compete pulling a rope to bring the other team certain distance, also fit under the definition of the game. Board games are defined by the use of a board by two or more players. The types of board are varied and may contain tokens or pieces such as dices, cards, stones, or shaped pieces that denote a meaning inside the game.

Archaeological digs have found board games that could have 7000 years old. Yet, it is possible to find similar board games being played nowadays. The irruption of video games and technologic devices like smartphones have changed completely the panorama. Technically, a video game refers to a game played by electronically manipulating images produced by a computer program on a display, but the concept usually aggregates any kind of game that is played through a digital device.

This chapter presents a brief overview of the history of board and video games. Further, the devices used to play and the most influential controllers are described. As the mobile devices are the target devices for the application developed, the subsection 3.1.3 cites the types of games that can be played in mobile and the technologies that support interaction between mobiles. Finally, the chapter covers the social components in the games.

3.1 History of games

The history of video games is relatively short compared with board games which have been discovered in ancient cultures and worldwide. However, their influence is noticeable and some of them have been translated into a digital version. To

illustrate this fact, a fast walk-through in the history of board games and video games is presented.

3.1.1 Board games

It would be very audacious to date the year where board games appeared due to the amount of games discovered in different cultures in a broad range of years.

A case that illustrates this fact is the standard European Chess set and a Japanese Shogi set. Inspecting the sets, it is easy to discover that they have different boards and playing pieces, however one of the pieces in each set features the same unique move (figure 3.1). This might imply the existence of an even older root game from where those two cultures evolved. Another example can be found in decks of playing cards from many different cultures, where all decks of cards are divided into suits and sequences.

(a) A standard European Chess set

(b) A Japanese Shogi set

Figure 3.1 *Games with similar mechanics: chess and shogi*

Senet[1] is a board game with pawns, somewhat resembles chess or checkers.

Tylor[42] was one of the first to have pointed out that games might be used to provide clues about cultural contacts. He suggested that some games may have its origin in Egypt, Northern India or China and were spread as a result of commerce, warfare and exploration. However, it is hard to know if some games reached first one culture and then spread to the neighborhood or vice-versa. Similarities in games such as the ones described previously have led to conclude that many games have a singular origin and were diffused to different cultures over time.

[1] http://www.britishmuseum.org/explore/highlights/highlight_objects/aes/s/senet_game.aspx

3.1.2 Video games

Even if it is a common thinking that video games appeared at the early 70's, the first digital games were conceived around 1950. Condon designed a computer that played the traditional game Nim[2]. Shannon and Turing created the first programs to play chess. In 1952, Douglass created the tic-tac-toe game as part of his research on human-computer interactions[3]. Five years later, the card game "blackjack" went digital. In 1958, an interactive computer game called "tennis for two" is invented, using an oscilloscope and an analogue computer. In the figure 3.2 is shown the oscilloscope used as a display and the input method associated.

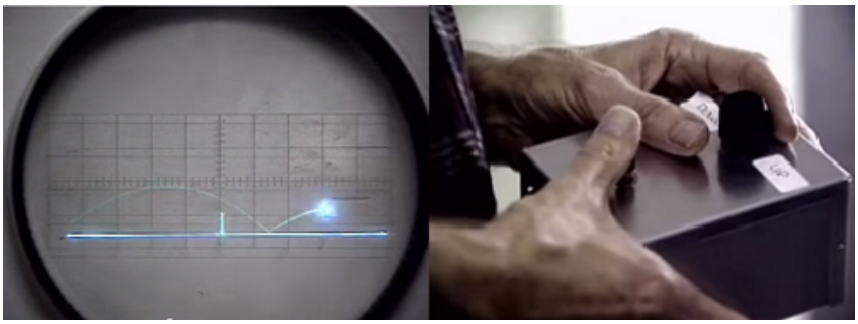

Figure 3.2 *The second ever computer game by Higinbotham using an oscilloscope and an analog computer*[4].

In 1966, Baer conceived the idea of playing a video game on television. Four years later, the home video game system Odyssey was commercialized based on his designs.

Seventeen years later, Atari released the first multi-game home console, the Atari 2600. It features a joystick, interchangeable cartridges, has games in color, and can switch for selecting games and setting difficulty levels.

The following years are marked by a rough competition between companies to prevail its multi-game home consoles. In 1989, the Game Boy, a hand-held console hit successfully the market due to its good gameplay, ease of use, and long battery life. This can be seen as the beginning of personal portable game-based devices.

From 90's until now, there are some remarkable games that have changed the games' industry. Titles such as Mario 64 or Zelda are known by their playfulness and for including 3D perspectives. As well, home consoles like Sega Dreamcast included a modem built-in to allow online play. Close to the end of the 21 century, the Artificial Intelligence of games grew in complexity, making the companies focus on single player modes.

[2]http://en.wikipedia.org/wiki/Nim
[3]http://www.pbs.org/kcts/videogamerevolution/history/timeline_flash.html

In 2006, Nintendo released a new game console with motion-sensitive remote that requires players to do physical movements. This new remote reached a new audience that was not interested in video games before.

Last but not least, the next section treats the apparition and evolution of games in mobile phones. As the application developed uses smartphones, an overview of the possibilities and successful games is described.

3.1.3 Mobile games

During the last years, many games have focused on the mobile phones market. Based on technical specifications, mobile phones are able to run highly elaborate games with high-quality graphics. Contrary to normal phones, smartphones have a high-resolution touchscreen display, WiFi connectivity, web browsing capabilities, and the ability to run sophisticated applications.

The game Snake for Nokia phones in 1997 is considered as the origin of mobile games due to its popularity. It has been estimated that over 400 million copies have been shipped since[5]. This game was originally a single player game but a few years later, a new version of Snake allowed to play a local two-players version using an infra-red connection.

In 1999 WAP broke into the scene, establishing a next step into the mobile gaming evolution. WAP stands for Wireless Application Protocol. It provided a connection to the World Wide Web, but sadly, this protocol wasn't optimized for fast-paced games.

In 2007, Apple offered a phone with an operating system optimized for complex games and highly superior capabilities than its competitors. This new device allowed passing from digital board games to high-resolution real-time games. Therefore, Apple changed the business model for game purchasing. The App Store let customers buy games and other applications directly from the developers.

In October of 2008, Google entered in the market following a similar approach to Apple. The new smartphones offered capabilities such as touchscreens, GPS, fast internet connection, accelerometers and sensors that soon were included in some games. They provided new experiences that could not be achieved by home consoles.

The number of smartphones has increased considerably in the past four years. In 2012, the total number of active smartphones was measured in 1 billion, having

[5]http://www.phonearena.com/news/History-of-mobile-gaming_id17949

grown to almost 2 billion in 2015. Statistics predict that nearly 25% of the world population will own a smartphone at the end of 2016.[6].

3.2 Types of video-games

The evolution of video games have sped up due to the exponential progress that computer science has achieved. However, it can be noticed that many successful games keep their origins in board games. Some games have been literally translated to a digital version, whereas others have taken advantage of technology to provide new features or include artificial players.

Games can be played by one or several persons. The first type is known as single player games and generally, the player competes against some artificial intelligence agents inside the game. It is possible to categorize the second group into two subgroups: the games played by several people at the same location (co-located games) and the games played over the distance.

Some co-located games opt to display several players on shared screen like many sports games (FIFA, NBA, NHL...), whereas others split the screen such as racing and shooting games. Finally, some games for portable game consoles or smartphones provide a single screen for each user.

Nowadays, it is possible to find an online multiplayer mode to play over the Internet in almost every video games. Some games only provide an online version, lacking of single player mode. These games are usually supported by communities of players who interact to meet online and play.

Massively multiplayer online (MMO) games are worth to mention because they give the opportunity of playing with many players in real-time. They create entire virtual universes where the game takes place. The best example is the game World of Warcraft, which reached more than 12 millions of active subscribers in 2012[7]. This game shares some common field with the popular board game, dungeons and dragons[8].

Furthermore, a new type of video games called SNG (Social Network Games) has gained popularity during the last decade. These games are played through online

[6]http://www.emarketer.com/Article/2-Billion-Consumers-Worldwide-Smartphones-by-2016/1011694

[7]http://www.statista.com/statistics/276601/number-of-world-of-warcraft-subscribers-by-quarter/

[8]http://en.wikipedia.org/wiki/Dungeons_%26_Dragons

social networks such as Facebook or Google+. They are mostly implemented via web browsers, however they can also be played from smartphones due to the web cross-platform capabilities. Social network games are amongst the most popular games played in the world, reaching millions of players. These games are usually free to play with add-ins or extra features that can be purchased within the game with real money. SNG usually lack of a declared winner and allow users to play asynchronously.

3.2.1 Video-games on smartphones

According to some studies, smartphones and tablets are going to be the first devices for gamers to make in-app purchases. Juniper projects 64.1 billion downloads of game apps to mobile devices in 2017, compared to the 21 billion downloaded in 2012[9]. It is clear that there is a migration from portable game consoles to tablets and smartphones. The challenge for game developers continues to be how games get discovered on mobile platforms and how to come up with a hit game that will stand out amongst hundreds of thousands of competitors.

Smartphones games have usually relied on interconnectivity through the Internet, according to the capabilities and limitations of the devices though. Their screens are not big enough to host several players on the same device, and they face the problem of intermission of the players' hands on the content displayed. Location-based mobile games, using GPS capabilities, allow to be aware of other player's presence or to interact with the real world. Bluetooth is also commonly used in order to communicate with other smartphones in a close range. With the use of the phone's camera and physical tags, it is possible to increase the realism of the games.

As well, some frameworks such as Wifi-direct or Alljoyn provide an interconnection between devices using the peer to peer (P2P) protocols. The introduction of Wi-Fi Direct protocol on top of the existing wireless technologies has facilitated the use of the P2P communication without any interface router or access point[18].

3.2.2 Asymmetry in games

Firstly, it is needed to define asymmetry. Indeed, many games define asymmetry as the opportunity for some players to distinguish their game from the others'. For example, games such as Age of Empires, Starcraft, Streetfighter or Counter-Strike

[9]http://techcrunch.com/2013/04/25/juniper-games-downloads-forecast/

provide asymmetry as the player can choose different characters / races with different features and / or different objetives[10].

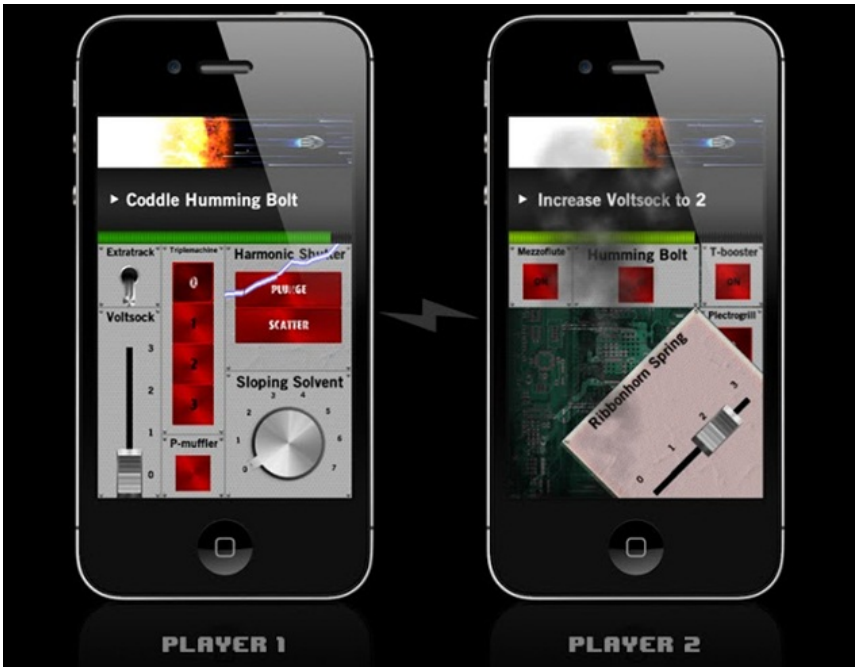

Figure 3.3 *Spaceteam. A cooperative party game providing asymmetry. Players must tell each others which button should be pressed.*

However, the asymmetry provided by the game developed is based on giving different information to the players. This concept is commonly referred as information asymmetry in the economic field. Lundgren[26] et al. state that the information distribution strongly affects how users act and interact. The lack of shared knowledge was already present in many board games that contain cards / tokens with objectives or tasks only known by some of the players, like for example Risk, Pictionary, Scrabble, Poker, etc. According to Stenros et al. [38], *asymmetry in information also creates an asymmetry in power and control*, as the person who lacks information cannot break out of the situation easily.

Games for home consoles in collocated environments can't provide information asymmetry because the game is shown on a common screen for all players. However, the use of several screens allow providing different information to each player. The list of co-located multiplayer games is not very large[11] with only a few titles like Spaceteam[12] (figure 3.3) that tackle the information asymmetry as the main concept to draw player's interest and create an engaging experience.

[10]https://davidgagnon.wordpress.com/2009/08/16/symmetrical-vs-asymmetrical-balance-in-game-design/
[11]http://www.localmultiplayer.com/
[12]http://www.sleepingbeastgames.com/spaceteam/

3.3 Social games and education

Even if board games look old and outdated, they have persisted until now. A board game is a mental and social game. While electronic games are unpredictable, stimulating multiple senses and emphasizing fast feedback, board games focus on the relationships with fellow gamers. Nowadays, it exists a large variety of themes to match with different people's tastes and ages. It is possible to find regular board game meet-ups organized by hobbyists in many places such as community.

Players need to understand the game's rules, and their fellow gamers' style or strategy. They must assess situations, weigh options and decide their strategy. Besides, players can create friendship ties and acquire useful skills in a fun and safe environment. Board games usually require some degree of negotiation with other players while electronic games are more individualistic. Anticipating, problem solving, decision making, creative thinking or strategic thinking are elements easily identifiable on games.

It is believed that video games isolate players from society, avoid social interactions and lead to negative behaviors if the content is violent. However, it is shown that gaming enhances social activity and encourages socialization between the players rather than discouraging it[7]. Altman et al.[41] analyzed multiplayer online games in diverse circumstances and context. They concluded that gaming supplement social interaction and may improve an individual's ability to multitask.

3.3.1 Interpersonal interactions among players

During the past decade, researchers have applied the Technology Acceptance Model (TAM) on individual games to examine the key factors that drive users to play. However, important factors as perceived usefulness and ease-of-use reflect a lower importance on the motivation of on-line games users. An added value of Internet-based games are the interpersonal interactions among game players that create cohesive on-line communities[17, 7].

A case of study that has become highly popular nowadays is the game "Clash of Clans". This game has been evaluated as the most successful game of the past year. The game introduces a good game concept plus a successful business model, which is based on offering a free version with non-free extra features to help get ahead in the game. However, the game has become really popular due to the clans that can be formed inside the game. Joining or forming a clan means to group along other people to fight against other clans and raise in the rankings as a team. Clans are a

really powerful social element, where chatting to clan mates and donating resources raises the feeling of belonging. Once people get into a clan, they are really invested and willing to play for a long time. [13].

MMO games offer the same activities than single player games but add social components. The shared experience, the collaborative nature of most activities and, most importantly, the reward of being socialized into a community of gamers and acquiring a reputation within it represent more motivation and satisfaction for the players. This collaboration and grouping is encouraged by the game. For example, WoW encourages players to form groups using two classic mechanisms. The first one because character classes have specific abilities that complement each other. The second because many quests and enemies in the game are simply too difficult to be tackled alone. In the case of WoW, as in Clash of Clans, players join guilds where most of their important relationships are formed, framing a social experience in the game. Guilds often organize raids and other events requiring planning, which could create a sense of obligation for the members[19, 7].

Location-based video games such as Ingress[14] organize events where many players meet in a common location and exchange virtual game tools. Although these examples belong to remote interaction of many players which differs from the scope of the game developed. They illustrate the arousal of experiences such as grouping, belonging or nurture. In the present case, it is aimed to define the experiences arise during the game-play.

Moreover, games can also be used as an ice-breaking activity. They can help to start a conversation with strangers and get to know them. Malaspachas[27] designed a co-located game for smartphones where players must connect the answers to personal questions with their authors. He observed that the information sharing process was less intimidating or anxious than it was in daily activities were the personal interactions are forced by the situation.

3.3.2 Collaborative learning in games

Online communities are also formed for learning purposes. These online communities of learning (CoLs) provide the opportunity to collaboratively learn regardless of the time and place, using technical media. Yet, personal traits, background and motivation have a heavier influence on how individuals engage in online collaborative activities than in face-to-face tasks[36].

[13] https://gauravonomics.com/clash-of-clans-best-mobile-game/
[14] https://www.ingress.com/

Collaborative activities through the use of technology for learning purposes are easily found in schools or public spaces such as museums. The use of games make activities more engaging and stimulate children to participate while having a reinforcing effect in learning processes[3]. Games can allow simple visualization and simulation of very complex data[21].

The basis of effective cooperation and collaborative learning is the promotive interaction among learners. In a cooperative game environment, the players work together in order to achieve a shared goal. Ezter et al.[8] assert that cooperative games can generate interest in encouraging and assisting others while boosting communication and interaction amongst players.

Maite et al.[13] suggest that cooperative games in schools can be very beneficial for children and teachers. Cooperation through games in schools gives the opportunity of performing edifying activities in a relaxed environment. The children enjoy themselves together with their peers, and the teachers are more aware of the children's emotions and ability to interact. It helps them to increase the knowledge about the different styles of personalities that his/her students have.

3.4 Summary

Although people usually associate games with fun, pleasure and free-time, their impact goes far beyond pure enjoyment. The act of playing and learning are connected in human development from the early years of a childhood. Games can provide information and knowledge while promoting personal development. In particular, the acquisition of social skills and social behavior can be supported by playing.

Games have been found in ancient civilizations. Several versions of a game have been discovered in different countries, sometimes being separated by thousands of kilometers. Nomadic tribes, armies, traders, etc helped to diffuse games.

Nowadays, games have changed substantially with the evolution of computers and the apparition of Internet. They do not require to be played in the same location or time. Game consoles can create high definition graphics, generating richer interactions and engaging more players. Artificial intelligence have reached high levels of complexity.

Portable devices that were used for communication purposes or simple entertainment devices have derived in powerful devices that support high-definition games with global interconnection. These devices are able to use elements such as localization, motion sensors, camera, etc, to be part of the game logic.

Not only games have evolved, but players have formed communities to discuss and gather together due to the global interconnection. Players from different countries can meet virtually and play a game together. The sense of belonging and player's status inside these communities boost the game participation. Besides, many games companies have their profit strategy based on rankings inside the game. In order to reach or maintain a higher status, players are forced to spend money on special elements.

Many studies have proven that games can be used to learn. Games increase motivation in the task done while reinforcing the memorization of actions or game's elements. Games such as Minecraft are used nowadays as a tool to learn a new language or to stimulate creativity[15].

Games are also an effective tool to promote cooperation and collaborative learning. Some games require collaboration among players in order to reach an objective. Even the competition in a game might require cooperation. The goal of a game defines the collaboration while the player's interpersonal skills determine the outcome. Games do not always have a competitive purpose. Ice-breaker or team-work games aim to improve user's social skills and form closer bonds.

[15]http://minecraft.gamepedia.com/Minecraft_in_education

4. IMPLEMENTATION

The concept has been shaped through an iterative process. The current chapter presents a paper prototype along with a storyboard of the first design. New features have taken place while some were excluded in the final design.

The application was conceived as a digital co-located game for personal devices. The main reason to use smartphones was to create a portable game and that could implement information asymmetry. By using several displays, tasks can be divided and information between players hidden.

To design a collaborative game concept several board games such as *Pictionary*[1], *Gestures, Scattergories* or Crosswords were taken as reference. Besides, digital co-located games like *King of the Opera* or *Spaceteam* were tested. Nevertheless, since the first designs, the application's theme has always been focused on a multiplayer drawing game.

The final design concept includes a collaborative and a competitive version. In both modes, one player, called leader or coordinator from now on, must describe a picture to the others. This picture is only known by him/her.

In the collaborative version, the rest of the players, known as painters, must team-up to replicate the leader's picture. Thus, the coordinator must describe the picture and give orders to every painter to avoid overlapping.

On the other hand, the competitive version gives to each painter an own canvas. The leader must only detail the picture without addressing specific orders. A time constraint has been added in both modes to complicate the drawing task.

The development of the application has been done in Java language targeting Android smartphones. The external communication framework "Alljoyn"[2] has been selected for the device inter-connectivity.

In the next sections, it is detailed the iterative process followed when designing and

[1] http://en.wikipedia.org/wiki/Pictionary
[2] https://allseenalliance.org/

implementing the game. Storyboards and low fidelity prototypes made reference to the first concept of the game. Furthermore, the implementation was split into small milestones, in order to get used to the communication framework and tackle the drawing functionality.

4.1 Design

Before defining the game details, it was performed a study of the connectivity technologies for Android devices in co-located environments. Although it exist several options, four were taken into consideration due to their relevance.

- WiFi-direct: The recommended version by the Android community to connect several Android devices without an Internet connection.
- Orchestra.js: A framework developed at the Tampere University of Technology to advertise public methods over the net.
- Peer Device Net: Similar approach to Alljoyn framework but developed by an independent user. Methods are advertised within a wireless network.
- Alljoyn: collaborative open-source software framework that allows to discover and communicate with others' devices.

Alljoyn was selected due to its documentation and growth. The number of companies involved in the project made easier to find on-going projects. Nevertheless, the forum support has not been as good as expected and it is not free from defects. More information about these technologies can be found in the subsection 4.4.2.

While a first version was being tested to verify the intercommunication between devices under the same wireless network, a storyboard was created to clarify the game's objectives and playability. Technical problems arose in wireless networks which do not allow to perform device discovery. This can be specified in the wireless security configuration. Nonetheless, private networks such as home networks or mobile hotspot networks do not suffer the cited problem. Besides, the communication layer does not require an Internet connection as the wireless network is used to communicate the devices and exchange information among them without accessing to the Internet.

4.1.1 Story board of early prototype

It is important to remark that the storyboard described below refers to the first game design, differing from the final implementation. The storyboard was useful to simulate a plausible scene where the game could be played.

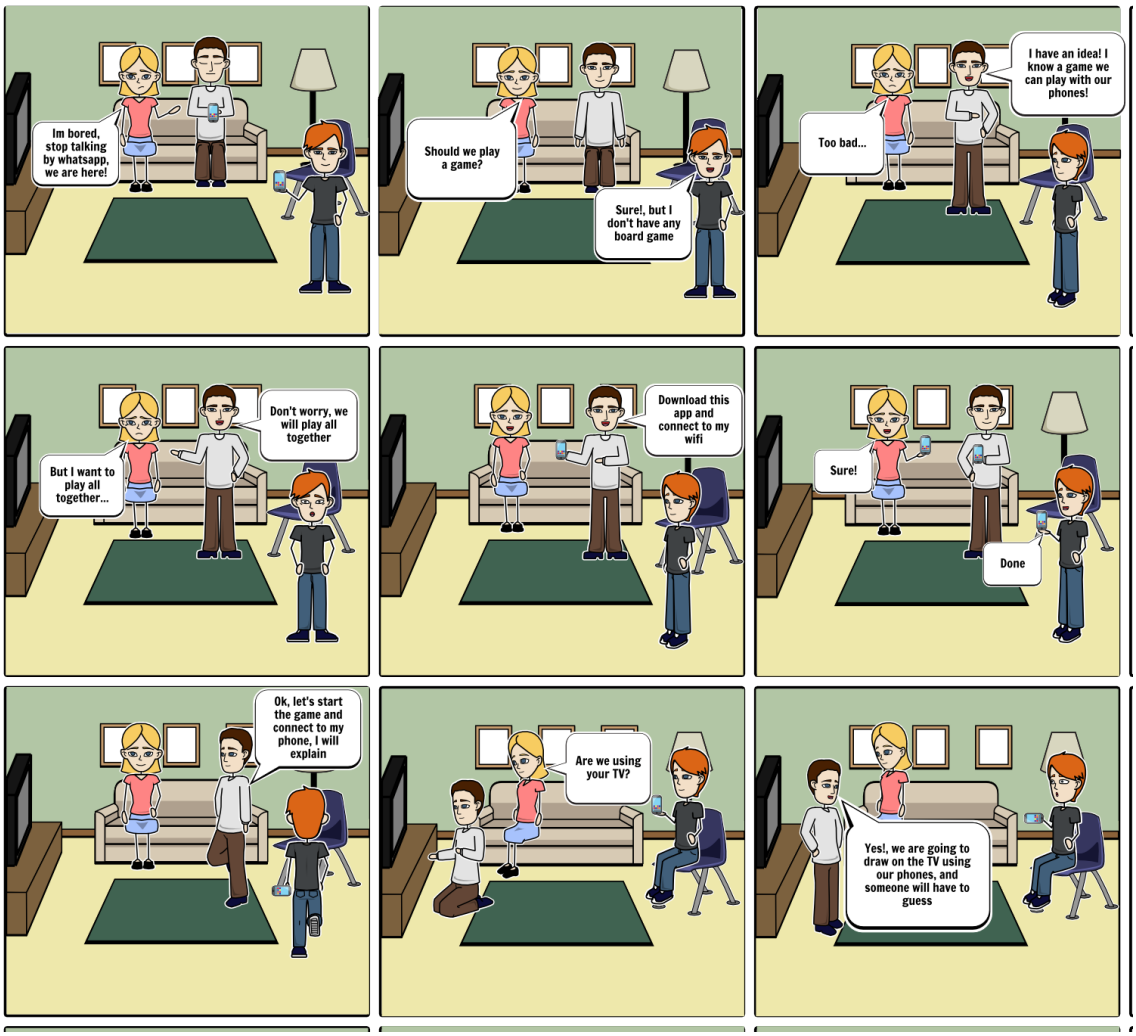

Figure 4.1 *First part of the story board. The picture shows 3 friends that want to play a game at home and how they end up using the Imaginary game.*

The initial idea contained an extra device that showed the outcome picture. In the present case, the device used was a smart-TV. One dedicated device acted as the server of the game and received the players' drawings. The outcome picture had to mirror the outcome picture into the smart-TV. Finally, it was opted to show the drawing in the leader's device which also contains the pattern picture.

The storyboard (figure 4.1 and figure 4.2) illustrates three friends spending their free time at a friend's house. They propose to play some board games. However,

the host does not have many games and he is bored of playing the ones he has. One of the friends proposes to play a digital game that he knows in their smartphones. Yet, the other players are reticent due to mobile games are usually individualistic.

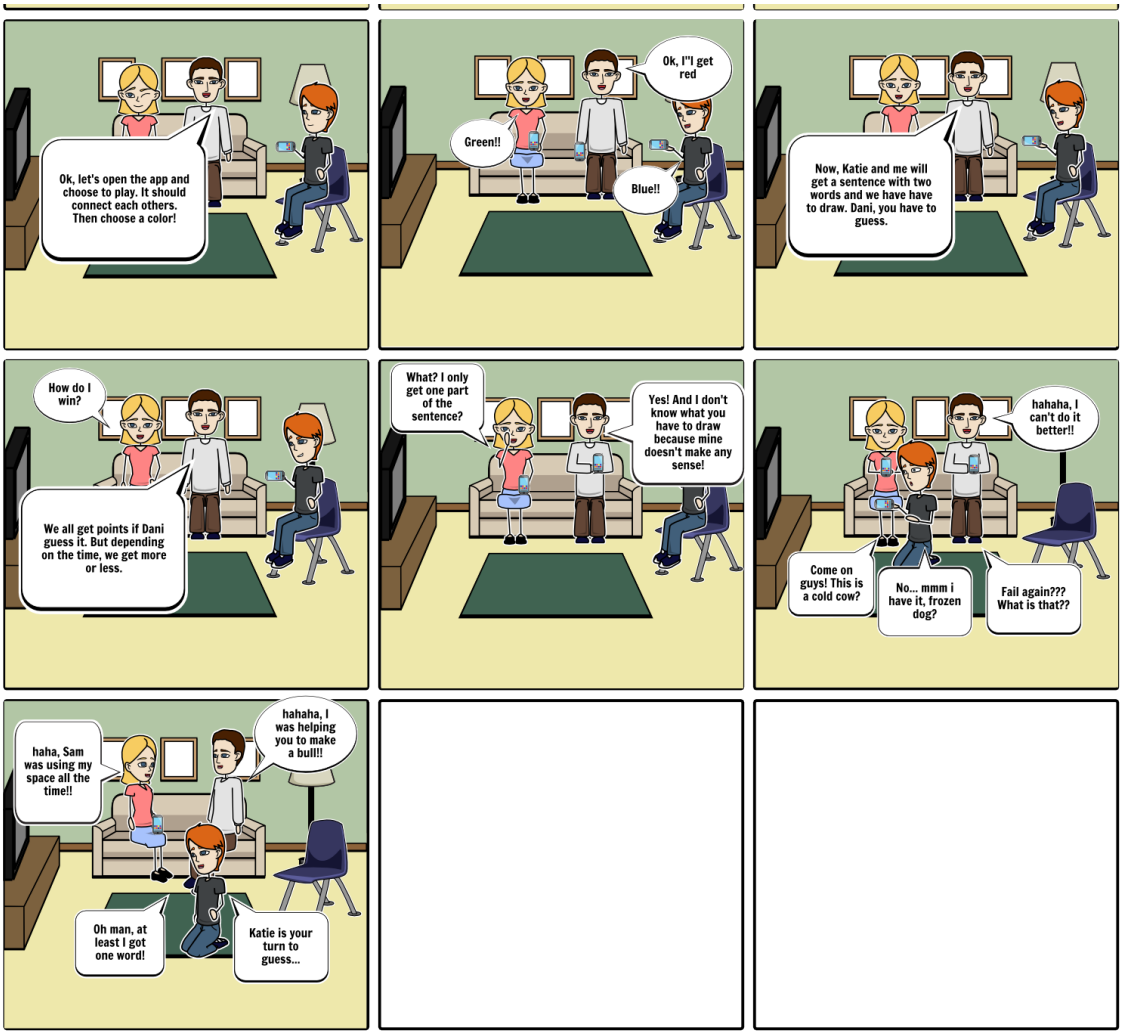

Figure 4.2 *Last part of the story board. The picture shows the three friends playing the game with the use of their smartphones and a smart-TV.*

When one of them explains the mechanisms and the collaboration theme, the game becomes intriguing and they are prone to playing it. One friend has to guess the picture that will appear on a screen (represented as a TV in the storyboard). The rest of players receive a part of a sentence that must be drawn in their personal smartphones.

After setting up the game, two friends receive some words in their phones while a countdown indicates the drawing time. These words form a sentence, like "the cat scratches the sofa". Each player receives a part such as "the cat" or "scratches

the sofa", without knowing what the other player has received. Therefore, none of them knows the complete sentence. The other player receives a sentence with empty spaces that he must try to fill guessing the TV picture. When the time is over or the person has completed the sentence, the drawing roles change.

To increase the asymmetry, the final version does not share the outcome between the players. In the final design, only the person who has to explain the original picture is able to see the outcome in real-time.

4.1.2 Low fidelity prototype of first design

The low fidelity prototype targets the same design as the storyboard is describing. Yet, some screens are shared between the initial prototype and the final version. The prototype helped to remove complex features and to redefine the buttons and layouts. The software *Prototyping on Paper*[3] was used to create an interactive version. However, only the paper screens defined are presented below (figure 4.3 and 4.4).

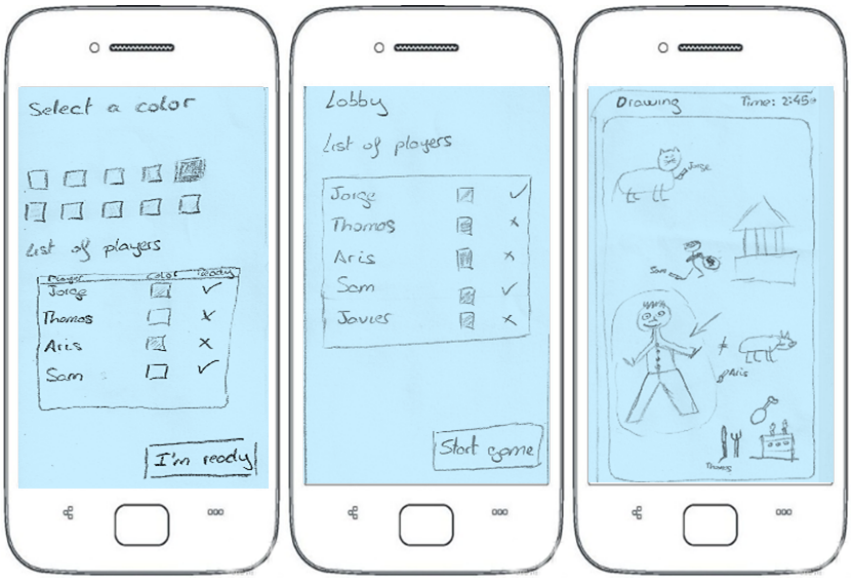

Figure 4.3 *Initial screens of the low fidelity prototype. From left to right: color choosing, lobby screen and collaborative drawing views.*

The game was originally designed in portrait version. Due to the pictures' dimensions, the orientation was changed to landscape in the final implementation. In the initial design, a lobby screen was included to allow players to join the game of their choice. Yet, this functionality required additional developing time and increased the

[3]https://popapp.in/

code complexity. As the game is usually played by small groups of players, the cited feature was not necessary. Therefore, the application connects to the first device that has created a game in the same network.

The color choosing screen (figure 4.3) was aimed to identify the drawings of every user in the final collaborative picture. This screen was developed in the early stages of the development to test the device to device connection. Due to technical problems with the framework, the list of players is shown only in the device that receives the drawings and acts as a server.

Next screens are based on the drawing part (figure 4.4). At this step, there are two different types of screens to identify: the ones used for drawing and the screens for the person who had to guess the picture. The drawing screen was designed with 4 simple buttons in order to make the draw action simple enough. This screen has been improved changing the zoom button with pinch or stretch gestures. Yet, the application must distinguish between moving around the canvas and drawing with the finger.

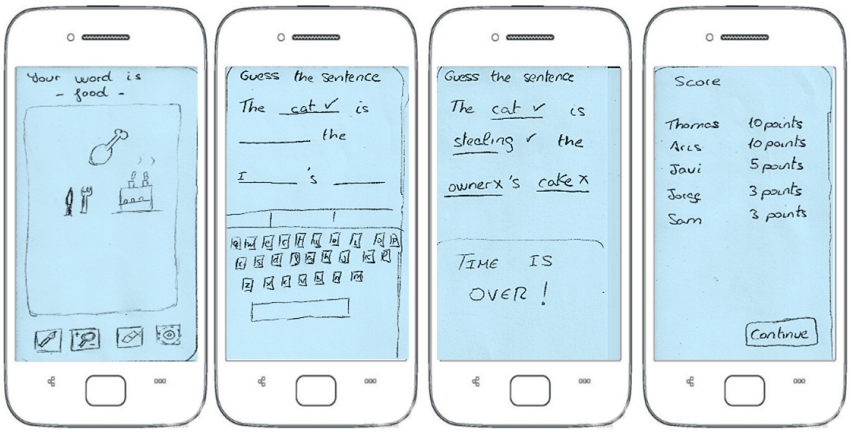

Figure 4.4 *In-game screens of the low fidelity prototype. From left to right: the screen of one of the players (painter), the screen for the person who has to guess (2 views). A post-game score screen.*

The screen for the guessing role has differs totally from the final design as the new goal of the game demands. In this version, the player had a sentence with some gaps that had to fill with the drawings that appear in the common screen.

Evaluations of the low fidelity prototype excluded the lobby screens and redefined the color choosing the view. Besides, the prototype helped to asset the concept of the game and the future tests. Thus, the storyboard and the low fidelity prototype gave the opportunity to look for ideas that could make use of smartphones capabilities.

In the following meetings, a new version of the screens was created. Yet, these screens were already integrated into the application and designed within the Android studio SDK (software development kit). Therefore, they evolved as the application did.

4.2 User Interface

This section covers the current interface with a brief explanation of the main core features. As part of the final design, a new feature was included in the game, yet it was not present in the evaluations. This feature let the players create their own pattern pictures for further use in the game. This option has been included in the main menu as a new button. However, it was created after the user evaluations and it does not affect directly to the game mechanism. Therefore, the present section tackles the UI used in the user study.

The main screen includes two buttons, one to create a game and another to join an already created game (figure 4.5). One of the players should choose the option *create game*.

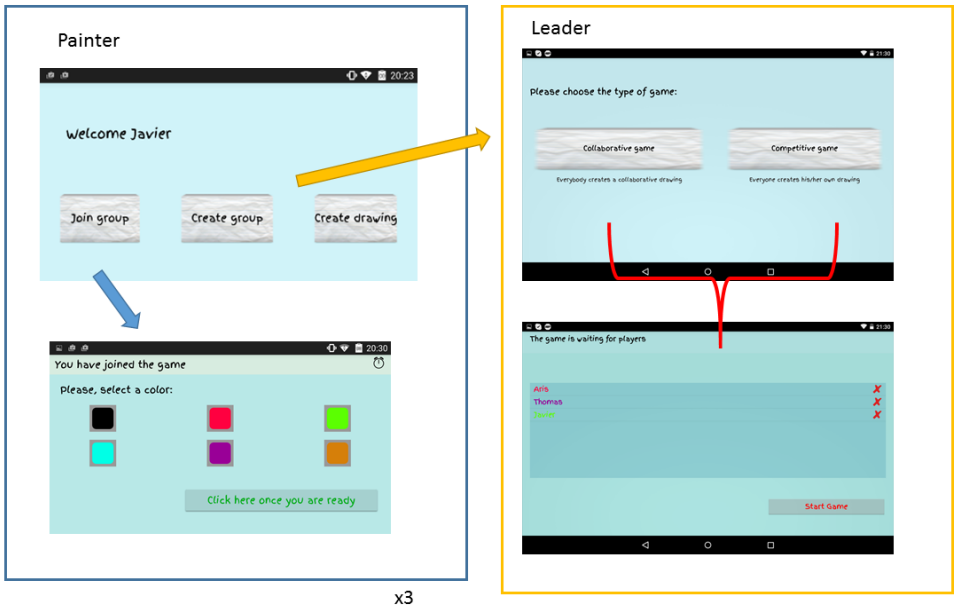

Figure 4.5 *Top left: The main screen. Bottom left: the join screen. Up and bottom right: the screens that the leader will see.*

Once the user choose to create a game, the application shows to new buttons to let him select the type of game to be played: the collaborative or competitive version. After selecting the mode, the device paints a table where the joined players will appear.

The other users who are willing to play should choose *join game* as it is illustrated in the figure 4.6. Once a game in the same network is found, the device shows a color-choosing screen. This screen was developed at the beginning of the development phase to test the Alljoyn communication platform, yet it was maintained as a lobby screen where users could wait for others to join.

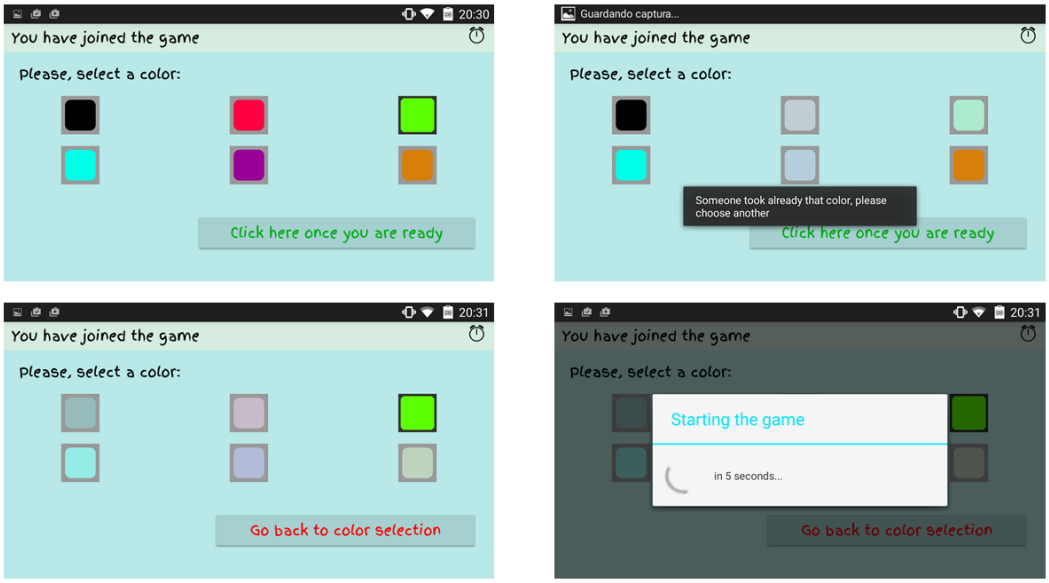

Figure 4.6 *Illustrates all the views that a painter has when choosing a color before starting drawing, including the selection of a color already taken*

If a color has been already selected by another player, the device prompts a pop-up to warn that the color is not available. Besides, the others colors that have been chosen will become deactivated.

Once all the players are ready, the player who hosts the game (server device) can start the game. In this phase, a countdown appears, which is used internally to synchronize all the devices. The player with the server device, known as coordinator / leader role from now on, displays an image that the user must describe to the other players. Besides, this player can swipe right or click on the right arrow to see the pictures of the others' players. This device must be handed through the players in order to rotate the leader role.

The other players, known as painters in accordance with their role, receive a canvas where they can draw using the touch-screen capacities of their devices (figure 4.7). By default, any line that they do with their fingers appears in the color previously selected. As well, these drawings are sent to the coordinator device. The painters can move around the canvas using zooming and dragging gestures on the screen. As

the devices can have different screen sizes, the canvas might be bigger than what the user sees. This capability allows players to paint in a specific part of the picture, avoiding doing big lines that overlap others' drawings.

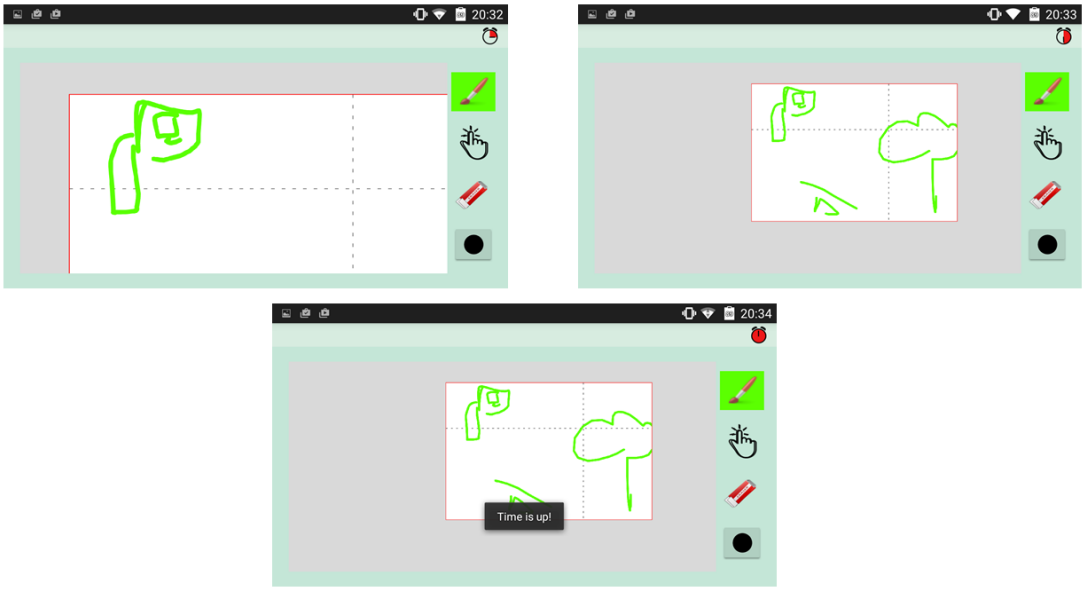

Figure 4.7 *Captions of the drawing process.*

The erase mode is represented by an eraser icon. Clicking on it, the user's finger becomes an eraser, simulating the gestures of erasing with a real eraser. The last button gives the chance to select different stroke sizes, in order to create lines with a different density that facilitates the drawing.

A countdown represented by a clock is attached on the top right. This clock changes gradually its color to red to indicate the end of the drawing time. The same functionality is presented in the coordinator screen, whereas in this case the time is represented by minutes and seconds in order to provide more accurate information. Once the time is over, the view is blocked and the player touches are no longer recorded. The figure 4.7 shows a picture in different phases, such as a zoomed canvas and a time-out pop-up.

The painters view is common for both modes (collaborative and competitive). However, the coordinator screen slightly changes for each mode. Both modes share a view where the pattern image is shown, yet the views that appear when the player swipes to the right change.

The collaborative mode contains a view which is the combination of all the drawings from the other players. In the competitive mode, the coordinator player can swipe to

the right as many times as players are. A screen for each player is shown containing his or her drawings in real time. Swiping to the left or right, or by the use of the arrow buttons, the coordinator can change between all the views as it is shown in the figure 4.8.

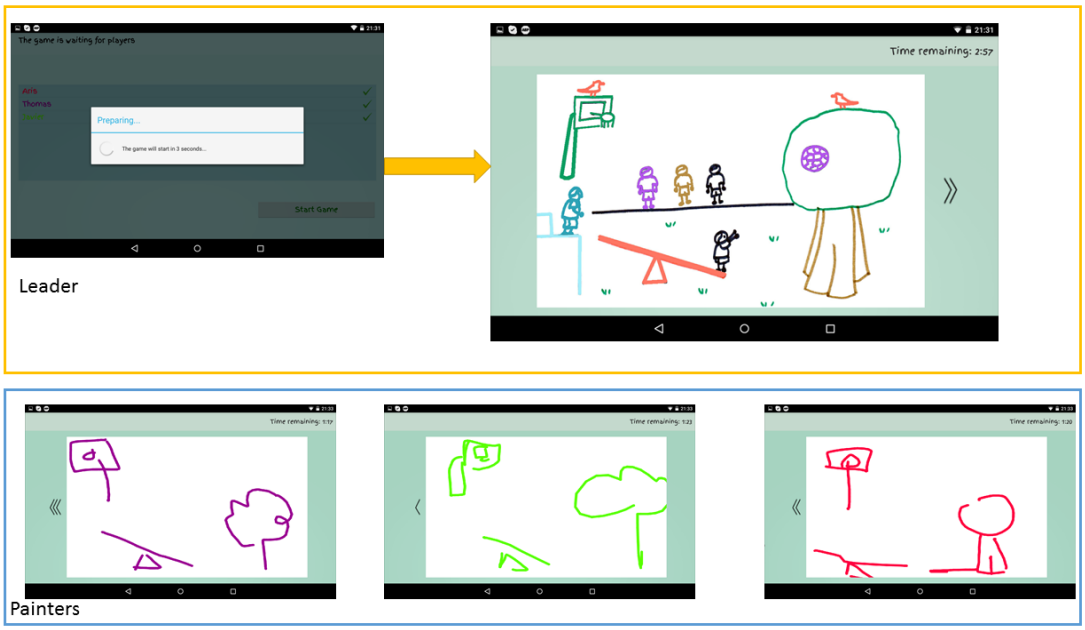

Figure 4.8 *The top images shows what the leader can see while the bottom ones represent every picture that each painter did.*

Finally, a pop-up tells the player to show the original pattern image and painters' drawings when the time is over. Once the players have seen and discussed the drawings, a "next" button allows playing again with a new image.

4.3 Playing the game

Although the game mechanism is simple and can be easily followed by the description of the screens, this section describes briefly the steps that players should do to play the game.

The game can be played up to 6 players, although 4-5 is the recommended number. The connection could support more players but due to screen limitations and the difficulty in coordinating all players, the game has been limited to 6. However, this limitation could be easily removed by adding more colors to the color picking screen.

Once the group of players is formed and the application is installed, the devices must connect to the same wireless network. Some networks cannot be used to play due

to their device discovery limitations. However, in case that the devices cannot find each other's, a wireless network could be created with the use of any smartphone or tablet with or without Internet access. The problem described is being analysed by the Allseen community that supports the Alljoyn framework.

Once all the players are connected, they must decide which device is used to create the game. Any device can be selected for this purpose, yet it is recommended to use a device with good performance. A big screen is also desired as it is the device that contains all the common pictures.

One device creates the game and selects the type of game to play (Collaborative or Competitive) while the others must join. If the connection is successful, the players can choose a color and then mark himself as ready.

Once the game starts, the leader receives a picture that must describe to the others. This picture is only known by him or her. This picture contains different colors but it is not expected to match them, yet it is up to the leader to do so.

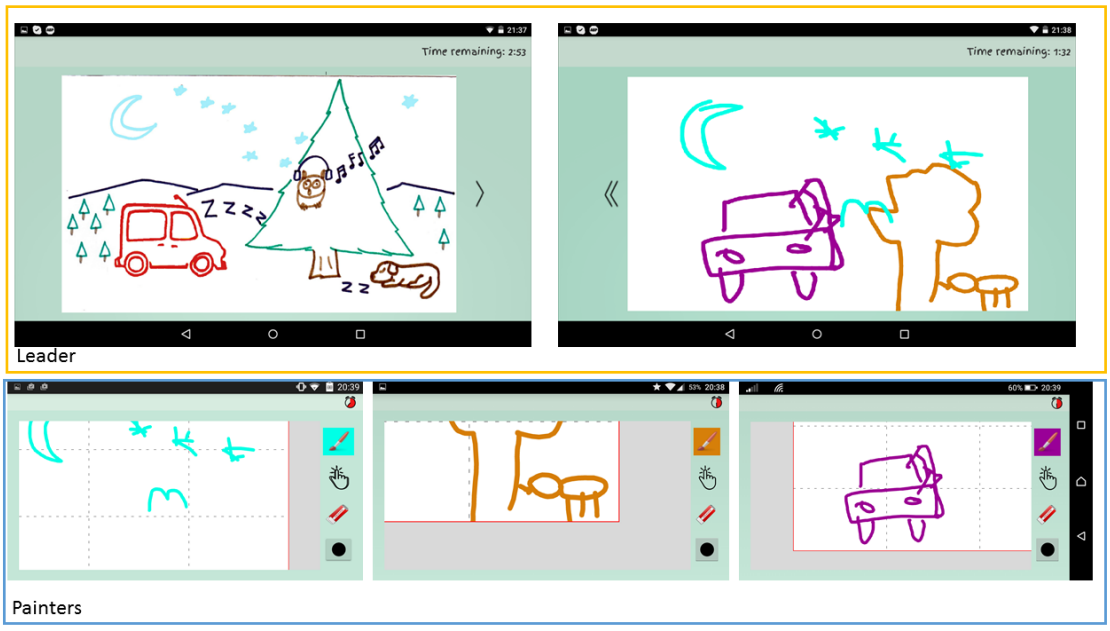

Figure 4.9 *The top images shows what the leader can see while the bottom ones represent the painters drawings.*

The rest of the players receives a view where they can paint with their fingers. Moreover, they can move the canvas, and erase. The asymmetry in this game comes defined by the lack of knowledge in other players' actions. Players do not see on their screen what the others are doing. By default, the screen presents a small grid dividing the screen into 9 parts to give hints about the own location but they have

access to the entire canvas.

The leader can see the others' pictures in real time swiping between the screens. This characteristic allows them to receive instant feedback about their description. In the competitive mode, the other players or painters do not share a common canvas. It creates as many final versions of the pattern picture as painters are. On the other hand, the collaborative mode (figure 4.9) shares a canvas for all the painters. Therefore, players can paint and erase over others' drawing. It is leader decision to describe the picture in any way or using any strategy.

Players can show the screens to the others, but the person with the pattern picture should keep it in secret. There is not written rules that dictate what others can or cannot see, but showing the pictures to the others usually reduces the asymmetry.

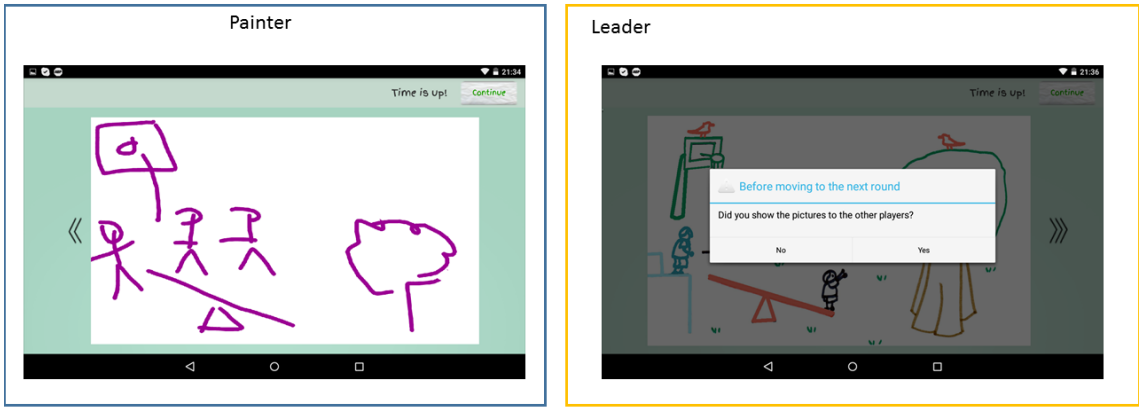

Figure 4.10 *The picture in the left shows a painter's outcome, while the image in the right warns the user to show the picture to the others before passing to the next one.*

Once the time is over, the game tells the leader to show the pattern and final picture to the others (4.10. The rest of the players might know or not what the others have been doing, but the final result with all the pictures is only known at the end of the time.

The game last as many rounds as players are. A round is defined by one pattern picture and 3 minutes to describe it. As the host device remains the same, players must pass this device after every round, thus everyone acts as a leader at least once. Once the round is over, the person who host the server device exchanges it with the device of a painter role. Players can play always with the same devices, as every device has a name and a color set up, or play with any other. There is no limitation in which device a player uses as the game does not maintain a user's score.

In the last version of the game, a *create picture* button gives the opportunity to

draw new pictures that can be used within the game. Yet this pictures must be done or sent to the host device.

4.4 Implementation details

This section addresses the implementation, focusing on the framework used and describing the communication between devices from a high level of abstraction.

4.4.1 Android

It was decided to implement the game for Android devices due to previous knowledge in Java coding language. Besides, some Android devices belonging to Human Computer Interaction department could be used in the evaluation process.

The game has been evaluated using Nexus 5 and Samsung Grand X devices, yet any other devices with an Android version over 4.1 are possible candidates. Due to the game's concept, it was pointed out by the participants that drawing with the help of a stylus or using Tablets will make the game easier.

4.4.2 Communication framework

Many frameworks have been evaluated before choosing Alljoyn for the communication protocol. First months of work have been focused on studying, evaluating and testing protocols that connect devices in a closer range of distance. Bluetooth technology was skipped due to its problems with multiple connections. The main technology that has gained popularity last years is Device to device connection (D2D). Yet, there are many implementations to achieve the same result. Android developer guide recommends an own D2D implementation over the core of Android with the use of already established functions and protocols.

This implementation allows connecting several devices without the use of an external network. However, the implementation might be more complex than other technologies and requires to use the device's wireless antennas for it, disabling the access to Internet. Moreover, it is really prone to have interference if other devices are close by. A successful implementation can be found in Malaspachas game[27] where he specifies the advantages and problems that this technology has.

Orchestratorjs is an implementation that allows to publish events to a server and create an internal connection between the devices that subscribe to those events. A

successful case of use can be found on their website [4]. However, real-time games as the present case can suffer lag, and as a result, a worse user experience. Last, two more approaches were found that are based on a similar skeleton.

PeerDeviceNet[5] and Alljoyn[6] communicate the devices through an external network. This network does not require an Internet connection and can be created by another device. However, if a device is used to create an ad-hoc network, it can not be used to play due to hardware limitations.

Alljoyn provides a framework to facilitate the connection between devices. To do this, a service is published with a given name. This name is identifies the connection inside the network. If other service tries to publish another service using the same name, the framework will raise an error. However, this behavior might be changed, letting the new service override the previous one. The other devices that join the network must ask for this name and wait until the connection is successful.

The communication established is bidirectional. The server device creates the game and publishes the service. It is able to communicate and receive information from the other devices connected, from now referred as clients. Nonetheless, this communication does not work in the same way for both directions. The clients can send direct messages to the server using some functions defined in an interface class. The clients use these functions to send the data to the server, and this one handles them accordingly.

The reverse communication (between the server to the clients) is done by signals. Clients subscribe to signals, which can be raised at any time. The server specifies the actions to take when they are captured. Yet, this communication did not work as expected, forcing to find an alternative. This bug has been reported to Alljoyn forum but due to the lack of responses, a new approach was developed as the final solution. Therefore, when clients should wait for a server event, for example when they are waiting for the game to start, they ask frequently if the game is ready to start. Once this event is ready to happen, the server sends a countdown to the clients in order to synchronize all of them. This solution increased the complexity of the game but allowed to communicate bidirectionally without dropping features. However, the device acting as a server should remain static. As a consequence, the server role (also known as leader role) cannot rotate to the other devices and forces the players to pass the server device.

[4] http://orchestratorjs.org/#/
[5] http://www.peerdevicenet.net/index.html
[6] https://allseenalliance.org/

It is important to point out that the communication tasks have been disconnected from the user interface processing. This fact has been done using two different tasks within the same application. The communication part is focused on sending and receiving information while pushing the data received to the user interface. The UI processing is in charge of painting the screen and record the user interaction. Creating two tasks is possible to avoid lags and refreshing problems because the user interface is not blocked waiting for the communication channel.

4.4.3 Drawing implementation

The user interface captures the touch events and sends them to the communication thread. If the network does not suffer connection problems, the events are received, processed and displayed in the server device without any visible lag.

Another reason that causes lag in the server's UI can be the lack of processing speed. If the device is busy with second plane activities, the UI processing can paint the points slower than the communication part receives them. However, as the input is based on human actions, the devices are able to send and process the human input faster than the player draws. Yet, the number of players increases the information to process. Therefore, it is a good practice to use the most powerful device as the device that hosts the game.

One of the biggest challenges that the drawing part faces is the possibility to zoom and drag the canvas without losing the real coordinates. As it is not a feasible implementation to send the complete picture every time that the player draws a line, the human touches are processed as they are done. Small lines are sent to the canvas as coordinates, requiring to keep the real distance from the (0,0) point.

When the user moves the canvas or zooms in or out, a scale function is applied to the canvas. Thus, the coordinate points returned for a touch event are not the the same coordinates in the original canvas. It becomes vital task to keep the scale and offset operations to obtain the real coordinates if differences between the painters' screen and the collaborative picture wants to be avoided. Besides, a pre-scaled to fit the canvas into the device screen is required at the beginning of the game.

4.5 Software architecture

This section presents four different figures that describe the structure of the application. On them, it is possible to identify the main classes and their relationship. In order to understand the structure and avoid complexity, the pictures paint

the connections from a high level of abstraction. If a more detailed description of the implementation is required by the reader, the source code is available in GitHub (`https://github.com/JavierT/SocioDraw.git`) with descriptions of every method and function.

An activity is a Java class that inherits methods and functionality to run on an Android device. An activity can have associated an XML file [7] with the user interface elements. Fragments are classes designed to take control of the user interface elements. They require an XML file to define the elements and structure. The main advantage of using Fragments is the abstraction on UI tasks from the main activity. Thus, the main activity can remain intact and exchange fragments as the user changes screens in the application.

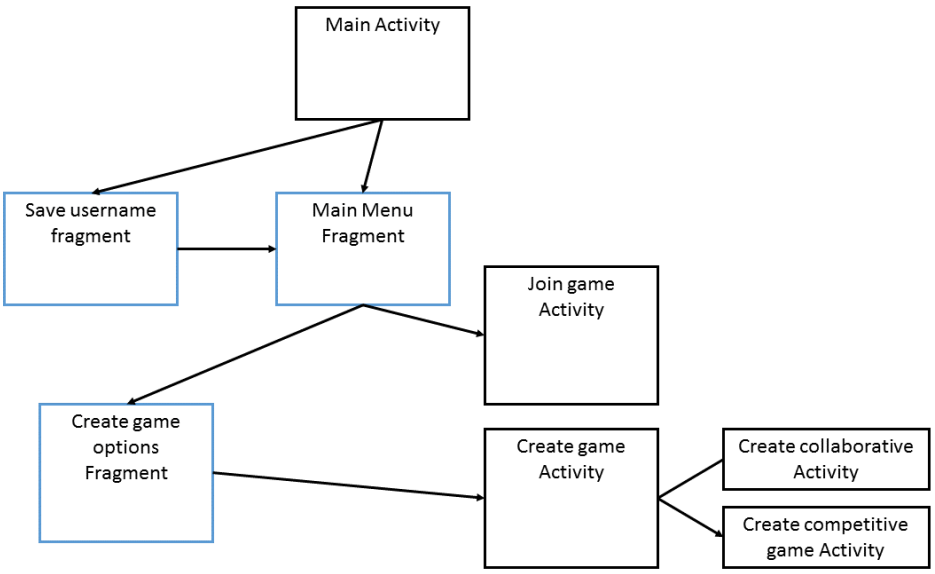

Figure 4.11 *"Main" activity flowchart*

Other elements represented in the pictures are Threads. Threads are pieces of code that execute asynchronously. Therefore, the main thread defined in the activity can continue executing code in parallel. Threads add extra complexity to the application because they require a specific method to communicate between them. However, they are highly recommended to separate heavy process that has to be constantly sending and reading data. In this case, two threads have been used. One for the communication tasks and another for the user interface processing.

The picture 4.11 shows three fragments and two activities. One fragment called

[7] http://developer.android.com/guide/topics/ui/declaring-layout.html

Save username is shown the first time the user enters in the application to save the name into the application database. Once the user enters his name or the next time he opens the application, the *main menu* fragment appears. Depending on the action chose, create or join a game, the activity shifts to the *create game* fragment or changes the activity to the *Join activity*. If the player creates a new game, it is needed to open an extra fragment to let the user choose between a collaborative and a competitive game.

The *Create activity* does not exist as such, whereas the create game actions are defined in two different activities. These two activities (create collaborative and create competitive) share some common code, but it was chosen to create two different ones because they will never be executed at the same time. Furthermore, the complexity of creating one single activity with both functionalities exceed the duplicity of code.

As explained, two threads take care of the user interface and communication tasks. The communication between them is done through the use of Handlers that send and receive messages in a queue for each thread. The thread reads the queued messages as soon as it finishes the previous task.

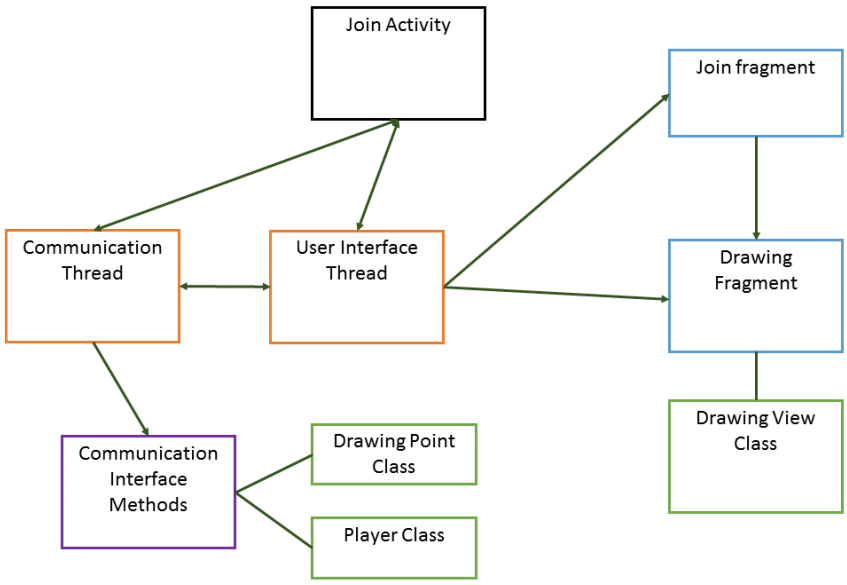

Figure 4.12 *"Join" activity flowchart*

The figure 4.12 presents the joining process. The *Join activity* is in charge of defining and processing the application actions such as the end of the game, initiating the threads or changing the fragments of the user interface.

By definition of the Alljoyn framework, the communication protocol must implement

an interface to share methods between the server and the clients. This interface is illustrated by the communication interface framework and contains the methods *"newPlayerConnected, getLobbyStatus,setPlayerStatus, setPlayerColor, setDisconnect, sendPoint"*. As it can be seen by the name of the methods, the painters, who execute the join activity, called these methods in order to send or retrieve information from the server. Two classes have been defined to act as a container of the exchanged information: (*DrawingPoint* and *Player*).

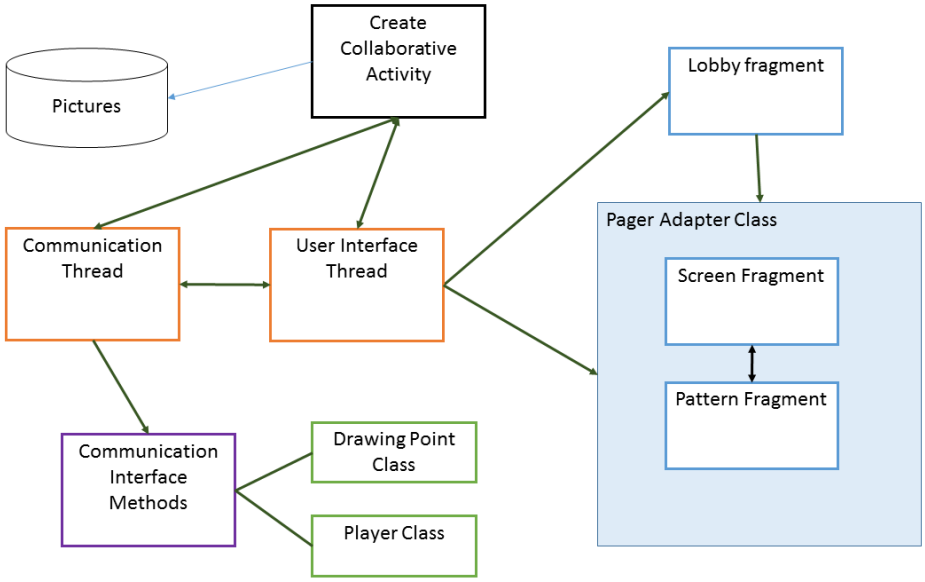

Figure 4.13 *Server device structure for the collaborative mode*

Create collaborative game (figure 4.13) has similar structure than the *Join activity*. It also uses threads in charge of the UI and the communication protocol. In this case, the communication thread receives the messages from the clients, performing the consequent actions and returning the data if needed. Performing the actions includes sending drawings to the user interface thread. It is important to notice that several clients might be sending points, so the communication thread must be free to push the data to the interface while keeping receiving data. As well, the server returns a flag to tell the clients if the time is gone. The user interface has also changed as it allows to swipe left and right to see different drawings. This is done by a *Pager Adaptor* class that keeps the drawing screen alive. If this screen was destroyed by the Android system, the drawings would be lost.

By difference with the Collaborative activity, the competitive activity (figure 4.14) must hold several screens that contain the drawings of each painter. As it was previosly commented, this is a task of the user interface thread by the use of the

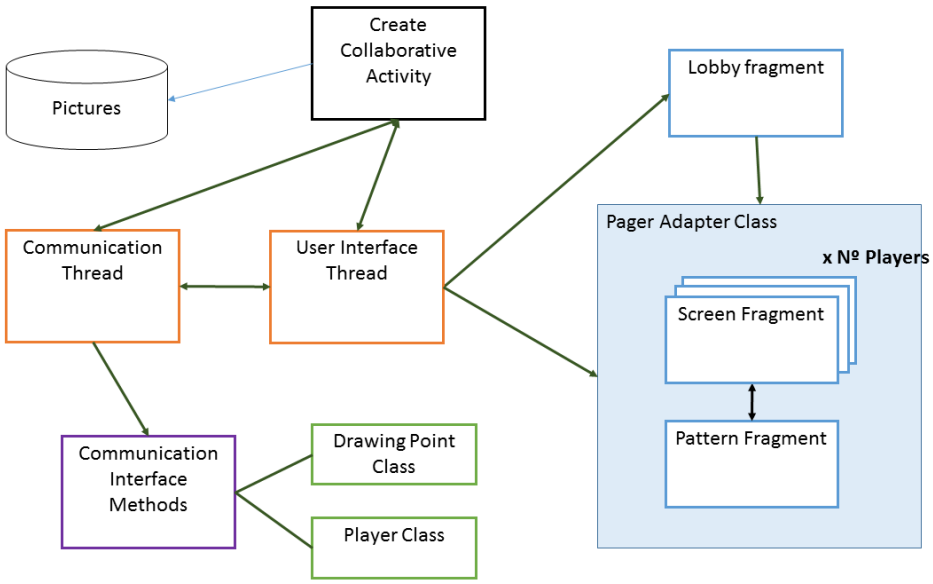

Figure 4.14 *Similar to collaborative mode in the processing structure but presenting major differences in the user interface fragments.*

pager-adaptor class. However, the create activity have some modifications to keep track of the identity of every screen.

As it appears in the picture but it has not been commented previously, the *create activities* consult the database to select the pictures. This database works with a specific folder on the Android device and a class *Pictures* which avoids repetitions.

4.6 Testing and research

Some testing has been done during the implementation phase in order to verify the correct behavior of the application. To test the concept and help to understand the future evaluations, a storyboard was designed. This resource was crucial to explain the concept and reach a common ground between the student, the assistant and the examiner.

Several applications and examples were downloaded and tested from the technologies that support the inter-connectivity between devices. The comparison of those technologies helped to determine the most convenient one for the game's purposes.

Furthermore, the game concept changed during the implementation to focus on the research questions. To find the best concept, several multi-player games for co-located environments were tested. Some drawing applications were checked as well

to avoid replicating an existing game.

Finally, a pre-evaluation was done with co-workers to find possible bugs, discover points of confusion in the user interface.

5. USER STUDY

In order to analyse the user behavior and interaction when playing the game, a user study was conducted by 6 groups and a pilot test. Each group consisted of 4 or 5 players. Event though the game supports up to 6 players, it was detected through the pilot and first tests that the recommended number of players is from 4 to 5. A larger group might have periods of time with inactive players and increases the level of complexity of the coordinate task. A lower number of players makes the drawing task too difficult for the given time and decreases the uncertainty.

Users were asked to fill out a questionnaire composed of 8 questions to get the relevant background in games and teamwork experiences. Both versions of the game were played, rotating the order between groups. After each round, players were asked to complete a form, in order to evaluate their playfulness and overall experience. The Same form was handed again after the second round. In this case, players had to evaluate their emotions with a different pen colour. Finally, a discussion time was opened, encouraging the participants to share their opinions, compare game modes, strategies, and related experiences.

All the sessions were video and audio recorded for further processing.

5.1 Study objectives

The purpose of the user study is to evaluate the effectiveness of the game to boost social interaction in co-located environment with the use of technology.

Besides measuring the social interaction and the easiness to start and maintain a conversation, it is interesting to see how the composition of the group and different person's behaviors affect the outcome.

Moreover, playing both version of the game, competitive and collaborative, gives the opportunity to observe how players divide and coordinate the task among others and the degree of comfort when doing it.

Each player is free to take his/her own actions and strategies, yet it is up to the

group to facilitate and agree to them. Passing the leader role allows evaluating the user's feelings and the group's acceptance for each player within the team.

5.2 Recruitment procedure and participants

The user study was published through the university network and the department contacts, in order to reach people with different backgrounds. Students of different nationalities and people with human-computer interaction background were contacted through these channels. In order to find a large number of participants, several time slots were opened providing users with an ability to select the most suitable time. The website *WhenIsGood*[1] was chosen due to its easiness to select several slots and its free version. Besides the user study advertisement, a small questionnaire gathered contact details and demographic information[2].

Thanks to the number of participants registered, it was possible to bring together people of different backgrounds and nationalities. Yet, the average age was 26 years old, being similar in all groups. Moreover, all participants were familiar with technologies, being able to use smartphones without problems. As a token of a gratitude, a free movie ticket was offered to each participant.

Even if the game demands drawing skills, it was not a requirement for participation in the study. The advertisement through the department mail list and the university portal described the game as *a new concept where you can draw pictures collaboratively with your mobile device and test your teamwork skills. However, no particular drawing skills are needed.* As well, the text used did not describe the game, in order to keep uncertainty, avoid game advantages and receive an honest and objective feedback. It was important that none of the participants knew the pictures to be used.

After one week's time, 56 volunteers filled the form to participate in the study. However, the maximum number of participants was reduced to 30 due to time preferences. Six sessions were conducted with groups of 4 to 5 participants. Every session was organized taking into account the demographic data in order to have people of different nationalities in every group. Yet, due to time limitations, some nationalities were predominant. The user studies were conducted in English and due to the variety of nationalities, the language used by the participants during the game was English. Detailed information is presented in the table **??**.

[1] http://whenisgood.net/imaginary
[2] http://thesis.javiertresaco.com

Session	Age range	Nationalities	Male / Female
1	22-29 (25)	Russian, Spanish, Canadian, Cameroonian	2/2
2	21-37 (27)	Indian, Finnish, Italian, Spanish, French	2/3
3	22-29 (25)	Iran, Finnish, Indian	2/2
4	23-29 (25)	Jordanian, Indian, Bangladeshi, Slovak	2/3
5	23-32 (26)	Pakistani, Indonesian, Hungarian, Italian	0/4
6	26-29 (27)	Pakistani, Iranian, Indian	0/4

Table 5.1 *The main characteristics of each group of participants of the user study*

It was preferable for all the participants to be strangers to each other, however, it was not possible to detect the degree of familiarity with the recruiting process. The background questionnaire tackled the relationship between them, having only one exceptional case were a participant described another as a friend. Others described the rest of participants as strangers or as people who had participated in common activities such as lectures or events.

5.3 Methods and procedures

The user study took place in a quiet and cozy room inside the University campus. The room facilities helped to create a more relaxed ambient where participants could express more freely and without the pressure of being part of a user study. The figure 5.1 illustrate the distribution in a semi-circle to boost the interaction and visual contact. The organizer was present during the whole experiment in order to solve doubts or questions.

The user study was divided into 5 phases. Firstly, the organizer explained the user study and handed out the background questionnaire to the participants. Next, the organizer and creator of the game explained the game mechanism to the users, letting them draw and presenting the interface, modes, and rules. Thirdly, a first round was played in competitive or collaborative mode. After playing, a questionnaire to evaluate emotions and playfulness was filled. Once the form was completed, the participants played again in the other mode. The same questionnaire was given out again where the participants marked with different colors the emotions aroused in the last round. To conclude the study, an open discussion encouraged the users to express their opinions about the project's concept and their feelings when playing it.

Each playing mode took around 20-25 minutes and the open discussion lasted around 15 to 20 minutes. The total length of the session was on average 75 minutes.

Figure 5.1 *Participants of the pilot session, playing the collaborative mode.*

5.3.1 Background questionnaire

The background questionnaire was handed to every participant at the beginning of the session. The questions were related to social relationships and technical background. The questionnaire started with a question related to their current emotional state, in order to know if they feel relaxed, anxious or excited. States like anxiety affect the result of the game and the relationship with others, thus, it is important to take them into consideration.

Seven questions within the Likert[3] scale from 1 to 7, being 1 strong disagreement and 7 fully agreement were included to focus on personal background details, such as *"I consider myself an active person, I like to play boardgames, I am positive towards applying technology to get to know new people"*. Likert scale was convenient to provide quantitative data that do not require long and personal's opinions. The full set of questions can be found in Appendix A.

Usually, questions related to games are focused on board games. Board games are usually played in co-located environments where all players are present and issuing face-to-face interactions, whereas digital or mobile games happen less frequently in co-located environments. It was thought that asking directly about playing digital

[3]http://www.simplypsychology.org/likert-scale.html

games in a face-to-face environment could raise doubts between the participants, affecting the data gathered. Knowing if participants like to play board games gives the possibility to know how they feel about games that require social interaction[2].

The second block of questions aimed to provide information about the frequency of playing games in social platforms and the relationship with other players. These questions are relevant to know if the participants will feel awkward playing with others or on the other hand, they were used to play with strangers. As well, the frequency of playing board games can be related to the degree of comfort when playing new games and level of engagement. A person who does not play games with friends or strangers is more likely to show a lower level of engagement than a person who usually does.

Next two questions explore the participant's feelings when interacting in teams. One is about the degree of participation within a team while the other inquiries about the leader role. As the game forces to take the leader role at least once for every participant, it is desired to know their leadership skills beforehand.

Last questions of the questionnaire talk about the degree of acquaintance with the rest of participants. It was asked to describe their relationships with others in order to know if the later interaction was boosted by friendship relations or limited by the lack of connection.

The table 5.2 shows the data gathered through this questionnaire. Many participants reported a medium level of excitement, having some exceptions who reported a higher level.

Questions concerning to user's feelings were evaluated from a calm state (1) to an excited state (7), whereas skills and auto-self-evaluation of leadership fit into the scale disagree(1) / agree(7) to the question statement. Questions 9,10 and 11 were measured with only 5 options (*1. Less frequently, 2. Weekly, 3. Few times a week, 4. Daily, 5. Several times a day*).

Some of the questions pointing to user's skills or self-evaluations show medium values as predominant (neither agree nor disagree). Usually, the auto-evaluation of a state and skills are harder to answer than other questions, thus, the neutral answers are the most predominant values. It is possible to state that participants were positive towards playing a game in a group due to the values registered in the question 3, 6 and 7. Yet, they could feel anxious as the topic of the game was based on drawing actions and they were self-evaluated with low drawing skills (question 4).

Question	1	2	3	4	5	6	7	Mean	S.D.
1. How do you feel now?	2	1	4	8	7	1	4	4.3	1.9
2. I consider myself as active social person	0	2	2	3	9	6	7	5.2	1.5
3. I like to play board-games	0	2	2	5	5	4	10	5.3	1.7
4. I am skillful in drawing	3	8	6	5	5	0	2	3.3	1.6
5. I consider myself a skilled user of IT	0	2	2	5	9	5	6	5.1	1.5
6. I believe technology can have a positive effect on everyday social life	0	1	2	6	4	10	6	5.3	1.4
7. I am positive towards applying technology to get to know new people	0	3	1	3	9	10	3	5.1	1.4
8. I consider myself as a gamer	2	4	5	7	5	1	3	3.9	1.6
9. Play games through a social platform	25	3	1	0	0	-	-	1.2	0.5
10. Play mobile or board games with your friends	15	8	4	1	1	-	-	1.8	1
11. Play multiplayer games with strangers	21	2	4	0	2	-	-	1.6	1.2
12. How active are you when participating in collaborative work	1	0	2	3	4	14	5	5.4	1.4
13. How do you feel taking the leader role?	0	2	2	6	6	5	8	5.2	1.6
14. Do you know people present in this group?	13	5	6	0	1	1	3	2.5	2

Table 5.2 *Background questionnaire answers. S.D. Standard Deviation*

The section about playing games on social platforms or with friends discovers that many of participants are not familiar with the concept of a social game. The underlying reason for stating that they do not play games is the fact that digital games usually fall into the category of home-console devices, such as Xbox or Play Station, However, many of them said in the open discussion that they have played mobile or web games such as Clash of Clans, Candy Crush, Cross-worded or online Poker between others. Games as Clash of Clans are included in the question 11 while Poker through Facebook could fit onto questions 9 and 10. Presenting some examples in the questionnaire would have helped to clarify and delimit the scope.

The high value representing an active role in the collaborative task for the question 12 can have its correspondence into the fact that the questioners have chosen to participate voluntarily. If the same question runs over a different environment where participation is random, the result could be closer to a middle value (either uncomfortable or comfortable).

Results of question 13, where participants were asked about their feelings when taking the leader role, represents that they feel in control of the situation when giving orders to the others. As it is possible to observe in the video recordings, some people acted more active where others were more reserved. Yet, everybody reported that as the game went on, the environment became more relaxed and the leader role differed from formal situations where their actions have more relevance.

The last question aimed to evaluate the degree of acquaintance between participants. Besides the 1-7 scale, being 1 strangers and 7 close friends, participants wrote extra information in case they knew some of the participants. In all groups, there were always a couple of them who had a closer familiarity than the average. However, it can be stated that the average level of familiarity among them could be estimated as strangers that have run into similar activities such as lectures or activities.

The background questionnaire was answered by each participant individually in order to gather data about their personality that could help to interpret further results and behaviors.

5.3.2 Questionnaire

Once the game was explained and played in one of the modes, the questionnaire described below was handed. The questions refer to feasible experiences they feel during the game plus two open questions to describe the game with tags. Using this approach allowed comparing both play modes (competitive and collaborative) in a numerical scale, providing more detailed information than if the participants were asked to report directly their feelings (i.e. *How did you feel when playing the game?*).

An exact copy of the questionnaire can be found in the Appendix B. The findings concerning to this questionnaire and the post interview are presented in the chapter 6. The selected questions are based on Andres Lucero's article about creating delightful user experiences where he aims to measure playfulness in games in order to be exported for other products[25]. As he reports, playfulness goes beyond pure entertainment and the factors that make games engaging and enjoyable can make other kinds of products more exciting. He defines playful experiences as any activity that is approached from a playful point of view, such as jumping into a pile of fallen leaves or the piano stairs at the Odenplan metro station[4].

He proposes a framework (PLEX) to categorize these experiences through the analysis of a wide range of experiences elicited by playful approaches to interactive products. The PLEX model includes 22 categories, yet 20 have been selected for the present questionnaire due to their relevance with the game designed. In his study, the PLEX categories are printed on cards to let users and designers evaluate and create playful experiences. In the present case, it was chosen to present a 1-7 scale

[4]http://www.dailymail.co.uk/sciencetech/article-1218944/Scaling-new-heights-Piano-stairway-encourages-commuters-ditch-escalators.html

for the 20 categories. The objective of the questionnaire was to measure user's feelings when playing the game. Through the use of a pilot study and tutor's meetings, it was decided to provide several emotions in categories that helped the participants to give a detailed outcome. Besides, this type of approach allows a faster processing than open questions.

Furthermore, none of the participants reported that the questionnaire was hard to fill whereas it is usually reported when asking the users to define their emotional state. Moreover, the interview and group discussion helped to verify the results of the questionnaire.

One of the last two questions asks the users to define the game and interaction with tags. As it was an individual task, it is interesting to find that several participants used similar tags to define the game. Since they fill the same questionnaire twice (one for the collaborative and another for the competitive), they could add more tags after each round. This is an interesting fact because some of them reported in the first round that they did not have the required 10 tags that the question demands. Letting them complete the questionnaire after the second round lead to more meaningful tags.

Finally, a last question inquired about the reasons that made the game enjoyable using their own words. This question was aimed to collect their own impressions without worrying about writing a formal opinion. The goal was to get the feedback that the participant would have given to a friend.

5.3.3 Interview and group discussion

A discussion time was opened before finishing the user study. In this part, the organizer took part in the discussion, proposing topics and questions, gathering participant's opinions and leading the conversation to some questions or opinions that he considered more relevant. Four main blocks were in the agenda. The first block made reference to the collaborative mode and the second one to the competitive mode while the third section tackled the experience instructing the others. Some general questions about related and future experiences from the last part.

First part:

- What was it like to draw in collaborative mode?
- How did you feel when you didn't know what the others were drawing

- How did you feel about the end results i.e. the pictures
- How did it feel, being part of a group in collaborative mode?
- Did you have some strategies in coordinating the work?
- What do you think about the side discussion while playing?

Second part:

- What was it like to draw alone?
- How did you feel about the end results i.e. the pictures
- How did it feel competing against others?
- What do you think about the side discussion while playing?

Third part:

- How did it feel instructing the collaborative work?
- How did it feel instructing the competitive drawing?
- How was it, being able to see what the others were drawing?

The open discussion questions included two more about related group work experiences and the people whom would they play the game with.

Nevertheless, many interviewers talked about the leader role in the first two blocks, thus, the third block was skipped. The first and second sections have similar questions, yet the collaborative mode raised more discussion due to its novelty, whereas competitive modes are commonly found in games.

The collaborative section aimed to know how they felt when drawing in groups, the asymmetry, the outcome picture, the teamwork, and followed strategies. Besides, it was asked about the side-discussion that the game raised and how the level of familiarity affected to it.

The competitive mode tackled similar questions, however, it avoided the questions that were related to the collaborative mode. Additionally, they were asked about how they felt when playing against each other.

Some questions about the leader role were included in order to note the differences between leading in both modes from the point of view of each participant and their opinion about taking the control of the group.

None examples were given when it was asked about similar experiences, in a way that the users could relate the game with others that they thought it was similar to. Some participants related the game to some ice-breaking games while others cited some team-work activities or just collaborative games.

5.4 Summary

To evaluate user's feeling and behavior when playing the Imaginary game, a user study with 30 participants formed into 5 groups was done. Besides, two pilot test were executed in previous phases to polish game's details and prepare the user study. 60 participants were ready to take part but due to time limitations, the user study was reduced to 30 participants. The average age of the user study was 26 years old, consisting of people with different backgrounds and countries. However, as the user study was run at the university, all the participants were students or people working at the university.

The user study lasted around 75 minutes during which game was played in two modes. At the beginning, a background questionnaire was handed followed by 10 minutes of a tutorial where the participants learned how to play the game. After each mode, a questionnaire was run to measure the game experience based on PLEX framework.

Finally, an open discussion time took place where participants were asked to honestly express their opinion.

The questionnaire outcome and video recordings have been used to produce observations and conclusions about the game that are described in the next chapter.

6. RESULTS

This chapter presents the results drawn from the questionnaire handed out during the game session and the following open discussion. Additionally, the comments, actions and behaviours of the participants in the course of the game are taken into account.

The chapter starts with the analysis of the tags that allowed to classify and describe the game. Statistical analysis of the questionnaire results is carried out in the next section. Graphs have been used to show the differences between individuals and groups for both game modes.

It is important to highlight that the composition of the groups and the personal behaviours affected the course, interactions and outcome of the game. Competitive players make the atmosphere tenser whereas groups with a defined leader role feel more enthusiastic [35].

6.1 Overall feedback matching results into a tag cloud

The tag cloud illustrated in the figure 6.1 represents the words that participants chose more often to describe the game after playing each mode (competitive and collaborative).

The number of tags registered was 178, usually formed by one or two words. Two different types of classification have been performed. Firstly, all the tags were grouped by semantic similarity. At this point, only 30 tags had been repeated more than once. However, a second categorization was created in order to group tags with similar meaning. After merging similar labels, this new table comprised approximately 50 tags. In order to easily compare results, another grouping has been done to reduce the ideas to main concepts. A similar approach can be found in the affinity diagrams where user's ideas are grouped in broader categories[1].

Finally, the tags were grouped into 25 categories, being only 11 the categories se-

[1]http://www.usabilitybok.org/affinity-diagram

lected by at least 15% of participants. The most repeated one is *fun* with 27 occurrences, followed by *creative* tag with 15 repetitions. Besides, tags as *excitement, nice, interesting* and *enjoyable* define the game as a playful experience.

Figure 6.1 *Tag cloud describing overall users' feedback.*

Furthermore, tags that characterised the game as a fresh experience that mixed collaboration and competion were ratified in the open discussion time. The game was described as a challenging one that demands attention, communication, coordination and drawing skills. Tags such as *curiosity, surprising, unpredictable, adventurous* could be interpretedas the application being seen as a dynamic game where the participant' s behaviour affects the playing process and the outcome.

On the other hand, it is also possible to find tags that define the game as a stressful or demanding experience, being the time limitation feature one of the main components that aroused those feelings. It is interesting to highlight the tags *auto-evaluation* and *improvement* since they are related to a plausible effort coming from the players to create a more meaningful experience.

Finally, some tags concerning game problems like *English skills, strange concept* or *connectivity problems* have not been included in any category because they were reported by a single participant.

6.2 Measurements of Experienced Playfulness

This section refers to the data acquired from the same questionnaire as the tag cloud from the previous section.

Although the PLEX model was created as a designing tool, this study takes advantage of the PLEX framework to evaluate the end-user's feelings

In order to compare ordinal data that represents agreement or disagreement with an emotional state, quantiles have been used to discriminate the average opinion of the players.

To create the following charts, the data for each emotion has been divided into quartiles as the figure 6.2 illustrates. In other words, the data between quartiles 1

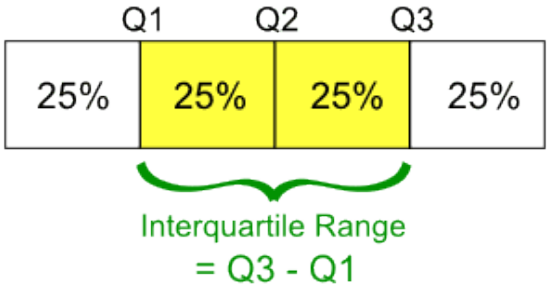

Figure 6.2 *Interquartile range explanation.*

and 3 (interquartile range) represents the average opinion excluding the ones that are in less accordance with the average values. This measure gives the opportunity to draw the average opinion in a broader range than plotting a single value (media).

In order to understand the figures, the meaning of every dimension is described below. The table 6.1 from Lucero's article "Designing for playful experiences" contains a brief description of the dimensions introduced in the present study as well as the questions included in the questionnaire.

The next subsections plot the data of every dimension to illustrate the differences. This sorting is done to compare game modes. In the first case, independently of the group's belonging. Whereas, the second subsection illustrates the values for every group.

6.2.1 Comparison between individuals

This subsection contains the average values of the entire set of participants without taking into account their group.

Two charts are presented regarding to each game mode. Figure 6.3 for collaborative game and figure 6.4 for the competitive one.

Table 6.1 *Describing PLEX dimensions by Lucero [25]*

Name	Lucero's description	Question proposed
Captivation	*Forgetting one's surroundings*	I was so captivated that I forgot my surroundings
Challenge	*Testing abilities in a demanding task*	I felt like testing my abilities in a demanding task
Competition	*Contest with oneself or an opponent*	I felt competing against the others
Completion	*Finishing a major task, closure*	I felt completing a major task
Control	*Dominating, commanding, regulating*	I felt controlling the others
Cruelty	*Causing mental or physical pain*	I was causing mental pain to others
Discovery	*Finding something new or unknown*	I discovered something new or unknown
Exploration	*Investigating an object or situation*	I felt like I was exploring something
Expression	*Manifesting oneself creatively*	I was expressing myself creatively
Fellowship	*Friendship, communality, or intimacy*	I felt friendship or communality
Humor	*Fun, joy, amusement, jokes, gags*	I experienced humor
Nurture	*Taking care of oneself or others*	I felt like taking care of others
Relaxation	*Relief from bodily or mental work*	I felt relaxed
Submission	*Being part of a larger structure*	I felt like I was part of a larger structure
Subversion	*Breaking social rules and norms*	I felt like I was or we were breaking social rules and norms
Suffering	*Experience of loss, frustration, anger*	I was experiencing loss, frustration or anger
Sympathy	*Sharing emotional feelings*	I was sharing emotional feelings with the other players
Thrill	*Excitement derived from risk, danger*	I was feeling excitement derived from risk or danger

As it is possible to see in the figure 6.3, the values which get a lower value, meaning that participants did not feel the corresponding emotion, are *cruelty, subversion* and *suffering*. These values are in accordance with the game's topic which does not aim to arise fear, disconformity or suffering. As it is expected, similar values appear in the competitive version. While *thrill* is not an objective of this game, higher values have been found for both versions. This value can also be linked to the expectation and excitement of the participants when the outcome pictures were shown.

Dimensions such as *control*, *discovery*, or *sympathy* fell into neutral values. *Control* has a tendency towards disagreement values as the game implements asymmetry. In this case, participants do not have all the information available.

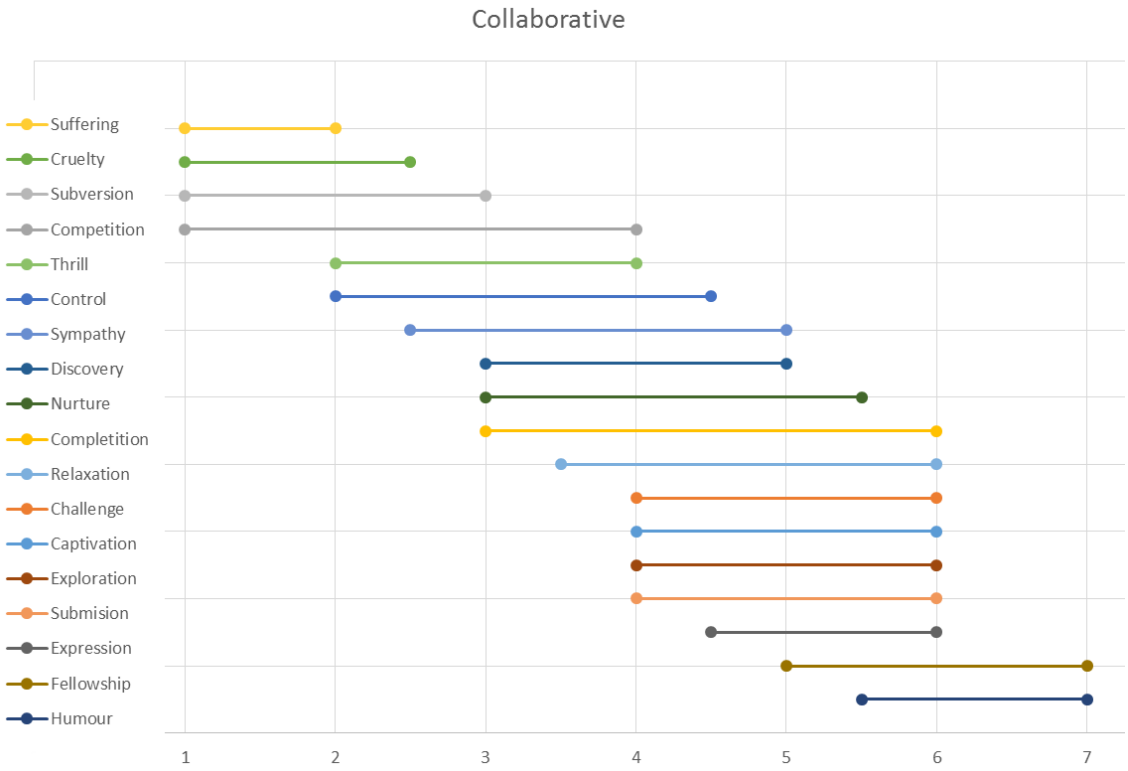

Figure 6.3 *Results from the collaborative questionnaire. 1: Not elicited at all, 7: Experience arisen*

Experiences such as *discovery*, *nurture* and *completion* score neutral values as well. These values in dimensions like *nurture* and *completion* can be expected. A painter's actions influence the overall drawing as they can erase what others did. Besides, as a coordinator, they must take care of the others actions and they are the final responsible of the outcome drawing. Nevertheless, Imaginary is just a game whose outcome does not imply further consequences.

It is important to highlight that the participants did not know either the pattern pictures or the final outcome until the game is over. Thus, the value of *discovery* can be related to this fact.

The *relaxation* value has correlation with the atmosphere. Participants knew that they were playing a game and that the final outcome was going to be evaluated solely by them. Nevertheless, a game can be relaxing and challenging at the same time. In the present case, the level of *challenge* was not excessive for most of the participants.

According to the results shown, the participants agreed that the game aroused experiences such as *captivation, exploration, submission* and *expression*. Those ex-

periences go along with the tags described in the previous section. Opposing the competitive version, the collaborative one intends to let players express their creativity while playing as a team.

Finally, the participants flagged *fellowship* and *humor* as the two strongest experiences they felt. A high score in *fellowship* could mean that players did not feel inhibited or strongly evaluated by others, maintaining a friendship environment. Yet, it must be taken into account that they were participating in a user study and with a low degree of familiarity among them.

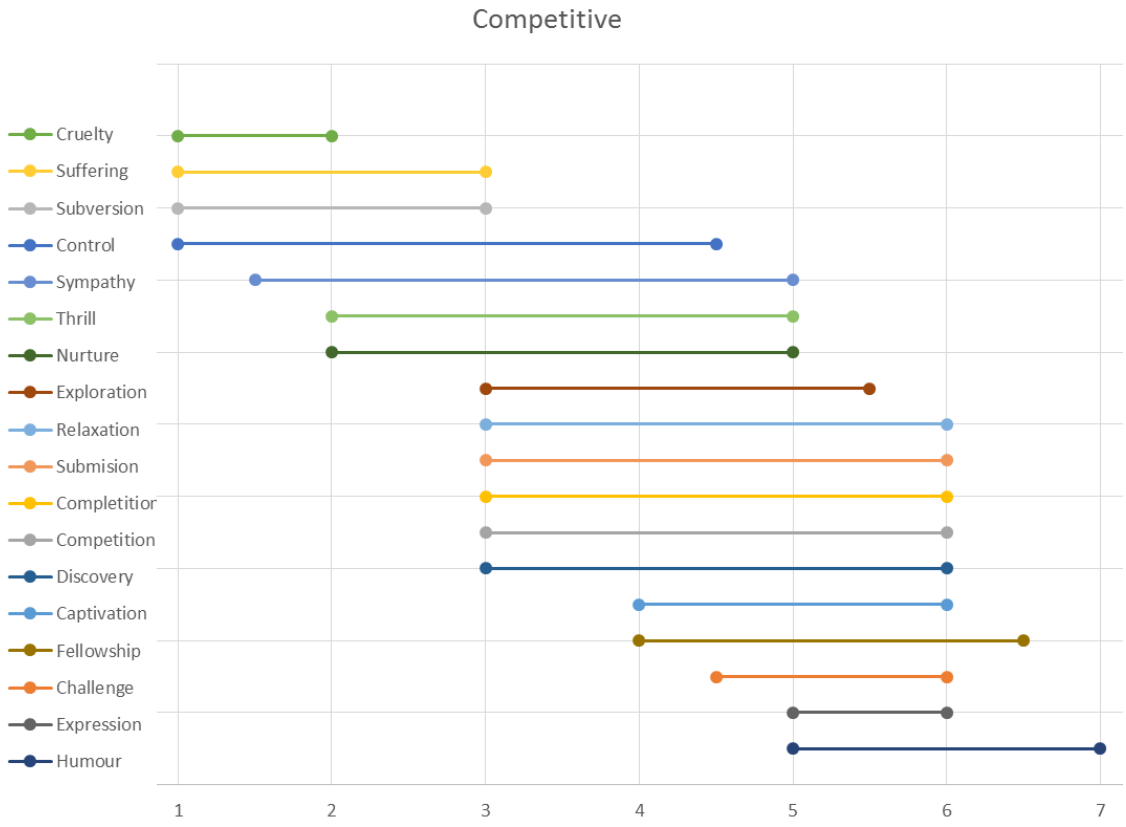

Figure 6.4 *Results from the competitive questionnaire. 1: Not elicited at all, 7: Experience arisen*

The first clear difference that the figure 6.4 presents is the higher values of the *competitive* experience when compared with the collaborative mode. *Cruelty, suffering* and *subversion* maintain lower values, as these experiences were not elicited.

In contrast to the collaborative game, the *control* experience shows a broader range that includes full disagreement. It could be expected that participants may attain lower control levels when they do not have access to the whole picture. However, focusing in a part of the picture and letting the others do the rest may decrease

the amount of workload and allow them to concentrate on the given task. In the competitive version, the players must keep drawing while paying constant attention to the new instructions, thus having less control in what they are doing.

It was expected to find decreased values of *nurture* in the competitive game mode as the players do not have to be aware of the others when drawing. Yet, as the coordinator role must take care of the players' outcome pictures, the nurture value did not vary too much. As *completion* does not require the task to be completed as a team, a lower value could have been anticipated.

Competitive version eliminates the teamwork component, thus emotions such as *sympathy, nurture* and *fellowship* decrease. However, the lack of a final score reduces the *competition.*

Experiences like *exploration, relaxation, submission, discovery* or *completion* present neither agreement nor disagreement values. Sometimes neutral values might appear due to the difficulty to assert the apparition of an emotion or experience. An example is found with the values of the *relaxation* dimension where the participants reported that the game was challenging, demanding both skill and constant attention but at the same time it was labeled as an easy going game played amongst friends in a relaxed environment.

Finally, *challenge* and *expression* slightly increase their values compared to the collaborative version. As the players declared, the competitive version was challenging because one had to put attention on what the coordinator was saying while constantly drawing at the same time. However, from the coordinator point of view, the competitive mode was easier to manage. The *expression* value could be explained by the possibility of drawing the whole picture.

6.2.2 Comparison between groups

A similar approach to the previous section has been chosen to compare the groups. However, as the groups were composed of 4-5 participants, the quantile's approach is neither optimal nor representative. In this case, it has been chosen to draw the minimum and maximum values scored in each group for each dimension/emotion and game mode. The collaborative mode is illustrated by blue lines and the competitive version is painted in yellow. Each chart has two lines; The left line represents minimum value of the group and the right line represents the maximum. Although it might be hard to exploit conclusions from small data sets, the figure 6.5 and figure 6.6 illustrate differences among groups and represent the heterogeneity or

homogeneity of the group. All the experiences are measured in the scale [1-7] (1: Not elicited at all, 7: Experience extremely noticeable).

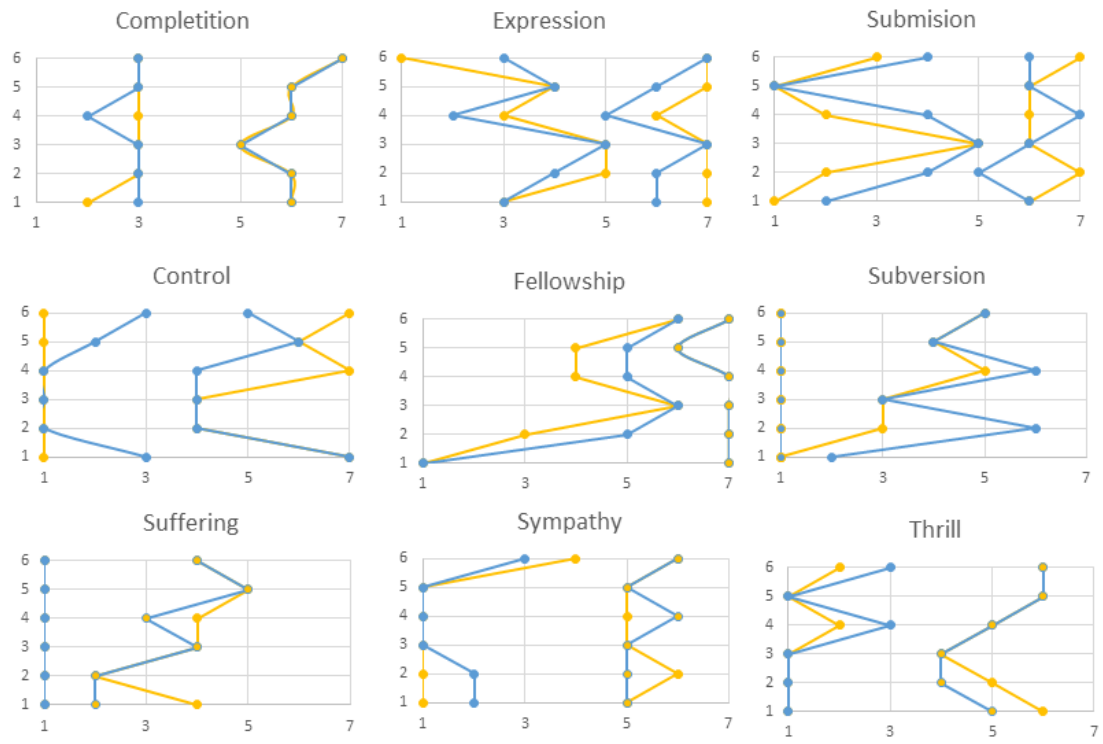

Figure 6.5 *Comparison between groups and game modes for each dimension (1/2). The yellow line represents the competitive version and the blue line the collaborative. Y-Axis: Different groups. X-Axis: Level of arousal (1: Very low, 7: Very high).*

In these charts, it is possible to see how groups vary among each other. In overall, the charts show that the competitive (yellow) and collaborative (blue) lines usually follow a similar contour line or curve. It is worth to mention that the participants filled the second questionnaire over the first answers. Therefore, their answers could be affected by what they answered in the previous mode.

Factors such as player's behavior, game strategy, coordinator role or degree of familiarity among participants affect directly to the game experience. However, it is possible to see how the measured experiences were affected depending on the shape of the lines. Straight vertical lines indicate a lower variation between groups and therefore less dependence on external factors.

Taking a closer look to experiences such as *cruelty* or *submission* it is possible to see a high variation between groups. For example, groups 2,3,4 and 6 for the *submission* experience had homogeneous values whereas the opinions of the other groups present a high variation. Yet, both modes perform in a similar behavior. Another example

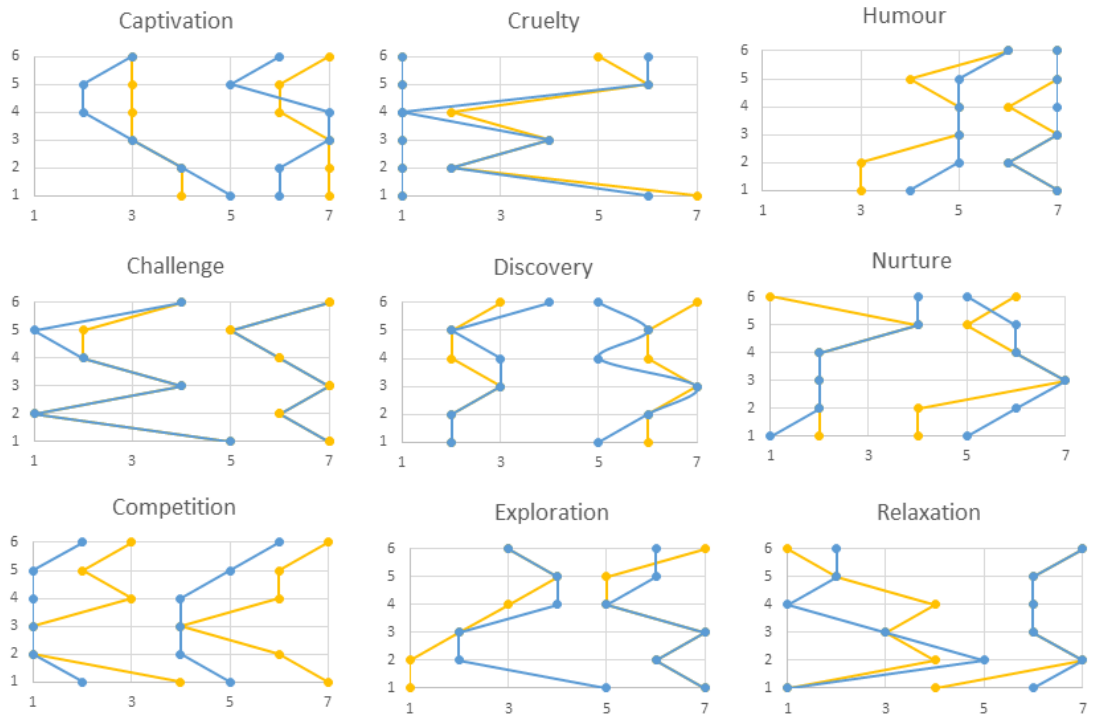

Figure 6.6 *Comparison between groups and game modes for each dimension (2/2). The yellow line represents the competitive version and the blue line the collaborative. Y-Axis: Different groups. X-Axis: Level of arousal (1: Very low, 7: Very high).*

that illustrate the difference between groups can be seen in group 6 for *control, relaxation, nurture*, and *expression* experiences. All of them score a minimum value for the competitive mode whereas the collaborative version has a higher value. A participant with little affinity with the game theme in a competitive group can cause this values.

Fellowship values for groups 1 and 2 also score the minimum value possible while other groups differ heavily. Yet, the maximum values indicate that not all the group shared the same opinion. Another divergence in opinions is found in *subversion* experience. All the groups agree on the minimum values whereas the maximum values present a diverse range of values.

Besides, *captivation* and *challenge* have correspondence between groups. For example, groups score similar values for both experiences and modes while only the minimum value of group 2 for challenge experience digresses.

Nevertheless, this data must be handled carefully. As it is based on maximum and minimum values, individual opinions affect heavily to the figures.

6.3 In-game observations

In overall, it can be stated that all groups were active and present a good side discussion with questions between participants. In order to summarize the group behaviour, the table 6.2 shows an overview of the groups' interaction and remarkable actions.

Group	Interaction	Leadership	Strategy	Drawing skills	Difficulties
1	Very active	One noticeable leader	Divide by objects	2/4 with good skills	English skills cause some difficulties.
2	Active and helping each other	Equally	Constant communication and feedback with the leader	Average	Many different nationalities with different English skills
3	Passive	Not a noticeable leader	Each leader decided its own	Average with one person a bit more skilled	Some technical problems
4	Active	2-3 people tried to impose their ideas	Each player in charge of a part of the screen	Under the average	Discussing for the strategy, they feel more anxious. Task oriented group.
5	Very active	Each leader decided his own strategy	Giving task to players and players asking questions	Average	The groups put more importance in having a good time than the outcome pictures
6	Passive	Each leader decided his own strategy	Some rounds showing their phones to the others.	Under the average	Giving short orders and the painters did not ask for more details. When they finish its order, they wait instead of asking.

Table 6.2 *Groups' interaction and behavior*

The interaction improved as the environment became more relaxed and players familiarized with the game. The levels of interaction defined in the table are based on the conversation and exchange of information between players according to the author of this thesis. For example, the first group had a constant communication and a highly active post-game communication. They usually interrupted leader's orders to get more details. By contrast with the first group, the players of the second group who were painting tried to answer the questions of the other players. Other groups like third and sixth were more passive, with less communication and comments on the outcome pictures.

As the game went on, the conversation flowed easier and smoother. In general, players did not feel uncomfortable when interrupting and addressing each other's to get more details. Once the time was over and the picture shown, they usually commented their experiences and problems during the game. Sometimes they were referring to similar experiences that all suffer when addressing a difficult part. Besides all groups reacted with laughs to the outcome picture, having good comments to what they had achieved as a group.

The open discussion time started with a simple question about the general opinion of the game. All groups defined the application as a funny game while adding adjectives such as creative, enjoyable, new, easy or interesting. The participants were asked to extend their responses. As a results, some challenging parts were brought to scene: *"Harder than the paper version, useful to test the communication skills, requires team work effort, and test your English skills"*.

6.3.1 User's skills and behaviour

It could be noticed in some groups that players with lower drawing skills felt peer pressure while competing or collaborating. The English language made things more complicated in some cases as participants were from different countries with heavily marked English accents.

There were groups with less active people that lead to lower interaction. For example, the group who had a majority of Finnish people developed a non-written conversation rules where the rest of the players tried to make eye-contact with the leader before interrupting.

In general, participants were active and friendly with others while playing the game. Sometimes, they were using hand gestures to represent parts of the picture. It was a common practice among most of the groups to give feedback to the coordinator once the time was over. The participants felt comfortable with the game's interface. Some of them reported during the game that they were having fun with the game's concept. Some of the in-game statements recorded were: "*I'm having fun, that was a really cool picture; our version is way better; I would love to see others' groups pictures; This game is full of surprises* "

It was discovered that shyer participants got fewer tasks, as they did not interrupt the coordinator for details or duties. Sometimes, they were quiet without anything to draw if the coordinator did not notice that they had finished drawing their last tasks.

The competitive game led to lower interactions between participants as the painters were more focused on their own drawings. In this mode, the players frequently interrupted leader's descriptions when asking for details or when they were ahead or behind leader's instructions. Some quotes that denote this behavior are: "*Ok, What's next?; I finished the plane, what else?; Could you repeat the last one?; Where did you say the table is?;* ". In other cases, it was the leader who asked frequently if they have finished the current task.

6.3.2 Strategy and leader skills

After a few rounds, the leader became more familiar with the interface and started giving feedback more frequently. Swiping to the right, the coordinator was able to go through the player's pictures and correct some mistakes: *"No, that bear must be in the left side; the river goes to the top in your picture"*. In the competitive mode, the leader gave personal feedback when seeing major mistakes.

The collaborative play raised more comments as the corrections given by the leader usually required erasing elements. Therefore, the leader had to give detailed instructions to avoid overlapping. However, the confusion generated by the leader's feedback or user's actions usually end up with laughs and good comments. *"Painter: Should I erase all? Leader: No, erase a part of the lake, but only the left part because in the right there is the mountains"; Leader: Great, now the car disappeared, can you do it again?.*

In some minor cases, people who reported a higher level of leader skills try to establish some rules for the collaborative game when they did not have the leader role. Even thought, other players tried to give the leadership to the person in charge of describing the picture, some others with a higher degree of command kept interrupting to make prevail their ideas.

A situation that describes this fact happened in a group where one player proposed a strategy to divide the picture while having the painter role. Then another player pointed out that this decision should be taken by the coordinator / leader. As a result, the coordinator, who was a shyer person, took the strategy proposed. Even if the outcome picture was not good, the same strategy was chosen again in the next picture as the player who proposed was leading. After another poor result, the next leader opted to divide the collaborative canvas in two instead of the four corner division used previously. However, the player who proposed the previous strategy immediately divided his part with other player. As a result, the group left out the new leader's idea and kept the old one. Yet, the environment was pleasant and the

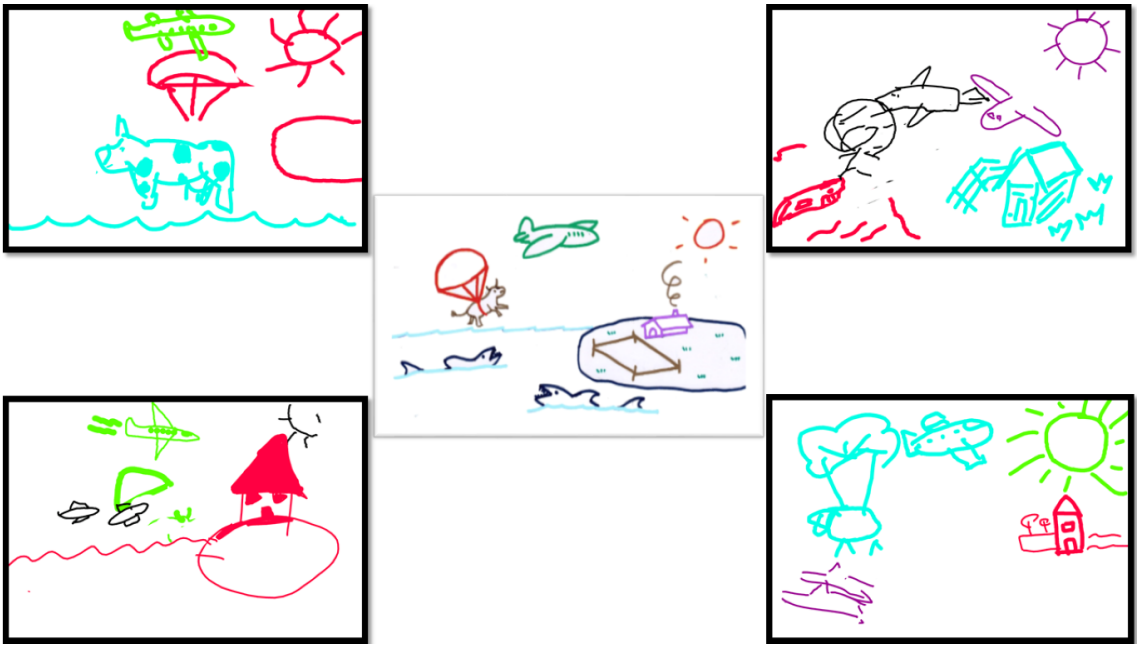

Figure 6.7 *Example of four different drawings created by the different groups when shown the central image*

difference of opinion generate laughs and jokes. The outcome picture can be seen on the top right of the figure 6.7 where is possible to appreciate duplicity of elements and, by consequence, a lower coordination than other groups.

6.3.3 Auto-evaluation and discussion

Once the time was over, the discussion was mainly about the outcome pictures. They were explaining funny anecdotes or troubles they have such as; *"This is where I deleted my ship, I thought it was a sheep;"* when he discovered after drawing a ship that the coordinator said "sheep" instead of "ship", or *"Hey, someone erased my hat.* when seeing that another painter had erased the farmer hat to draw a tractor. Some outcomes are presented in the figure 6.8.

Participants were asked about their feelings when showing the outcome to the others. Some answers make reference to a negative auto-evaluation as they stated that their final drawings were poor versions of others' or they were not able to coordinate a good outcome when leading. However, they reported that did not feel embarrassed or being evaluated by others as they knew they were playing a game. It is worth to mention that in some cases the game did not raise a very active conversation during the game, having a mainly speaker with small interruptions.

The lack of familiarity, shyness or difficulties with the language can be seen in the

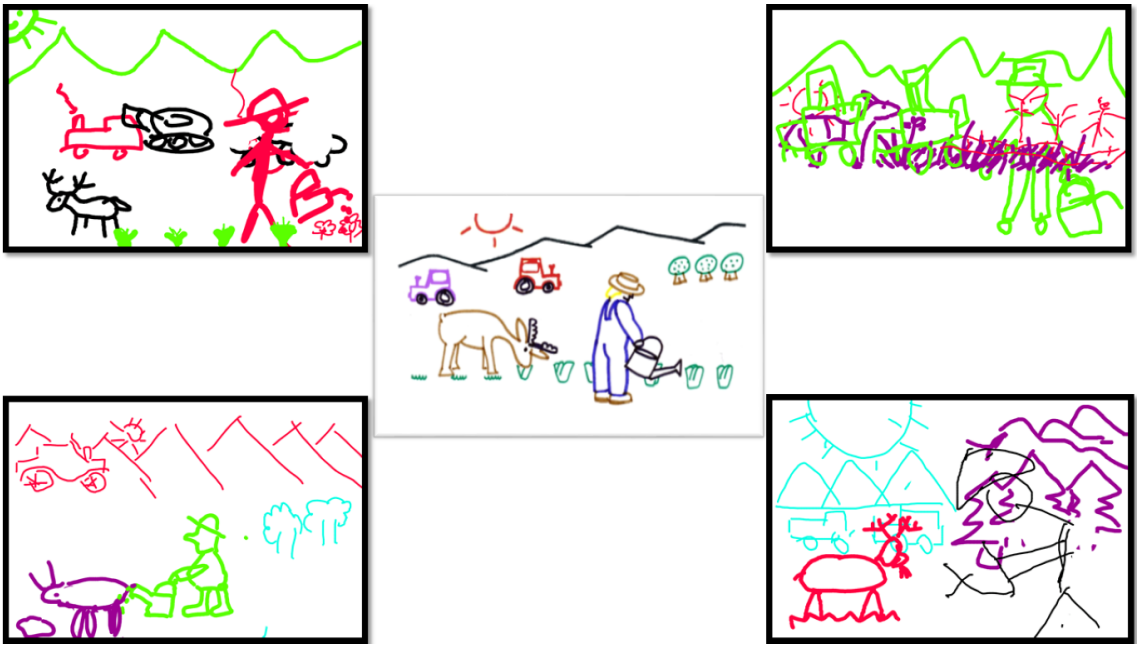

Figure 6.8 *As it can be observed, different images can be interpreted in various ways by different groups*

recordings as factors that affected to the interaction. The lack of familiarity can be drawn from comments such as *"Please don't judge me, I tried my best."* when showing the outcome.

Furthermore, it is visible that extrovert people boosted the communication as they were encouraging the others before and after the drawing time. In these groups, it was more prominent the apparition of comments about their own pictures while drawing: "*my monkey is tiny, the coconuts are bigger; I thought I was good at drawing; I don't have any place for a tractor, it's gonna go to the mountains; I don't know how the flag looks like; I did not have time to draw the reindeer because I had to erase the tractor*". This interaction was not referred to any personal details, yet it emerged with naturalness and spontaneity among people with a lower degree of familiarity. Many of these comments targeted own capabilities or were simply out-loud thinking.

It is interesting to point out that the players never agreed on the preference of one game mode over the other (collaborative and competitive). Even if the groups contained a low number of participants, there was always one person in each group that prefer the opposite mode than the rest of the participants. It is quite common to find groups without predominance for one mode. In general, the people who prefer the competitive mode were more active.

The possibility of having their own canvas and to compare the results with the others were the reasons for choosing the competitive over the collaborative mode. Some of them reported about this mode: *"you did not have to care about others messing up their draws; teamwork cuts more your creativity because you cannot take your own decisions; the game acts as an auto-evaluation for those who know how to draw"*. Besides, they usually stated that the collaborative version is for those players who have less creativity and are more afraid of mistakes as their actions are less noticeable in the final outcome.

Nevertheless, it was also possible to find people in other groups that had the opposite opinion, where they point out that the competitive version is better for those who have worse drawing skills. Players who preferred the collaborative version concluded that the higher difficulty of this mode makes the game more captivating as well.

6.3.4 Final thoughts

Some players reported that the time limitation makes the game challenging while the information asymmetry produces an intriguing and fun outcome.

The leader role was described as the most demanding task as it has the responsibility of explaining the picture and choosing a good strategy. Most of the players agreed on the difficulty of giving enough task to everybody.

To know how the interaction happened, the participants were asked about their side discussion while playing. Most of them answered that they did not have any problem to start a conversation with the others even if they were strangers as the game gave them something to do or talk about. An opinion regarding this matter was: *"It was surprisingly easy to fit in the group even if I didn't know anyone"*. Furthermore, the participants stated that they will play the game with friends and family, but it could also be used as a teamwork activity.

According to the players' opinion, the game falls into a new category between ice-breaker games and board games, because as they reported: *"it makes you talk with the others even if you do not know them but it does not make you feel awkward while doing it"*. Besides, they gave a better opinion than other group activities: *"it is not as strict as other group activities that have many rules that make them annoying", "This game gives you more freedom, you are not force to talk in turns as others games. This is more natural"*.

6.3.5 Reflection of results

Comparing an individual work (competitive version) versus teamwork (collaborative version) makes possible to see that the collaboration of several individuals does not create a better outcome as Galegher referred in his book[12]. The distribution of the group, the individual's differences and communication issues can counteract the final productivity.

According to Bendford theories[3], the possibility of doing a shared task does not imply collaboration as some people prefer to work alone. The application developed gave the opportunity to evaluate the realization of similar tasks individually and by groups. The game showed the prevalence in some cases for the competitive version even though collaboration is the main essence of the game. It was possible to discover different strategies depending on the competitiveness of the leading person. Some were focused on achieving the best possible outcome while others put its attention on the inclusion of everybody.

Many of the studies cited in the section2.2.2 (computer supported collaborative learning in synchronous face-to-face environments) illustrates the importance of the person in charge of moderate and coordinate the interaction. This person must know at any time the state of the interaction in order to encourage and facilitate it. The asymmetry of the game made the players' actions rely on coordinator's instructions. Thus, the leader's defects and strengths have a higher impact on the game results.

This game stands out from similar CSCW studies where the outcome is common for all participants[33]. Therefore, some design frameworks can be difficult applied to the current application. This game defines collaboration as an entertaining process to achieve an outcome that can not be accomplished by single work. Finally, this game does not present any written rules, thus, it is up to the players to decide the level of asymmetry and interaction. As many other board games, players must negotiate with other players in order to find a state where all individuals feel comfortable with.

7. DISCUSSION

The purpose of this thesis was to create a phone application that avoids the isolation produced in gatherings between friends and strangers where people focus on their own smartphones forgetting the surroundings. For this purpose, it was designed a game that combines the face-to-face interactions from the board games with some digital game's capabilities. This game has allowed evaluating how players feel when collaborating and competing within a small group of people with different levels of familiarity.

This game aims to encourage social interactions between people in close proximity through the use of the technology. The game is a tool to spend time with friends from different levels of familiarity at any location. Sometimes, family members or friends get along and play board games such as Pictionary, cards, crosswords, etc, but for those games, it is needed the physical game and a predisposition to play it. Imaginary aims to let friends play a digital "board" game without the need of a physical board and making use of the tools that technology provides.

7.1 Summary and Interpretation of the Results

One of the main points of the game was to create an easy going application that did not require long learning process or force users to create complex mind-maps with rules and instructions. Therefore, the game let the user establish their own rules and the user interface provides simple buttons for the available features. The in-game observations along with the later discussion have shown that participants did not have difficulties either with the user interface or the game's concept. Participants did not require the help of the instructor during the game except exceptional cases with networking problems. Besides, the initial tutorial was self-explaining for the rest of the game.

As it has been stated previously, the game aimed to encourage people's interaction, yet it has not been designed as an ice-breaker game. Icebreaker games are played between strangers with the goal of sharing personal details between each others'. Yet, it was discovered that the game helps establish a topic to talk with strangers

and to coordinate with others. Moreover, it was concluded that the game forced people to communicate with others in a relaxed and game environment where the pressure was lower than other group activities. Besides, making use of their phones allow players to escape from constant face to face interactions that can be more stressful.

Another interesting topic was to know how people react when leading others. As the game requires to coordinate other players at least once, it was observed how participants felt taking the leader role. Differences between extrovert and shyer participants influenced in the gameplay sessions. First ones usually feel more confident leading and boosting the conversation. It was detected that a strong leadership can produce the opposite effect as other players starting seeing the game as a duty to accomplish with success, whereas a good leader that keeps the environment relaxed received a higher motivation and participation.

Moreover, an interesting fact that has been studied during the game has been the behavior of people with high leader skills when taking a passive role. Sometimes, active people wanting to boost the game's interaction made the current leader felt inhibited or restricted to their command actions. Just proposing strategies or interrupting the leader in the descriptions to ask for more details or to get more tasks were actions that complicated the coordinator task.

This game does not apply any type of restriction to the strategy chosen by the leader. As it was said, it is recommendable to avoid showing the pattern picture. Nevertheless, the strategy to split the picture or to manage the time is up to the leader/group. Usually, the leader of each turn decides his own path, yet, some groups presented a small brainstorming before playing. This fact was useful to see how groups managed their strategies and act as a group.

Although there is not a correct strategy and the gameplay can vary depending on the amount of players in the group, some strategies are more appropriate to divide the work and avoid having inactive players. Some leaders tried to give instructions using references to what others did. This approach usually confused the targeted painter as he or she was not aware of what others' drawings on their own screen. It was possible to advert that some leaders were not familiar with the asymmetry of the game. Nonetheless, it is a new concept that it is not usually presented in other games.

The game was not designed to measure teamwork but it is useful to see the different strategies. Some groups did a brainstorming before every round while others evolved their strategy as the game went on. Nonetheless, other participants acted in a more

individualistic way disregarding the group opinion.

7.2 Design Reflections

The game was developed through an iterative process where the design of the screens has been changing constantly. Yet, the final design is not exempt from improvements or mistakes. For example, it was detected that if one device loses the connection, the device acting as a leader still remains its connection. Moreover, it was discovered that many players did not realize about the possibility of swiping to see the outcome's screen during the game. To overcome that problem, a new animation with arrows was included to make the action more prominent. Yet, in following games, it was possible to see that some players still forgot to check the outcome picture until the last seconds of the drawing time.

Another point to improve the usability of the game, as it was reported by the participants, was the inclusion of stylus which let the players be more precise when drawing. Ideally, the game is aimed for phones with big screens or tablets, yet it is compatible with any android device running Android 4.0 or higher.

It is important to point out that the pattern pictures have been created by the developer of the application and writer of this thesis, therefore, they are limited by the drawing skills of the present author. Nonetheless, a new feature has been included in the game that allows players to create their own pictures using the device itself. However, due to time limitations this feature was not included in the user study.

Moreover, technical problems have transformed the final design of the game. The initial idea aimed to have the same device for each player during all the rounds whereas connection problems made this task unachievable. The final design chooses a device which acts as a server and leader/coordinator of the game. This device must be exchanged in every round so every player acts as a leader at least once. This new design dropped out the possibility of including scores. As the participants were exchanging devices it was not possible to keep track of the scores. The lack of this feature could have led in a lower motivation as the competitiveness of being on top of a scoring table is an important motivational factor.

Finally, the lack of time to create a web service to host all the outcome pictures did not allow to create a real-time group's comparison. Again, the lack of this feature could have decreased the team work's effort as they could not compare with others' work.

7.3 Methodological Reflections

The methodology was applied to measure the playfulness of the game and its use as a tool to fight isolation. The user study was well structured and provided meaningful feedback. Besides, the observation and interview methods provided enough information to relate the questionnaires results with the after-game interviews. However, the user study could have been improved in some details. As a positive point, it is important to emphasize that the order of the game modes were altered through groups. It was noted that the participants appeared more enthusiastic and willing to play in the second round as they got used to the game's features.

On the other hand, the use of the same questionnaire with different color pens to mark the user's feelings could have affected to their results. Seeing the previous answers could make them mark the second mode thinking about their answers of the previous mode instead of evaluating the new feature. However, none participant reported this fact, yet it must be taken into account due to the lack of difference between modes in some questions.

The game provides a mode that demands collaboration among players, yet there is not a measuring tool to determine what a good or a bad outcome is. The players are the judges of their own work and their teamwork effort is decided only by them. However, the game allows to test own leadership skills and can be used as a teamwork tool to compete against other groups in work environments or in a classroom.

The user study and therefore, the results could be improved if more groups are evaluated. As the game has been tested only with 6 groups, the personal opinions have a big impact on the final results. The user study used helped to identify usability problems such as the ready button lobby screen where players wait before starting drawing or the need for a button that skips the actual drawing in case it is repeated. Yet, in order to measure the teamwork experience, another user study joining two or more groups playing against each others' could increase the awareness in this matter. The methods used raised good results to measure individuals whereas are harder to extrapolate to groups.

Last but not least, the game has been tested off-record with people that spoke the same language, in this case, their mother-tongue. The in-game conversation was much more fluent and complete, with more detailed descriptions. Yet, players were less aware of the size of the objects, creating situations where several players collided at the same point. As the game was tested in a friend's gathering, the post-game conversation keeps on going about the outcome pictures and the difficulties the players found. Furthermore, the players looked prone to play the game again with

their own pictures as they finished all the pictures the game provides. As it was observed, pattern pictures with more objects and different sizes could improve the playfulness as they require more exhaustive descriptions.

7.4 Conclusions and Future Work

The game *Imaginary* was created to provide a new group activity that makes use of the current technologies to avoid situations where the technologies create isolation. Overall, the game design and concept has been proved as a feasible attempt to gather friends and strangers in a common activity that forces to create an in-game communication in a relaxed and enjoyable environment. Additionally, the game's approach combines the use of modern technologies and accredited gamification elements of board games. Thus, *Imaginary* brings face to face interactions to mobile games played in a collocated environment.

Imaginary can not be considered a game to improve teamwork or to act as an ice-breaker activity, however, it shares common a ground for both elements. Even if the game is mainly focused on friend's gatherings, it can still be played between strangers or with a low degree of familiarity as it happened in the user study. In those cases, the game gives the opportunity to interact and communicate with strangers in a fun environment, whereas the game's goal is not the exchange personal information as other ice-break games. Yet, after-game conversations are easily created even among people who do not know before.

The game provides two inbuilt modes (collaborative and competitive) with minor variations in the user interface. Nonetheless, it is impossible to determinate a more popular or playful version as several participants differed on their preferences. The user study gave the opportunity to see how people behaved in these different contexts. Both modes were scored with a high level of enjoyment, being emotions such as challenging, expression, fellowship, captivation and discovery as the most present experiences. Main differences among modes are found in experiences like fellowship or submission. Yet the higher values scored on the first one represents that the players did not feel inhibited or strongly evaluated by others. As it has been stated, there is not a preferred game mode but as the game was presented as a collaborative game with the possibility of playing a competitive version as well, it is interesting to see the preference of the competitive version of some participants.

The asymmetry that the game introduces along with the consequent collaboration can be decreased if players share their screen in every moment. As it was observed in the user evaluation, an increase in the uncertainty and asymmetry was related

to higher levels of interaction and most of the times to higher playful experiences. Lundgren's framework[26] in his article "designing mobile experiences for collocated interactions" also describes the information asymmetry, information distribution and to some extent engagement as key regulators onto the need for communication between users.

Finally, some technical aspects could improve the game experience as it has been commented in previous sections. Playing with a stylus, an option to skip a picture, a web service to upload the outcome pictures or fixing the technical problems that forced to exchange devices could improve the usability of the game. Yet, the most interesting option could be to include a scoring system and verify the effect of it on the player's motivation.

Beyond renewing the user interface or adding options, it is interesting to see the potential of this game as a learning tool. Many participants reported that the game can help to learn a new language as they have to describe and relate the words with the drawing. Besides, it would be interesting to evaluate the game with kids from different age ranges and propose a joint collaboration between educators and the present research group in order to get possible uses of the game in educational environments.

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APPENDIX A. BACKGROUND QUESTIONNAIRE

Background Questionnaire

Please take a few minutes to answer the following questions. We will use this information only to provide background and usage context in which to interpret the input and feedback you'll give us in the user study.

We will keep your name confidential. The results of this study will be reported anonymously.

1. How do you feel now?

Please indicate to what extent do you agree with the following statements.

2. I consider myself as active social person
(Fully disagree 1 , 2 , 3 , 4 , 5 , 6 , 7 Fully agree)

3.I like to play board-games
(Fully disagree 1 , 2 , 3 , 4 , 5 , 6 , 7 Fully agree)

4. I am skillful in drawing
(Fully disagree 1 , 2 , 3 , 4 , 5 , 6 , 7 Fully agree)

5. I consider myself a skilled user of IT
(Fully disagree 1 , 2 , 3 , 4 , 5 , 6 , 7 Fully agree)

6. I believe technology can have a positive effect on everyday social life
(Fully disagree 1 , 2 , 3 , 4 , 5 , 6 , 7 Fully agree)

7. I am positive towards applying technology to get to know new people
(Fully disagree 1 , 2 , 3 , 4 , 5 , 6 , 7 Fully agree)

8. I consider myself as a gamer
(Fully disagree 1 , 2 , 3 , 4 , 5 , 6 , 7 Fully agree)

In the last 3 months, how often did you:

9. Play games through a social platform
(Less frequently, Weekly, Few times a week, Daily, Several times a day)

10. Play mobile or board games with your friends
(Less frequently, Weekly, Few times a week, Daily, Several times a day)

11. Play multiplayer games with strangers
(Less frequently, Weekly, Few times a week, Daily, Several times a day)

12. How active are you when participating in collaborative work
(Very passive 1 , 2 , 3 , 4 , 5 , 6 , 7 Very active)

13. How do you feel taking the leader role?
(Very uncomfortable 1 , 2 , 3 , 4 , 5 , 6 , 7 Very comfortable)

14. Do you know the people present here in this group? How well do you know them? *(I know some / friends / colleagues, strangers,...)*

APPENDIX B. IN-GAME QUESTIONNAIRE

Discussion questions

How did you feel playing the game? Choose a character on the scale. If you felt extremely calm, sleepy and quiet choose the far left character. If you felt extremely energetic, aroused and awake choose the character on the far right side or any character in between.

1. During the game I felt:

	1 very slightly or not at all	**2** a little	**3** moderately	**4** quite a bit	**5** extremely
relaxed	1	2	3	4	5
happy	1	2	3	4	5
angry	1	2	3	4	5
nervous	1	2	3	4	5
enthusiastic	1	2	3	4	5
ashamed	1	2	3	4	5
determined	1	2	3	4	5
shy	1	2	3	4	5
proud	1	2	3	4	5

2. Did you feel uncomfortable at any moment?

3. Do you have any ideas/suggestions about the game?