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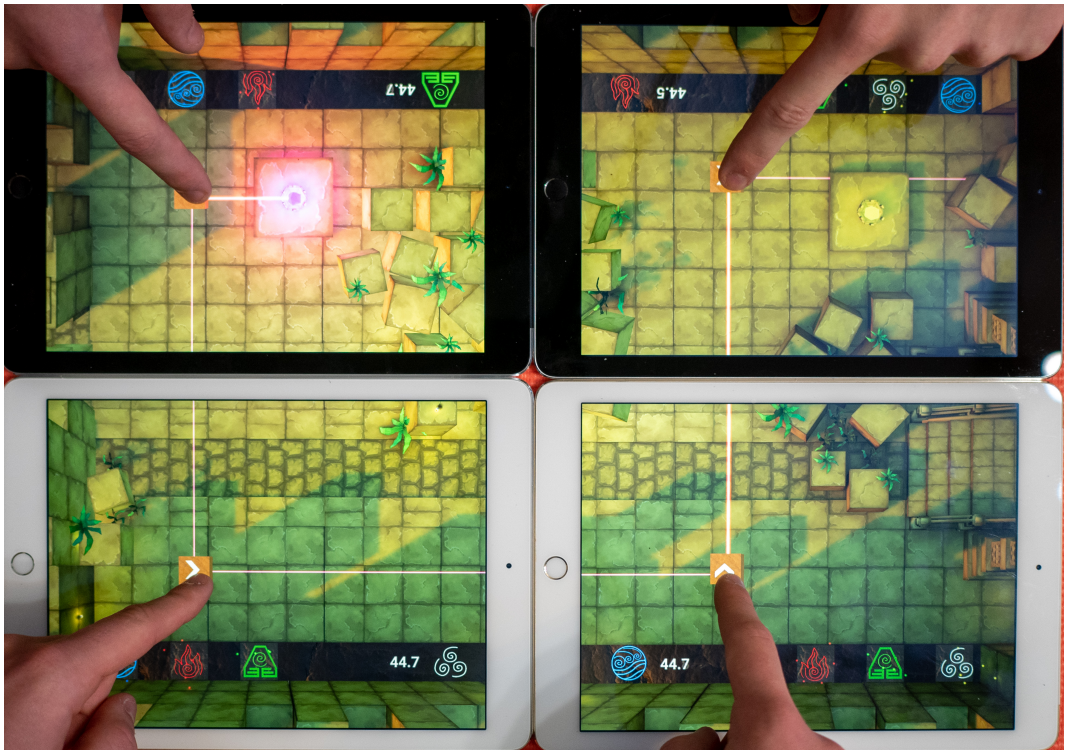

Laser Lunacy! A Collaborative and Co-located Multiplayer Game

Developing a Tool for Children to Practice Collaboration

Bachelor thesis at the Department of Computer Science and Engineering

JOAKIM AGNEMYR
ALEXANDRA GARRIDO JAQUE
CARL MÅNSSON
ANTON OLSSON
PAULINA PALMBERG
SPONDON SIDDIQUI

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
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Supervisor: Olof Torgersson, Organisation of Interaction Design at the Department of Computer Science and Engineering
Examiner: Mohammad Obaid, Associate Professor at the Interaction Design Division, Department of Computer Science and Engineering

Bachelor Thesis 2020
Department of Computer Science and Engineering
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: Four tablets arranged to make up the game map of Laser Lunacy! with players interacting with the game.

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Abstract

The development and spread of digital platforms have led to many new phenomena. Many of them positive, but many of them also negative. One such negative phenomenon is the increasing amount of time that children spend on platforms such as computers, tablets, and smartphones. Such isolation from social interactions with others can lead to underdeveloped social skills such as communicative and collaborative skills. It is for this reason that collaborative games have become a point of interest as they may be used as a tool for children to develop their social skills in an environment familiar and appealing to them.

In this report, a detailed development process is presented of a co-located collaborative game for children which can be used in learning environments. The purpose of the project is to develop a tool in the form of a four-player game spanning over four tablets which allows children to practice and develop their collaborative skills.

The game was developed through an iterative user-centred design process and based on previous studies about collaborative games and game design for children. The target demographic of the project consisted of children in ages of 10 through 12 years old and were involved in the design process through game testing. The project resulted in a temple-themed puzzle game in which each participating tablet made up a section of the game map. To complete the game the players had to use one-way directional blocks to redirect a laser from start to finish. The game idea was appreciated by the test players, however, an extensive number of bugs in the game prevented the players from fully enjoying the game experience. The game could potentially be a suitable tool for developing children's collaborative skills, but to reach this conclusion more extensive and long-term research would be required.

Keywords: collaboration, collaborative games for children, cooperative learning, gameplay design patterns, social and emotional learning, gameplay design for children, co-located games

Sammandrag

Utvecklingen och spridningen av digitala plattformar har lett till många nya fenomen. Många av dem är positiva, men många av dem är också negativa. Ett sådant negativt fenomen är antalet timmar per dag som barn spenderar på datorer, surfplattor eller mobiler. Denna isolering från sociala interaktioner med andra kan leda till underutvecklade sociala färdigheter så som kommunikativa förmågor och samarbetsförmågor. Av detta skäl har intresset för samarbetsspel ökat eftersom de kan användas som ett verktyg för barn att utveckla sina sociala färdigheter i en miljö som är bekant och tilltalande för dem.

I denna rapport presenteras en detaljerad utvecklingsprocess av ett samlokaliserat samarbetsspel för barn som kan användas i inlärningsmiljöer. Syftet med projektet är att utveckla ett verktyg i form av ett spel för fyra spelare som sträcker sig över fyra surfplattor och som gör det möjligt för barn att öva och utveckla sina samarbetsförmågor.

Spelet utvecklades med hjälp av en iterativ designprocess med fokus på användaren och baserades på tidigare studier om samarbetsspel och teori om speldesign. Målgruppen för projektet bestod av barn i åldrarna 10 till 12 år gamla. Målgruppen var involverade i designprocessens testningsfas. Projektet resulterade i ett tempelliknande pusselspel där varje deltagare använder enkelriktade block för att omdirigera en laser från start till mål. Spelidén uppskattades av testspelarna, men ett omfattande antal buggar i spelet hindrade spelarna från att helt engagera sig i spelupplevelsen. Spelet kan potentiellt bli ett lämpligt verktyg för att utveckla barns samarbetsförmåga, men för att nå denna slutsats krävs mer omfattande och långsiktig forskning.

Nyckelord: samarbete, samarbetsspel för barn, kooperativ inlärning, speldesign mönster, socialt och emotionellt lärande, speldesign för barn, samlokaliserade spel

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We would like to thank our supervisor, Olof Torgersson, for all his help and support during the entirety of the project. We also express gratitude towards Vasaskolan elementary school for participating in our test, and we especially thank the children who tested our game for their participation and feedback. We also express our gratitude to the members of CAVI for sharing their work with us and especially Rolf Bagge for aiding us with the network programming. Lastly, we also give thanks to the CITE project members for arranging for further testing of our game.

Joakim Agnemyr,
Alexandra Garrido Jaque,
Carl Månsson,
Anton Olsson,
Paulina Palmberg,
Spondon Siddiqui,
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Glossary

Alpha player: a player in a team that assumes a dominant role over other players.

Cross-platform software: computer software that is implemented on multiple computer platforms.

Game engine: a software development environment that is used for building video games.

Materials: defines how a surface should be rendered. Gives objects their look in regard to texture, colour and more [1].

Mechanic: a functionality of a game.

Mesh: the 3D-data that tells an object how its polygon should look. Gives objects their shape [2].

Minimum Viable Product: a minimum viable product (MVP) is a product with sufficient features to satisfy early users [3].

Persona: a fictional character which represent the intended end user and helps developers understand the user's needs, experiences, behaviours, and goals [4].

Screen time: time spent watching television, playing a video game, or using an electronic device with a screen (such as a smartphone or tablet) [5].

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Introduction

Digital platforms have become an integrated part of today's society to the extent that the Swedish government decided in 2017 to make significant changes to several syllabi. The changes were done with the intention of clarifying the schools' mission to strengthen students' digital competence [6]. This has resulted in it being common in Swedish schools today to provide students with a tablet or a computer as an assisting tool for their studies.

Though tablets, computers, and smartphones have many advantages and are used productively in schools, a child who spends a lot of time on the computer or on their smartphone may express behaviour that can easily turn into a problem when it affects other aspects of life in unfavourable ways [7]. The World Health Organisation (WHO) has defined this problem as a disorder, called gaming disorder, which is "*[...] characterised by impaired control over gaming, increasing priority given to gaming over other activities to the extent that gaming takes precedence over other interests and daily activities, and continuation or escalation of gaming despite the occurrence of negative consequences*" [8].

Children who spend a lot of time gaming have less interaction with their friends and family [9]. Social interaction is a crucial part of a child's development and their ability to handle and express thoughts and feelings [10]. While digital games seem to be the problem in this case, the right kind of game can also have the desired effect of increasing social interaction, in particular multiplayer collaborative games.

1.1 Purpose and Approach

The purpose of the project is to develop a tool for children to practice their collaborative skills in the form of a multiplayer game. The study will be done by designing and developing a game in accordance with previous studies done on the subject of collaborative games and game design theory. To determine whether the implemented design mechanics encourage collaboration between players, tests will be conducted with the help of test groups. The test results will then indicate the degree to which the implemented concepts encourage collaboration.

1.2 Final Product

To study the game mechanics behind collaborative games, such a game will be designed and developed. The game has to fulfil three requirements.

The first requirement is that playing the game should result in collaboration between the players. Players should show clear signs of interaction with each other, either through verbal communication (e.g. asking questions, giving advice, support, encouragement, etc.) or through the use of body language (e.g. pointing or gesturing).

The second requirement is that the game should be intended for tablets. Tablets provide the possibility to create large custom game maps by physically rearranging the tablets. They also implement touch technology, which has proven to be an intuitive and easy way for users of all ages to interact with a computer [11].

The third requirement for the game is that it has to accommodate for four players with each player playing on their own tablet (see Figure 1.1). Four players has been decided to be sufficient for the size of the project. Less players may give insufficient feedback on the success or failure of the collaborative mechanics, while more players could possibly make the project too large and intricate to satisfactorily complete in time. The use of an even number of players, and therefore also an even number of tablets, also makes it easier to arrange for a symmetrical map of proportionate size.

Figure 1.1: Four tablets making up the game map.

Various game design mechanics (e.g. *gameplay design patterns* [12]) will be implemented in the game. It is the implementation and use of these mechanics that will lead to an evaluation of successful or failed game design mechanics for establishing and encouraging collaboration.

1.3 Delimitations

The target group of the game has been set to children between the ages 10 through 12 years old, equivalent to years 4 to 6 in Swedish schools. The target group has been set to this age due to the developing stage of children. At this age children are in the prepubescent stage [13]. Close relations to their families are important. Moreover, at this age the relationships to friends and peers start to become increasingly more important and the children get their first tries at exhibiting adult behaviour.

The focus of the project will not be on the system architecture of the game, but rather on which game design structures are used to achieve different scenarios of communication and collaboration. While the report covers the implementation, the focus of the report does not lie on specific algorithms or frameworks that might have been utilised other than a brief account of them.

1.4 Societal and Ethical Problems

Bullying among schoolchildren is an old phenomenon and can be made up of e.g., physical contact, verbal abuse, spread of rumours, and exclusion [14]. In a collaborative game is it important to ensure that everyone contributes to the solution of the game. A scenario that could cause bullying is an insufficient contribution to the solution of the game by a player. Should this happen, that player risks being ridiculed or excluded from the game by the other players. It is therefore important to actively try to implement preventive measures against such scenarios.

1.5 Report Structure

The report begins with a theoretical section meant to give the reader some background knowledge about collaborative games, gameplay design, and game design for children. The section is followed by a presentation of the methods and tools used during the development of the game. This includes the agile process as well as the game engine platform. The next section describes the development process through iterations and includes design decisions, test results and evaluations for further improvements in the game. Following that, the final prototype is presented followed by a discussion of the results of the project. The report ends with a short conclusion in which the main points of the report are summarised.

2
Theory

This chapter gives a summary of some fundamental theory needed for the project. The chapter starts with a presentation of the previous work which this project is based on, followed by an explanation of collaborative games, a description of gameplay design patterns, a description of the meaning of cooperative learning, a section on children's social and emotional skills and ends with a theoretical section about gameplay design for children.

2.1 Previous Projects

StringForce [15] is a game developed as part of the *Touch AT!* project [16]. The game is part of a project which aims to provide children with special needs a chance to practice their collaborative skills. StringForce does this by enforcing the five key elements of *Collective Interaction* [17], which focuses on designing for co-experiences among co-located players.

The aim of this project is similar to that of StringForce. The game is meant to encourage collaboration between players in a co-located digital platform. The main difference of this project compared to StringForce is the target group. While the target group in StringForce consists of special-needs children in elementary school, the target group for this project is aimed at children in the grades 4 to 6 in Swedish schools, regardless of their cognitive functions.

The project is also developed in collaboration with the project *Collaborative Information Technology in Special Education* (CITE) at Aarhus University. CITE is a project which investigates how children in special education can learn communicative and collaborative skills with the help of digital technology [18]. Another aim of CITE is developing a platform for creating co-located collaborative multiplayer games. The platform has been used for the networking part of this project.

2.2 Collaborative Games

The differences between collaborative and cooperative games are explained in the article *Collaborative games: Lessons learned from board games* [19].

Though often used interchangeably, cooperative games and collaborative games are

not necessarily the same thing. In cooperative gameplay, players are put in a situation where they may work together to achieve a win-win situation. However, a cooperative game does not always guarantee that the players will benefit equally from working together or even benefit at all.

Collaborative games are similar to cooperative games in that they allow for two or more players to play together in teams. The difference between cooperative and collaborative games lies in the degree the players in the team share the goals, payoffs, and outcomes of the game. In a collaborative game, if the team wins or loses, then ultimately, all the players win or lose.

2.3 Cooperative Learning

Cooperative learning or small-group learning means that two to five students in small groups are working together to complete a task [20]. Working towards a common goal help the students learn together. It is often supervised by a teacher that helps the students cooperate. Cooperative learning methods consists of five principles:

1. The common task or learning activity should be structured in such a way that the students need to work together to solve it.
2. The group should consist of 2-5 members.
3. Cooperative and pro-social behaviour is used to solve the problem.
4. The students have their responsibilities and have to complete their tasks to make the group succeed.
5. Learning and working together is each student's responsibility.

Learning together has two important key components, positive interdependence and individual accountability [21]. Positive interdependence means that the students should feel that the group succeeds or fails together. Individual accountability means that no individual can exploit another student's success within the group. Everyone has to play their part.

2.4 Children's Social and Emotional Skills

The following information comes from the article *Promoting Social and Emotional Learning With Games* [22].

Social and emotional skills are important for children to learn to be able to have a healthy life. Social and emotional learning can lead to respecting others, positive thinking, treating others with compassion, communication skills, and a lot more. It helps the well-being of individuals but also their social relations.

Collaborative games can be a helpful tool to teach children emotional and social skills. Playing games is what children do because they think it is fun, but it is also important for their development. Having fun leads to positive emotions, which en-

hances the children's abilities to learn and solve problems. Playing games together under supervision can counteract bullying, build healthy relationships, and train cooperative skills.

2.5 Gameplay Design for Children

When designing a game exclusively for children there are a few things that are important to keep in mind. The following are nine of the most important ideas according to the book *Child-Computer Interaction* [23].

(1) The team or teams making the game or the design should be as varied as possible in order to integrate as much knowledge about children and design for children as possible.

(2) Since it was a long time ago the game makers were children themselves they might have a hard time remembering how children think. Also, today's children might not have the same preferences current adults had when they themselves were children. Therefore, it is important to engage children throughout the process to get their view on how aspects work. They can point out things that adults might miss and how things currently work for the younger population.

(3) When designing for children it is important to know that children playing the game probably will not be immediately affected by the game. Usually, children have to play the game continuously over a longer period of time in order for it to have an impact. Therefore, it is imperative to think in long terms for the design and layout of the game.

(4) It is usually not enough to just design the game. The designers have to think of the ecology as well; where is the game going to be played? Who will be present in the immediate area while playing? Since this is something that affects children when playing, the designers have to design the game with a specific environment in mind.

(5) Children need to feel like the game has been made for them. It needs to be personalised. If a child with a functionality disorder plays the game but the designers have not designed the game with disorders in mind, the child perhaps will not find it as attractive because they will not be able to play the game when other children their age can. Since everyone is different, this might be a difficult task to accomplish, but the more children feel like the game is specially made for them the better design.

(6) It is also important that children playing have the right skills and knowledge. If the children do not have the right knowledge to play the game they are more likely to lose interest in the game. It is the same with other subjects and matters such as e.g. mathematics. If one does not understand the basics, one will not be able to learn the more difficult things. The game cannot be too hard but neither can it be too easy. In either of these cases, children have a tendency to lose interest.

(7) The game should somehow make children use their creativity. When learning, it is easier and more fun if the task is done with a clear purpose in mind. This could be letting the children build something or put it in a meaningful context so they understand that the skill is necessary or good to have.

(8) Children have a tendency to never do as they are told, but instead, do the same thing as the adults around them. Therefore, it is beneficial to have someone the children look up to joining the game. Examples of this are a teacher, parent, or older sibling that helps set up the right learning environment.

(9) Children learn new things easier if they combine learning with physical activities. Therefore, it is good to add physical features in the game; intertwining physical use with screen activities.

2.6 Gameplay Design Patterns

Gameplay design patterns is a collection of patterns that have been identified in games. They make it easier to understand intentions and develop ideas relating to game design [12]. This section will give a presentation of the game design patterns used in or considered for this project as well as an explanation of what they are. All patterns and their explanations have been taken from Björk and Holopainen's book *Patterns in Game Design* [12].

Symmetric Information indicates that all players have the same amount of information. E.g. when playing chess both players can see the board with all pieces and therefore have the same information simultaneously.

Asymmetric Information is the opposite of symmetric information, meaning that the players do not necessarily have access to the same information.

Movement and Manoeuvring. Movement decides what and how things (e.g. players and weapons) can be moved around on the game board. An example is how the different pieces move in chess. Manoeuvring is what the players have control over. The users might have to avoid an enemy or control an avatar and the manoeuvring decides what is possible.

Asymmetric Abilities or Roles means that players have different actions or roles that are available for them to perform. One player might be able to use a gun while someone else throws grenades. Players cannot trade different abilities with each other.

Symmetric Abilities or Roles is the opposite of asymmetric abilities. It means that players can do the same things. There is not an ability that exists for only one player.

Experimenting means that a player has to experiment to solve problems. The game can be constructed to make the players learn how the game works or have

random tasks throughout the game where the players have to experiment. It can be a puzzle located somewhere on a level where the player has to guess the solution instead of finding a clue to what that solution is.

Rewards means that the player(s) get a reward when achieving something in the game. It can be a power-up that the player can use anytime they wish. It can also be winning a hand in poker; to receive the money you and other players have bet in that round.

Surprises is when the player gets surprised by different actions or happenings in the game. In a first-person shooter game the player might get surprised when it is attacked from an angle they did not expect.

Cooperation. All players have to cooperate to reach the main goal. The players might have subgoals they have to clear before the main goal is reached, although they are supposed to work together. A soccer team is a good example where the players have different individual tasks to achieve the main goal. E.g. the goalkeeper and the forward have different tasks they have to perform but eventually it leads to the main goal. This should not be confused with the aforementioned concept *cooperative games*.

Team Play indicates that multiple players have to coordinate their actions to complete a level or win a game, e.g. like a soccer team.

Social Interaction is when two or more players in a game have to socially interact with each other. The players need to have two-way communication between each other. It can be in a special phase of the game where the players have to interact to e.g. trade with each other. It can also be that the players have to communicate to collaborate and eventually win.

Trading is when two or more players can trade between themselves. It can be resources, actions, or elements.

Eliminate and Saviour means that a player can eliminate something or someone from the game board. It can be in a first-person shooter game where one player kills another; the killed player is eliminated but will respawn after a set time. Saviour is when one player helps another by removing an undesired effect, e.g. a player from another team before they get a teammate.

Traverse means to have the goal of getting something from one side of the game board to the other side. An example could be to move a pawn from one side to the other in chess to get a better piece or get the pieces in backgammon to the right side.

Concurrency. Two players or more have to do tasks simultaneously that a single player cannot manage.

Mutual Goals indicates that two or more players share a common goal. The players can have different subgoals but share the main goal of the game.

Gathering Gate forces the players to wait for each other by allowing them to only

continue together.

3
Methods and Tools

This chapter contains information about the game engine used for the development of the games, the framework used for platform networking, and a description of the work method for the development process.

3.1 Game Engine

Unity [24], a cross-platform game engine developed by Unity Technologies, was used as the game engine for developing the project. Unity can be used to develop 2D- and 3D games in a user-friendly environment and was very suitable for the project, as none of the project members had much prior knowledge or experience of game development.

To collaborate on the development of the game, Unity's built-in collaborative service, Unity Teams [25], was utilised. This allows small teams to save, share, and sync a Unity Project in a cloud-hosted environment.

3.2 Network Programming

The game was developed with the help of a framework based on Unity's high-level API *Mirror Networking*. Mirror Networking is used to make it easier to program multiplayer games by making the client and server share the same code base [26].

The framework is developed by the *Center of Advanced Visualization and Interaction* (CAVI), a research centre at Aarhus University [27]. The framework provides functionalities to connect clients to each other and to start the game on a local network. It also provides an example game that can be used as a template for developing multiplayer games over a network.

3.3 Design Processes

The project was developed through an agile process with a focus on user-centred design (UCD). UCD is an iterative process in which the designers focus on the users and their needs in every step of the design process [28]. To keep the focus on the end-user throughout the development and design process of the game, personas were created based on the target group of the project.

The iterative process in the project consisted of several iterations with each iteration consisting of the same four steps: (1) planning and requirements, (2) analysis, design, and implementation, (3) testing, and (4) evaluation. The project also included the initial planning phase but did not include the deployment phase of the classic iterative interaction design process.

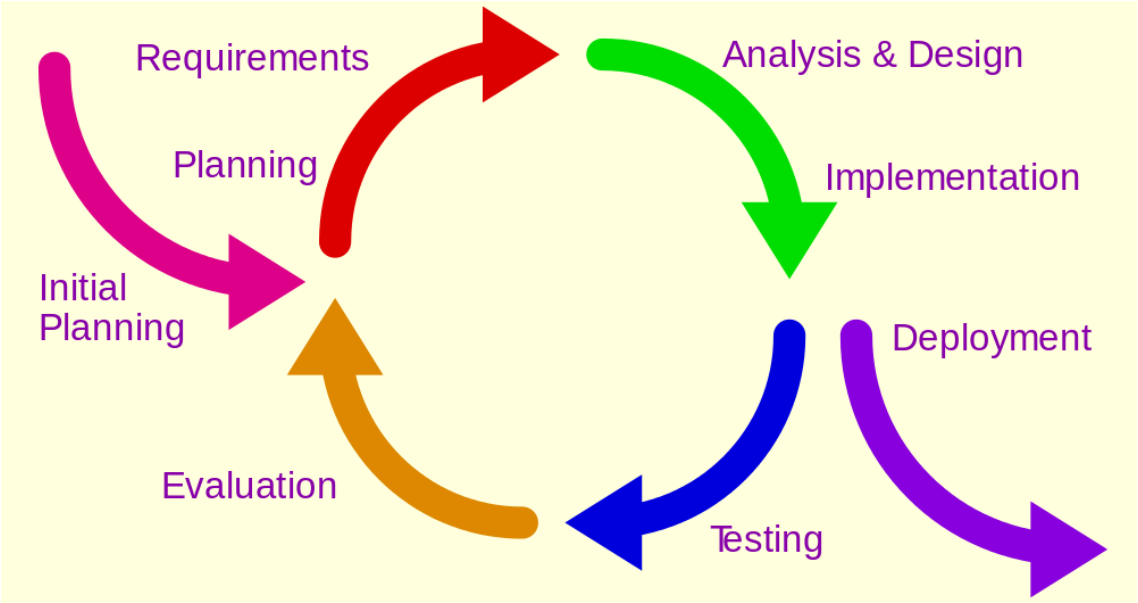

Figure 3.1: An image representing the classic iterative interaction design process with the four steps making up the inner circle as well as the initial planning phase and deployment phase. From [29]. Public domain

Following are descriptions of the contents of each step of the project.

Step 1: Requirements and Planning
The first step of the iterative process focuses on planning which means that requirements and tasks are defined for the iteration. Requirements can consist of environmental, functional, usability, and user experience requirements. Defining requirements and tasks makes it easier to keep the focus on the design of the game and can be used for evaluating the game at the end of each iteration [30]. The requirements will initially be based on the theory the project relies on, but might evolve throughout the development of the game.

Step 2: Analysis, Design, and Implementation
The second step focuses on creating a design based on the requirements defined in the first step. The design includes everything from user interface to game mechanics, resulting in a prototype.

Depending on which iteration the process is currently at, the prototype can be either low-fidelity or high-fidelity. Starting with a low-fidelity prototype, for example a paper prototype, is less time consuming and requires low effort to create [30].

The prototype can then evolve into a high-fidelity prototype by being implemented into a digital environment, which means that it will be easier for the users to interact with and more similar to the final product.

Step 3: Testing
Testing includes people outside of the project group playing the game-prototype. Testing is done to gather data that can be used to improve the design. This might lead to new ideas as well. Testing is preferably done on people from the target group. In the case of this project, on children between the ages of 10 to 12 years old.

Testing will be done by observing the players and their behaviour to determine whether they show signs of collaboration. Interviews will then be conducted to gather insight on the players' impression of the game; if they liked it, what elements of the game they liked, what they didn't like, and if they would prefer other functionality.

If needed in the iteration, A/B testing [31] might be used to compare two different designs that fulfil the same requirements. This can be done to determine which design works better after testing each version.

Step 4: Evaluation
After testing follows an evaluation of the game. The evaluation will be conducted through discussion of the test results, the design, and the prototype, after which the changes will be made accordingly for the next iteration.

4
Development

This chapter accounts for the development of the game through an iterative UCD process. The chapter starts with a section about the initial planning stage which consists mainly of the development of game ideas. After this section follows accounts of the iterations which describes the development of the game divided into four steps.

4.1 Initial Planning

The project started with acquiring knowledge about collaborative games. This was done by reading articles of previous works and understanding the purpose of the project. By acquiring background knowledge and gaining a clear view of the main goal it became easier taking the first step which was to generate an idea for a collaborative game.

To come up with an idea that would support collaboration between players, several brainstorming sessions took place and resulted in many different ideas, summarised in Section 4.1.1.

Parallel with the development of the game idea, a schedule of the timeline was compiled in a Gantt chart (see Appendix 1).

It was decided that the development of the game would take place in three iterations. The first iteration was planned to result in a low-fidelity prototype, i.e. a paper prototype, while the second and third iterations would result in high-fidelity prototypes, i.e. digital prototypes.

4.1.1 Game Ideas

The following is a selection of the more evolved ideas that were considered for development:

Escape Room
This game idea was inspired by the *escape room* concept where a group tries to solve a problem in order to be let out of a cell or room(s). Four players are imprisoned in four different rooms. The players can only see the room that is on their screen, in a first-person mode or top-down view. Each room has, for instance, items that are needed or buttons that can be pressed that help someone in another room. The goal

is to escape together from these rooms by solving a common puzzle where everyone plays a different role.

The problem with this idea is that since the tablets are connected to each other, creating a big screen, all players would, therefore, have *symmetric information*. In order to make the game idea functional the players need *asymmetric information*, meaning that they should not see the other players' screens. Hence, the game would be better played if each player had their own tablet, with no possibility of seeing the other screens. Connecting the tablets to create a map or a big screen is therefore unnecessary and the idea does not fit in the purpose of the project.

Water Pipes
This is an idea that is heavily based on an already existing game where water flows out of a pipe. The objective is to get the correct parts and lead the water to the goal. The screen would be split up into four parts where each player could navigate the water through their respective screen.

The idea was discarded due to the existence of this game in a single player version. Had this idea been chosen a lot of the design and functionality would already have been set and not allowed for designing a game from the beginning. Implementing the water pipes idea would simply have meant redesigning an already existing single player game into a multiplayer collaborative co-located game.

Laser Puzzle
The laser puzzle idea was loosely based on the same conceptual idea as the water pipe game. Players need to solve a puzzle in the form of creating a path to solve the game. This is done by directing a laser from a starting point to an endpoint with the use of mirrors that can be rotated to redirect the laser. This way the players are able to immediately interact with the laser and solve the puzzle together.

An extension of this idea was to replace the mirrors with blocks. This would mean that each player would receive blocks that they would need to place in front of the laser to redirect it.

4.1.2 Chosen Game Idea

The chosen game idea ended up being *Laser Puzzle*. Laser Puzzle is essentially a puzzle game where players have to collaborate to solve a puzzle that consists of finding a path from a start point to an endpoint through a labyrinth-looking environment. To do this the players have to interact with an object that redirects the laser.
The main reason for choosing this idea was the potential for implementing functions that fulfil the requirements of a collaborative game. All players have to be part of the solution to complete the puzzle. It is a simple game idea that can be further developed with different functionalities. Enforcing all players to be part of the solution encourages the players to collaborate and to communicate.

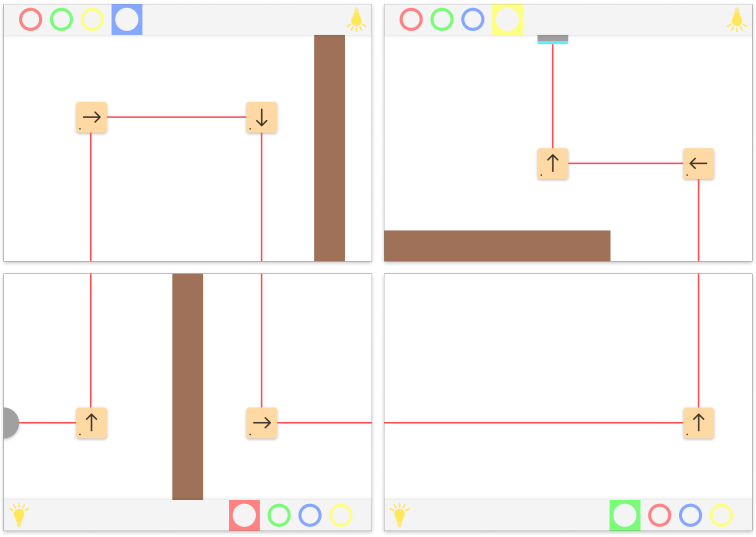

Figure 4.1: An early representation of the game idea Laser Puzzle.

Taking into consideration the fourth idea of gameplay design for children from Section 2.5, the ecology for the game was discussed. As it is beneficial to have someone children look up to and who can help setting the learning environment of the game, as mentioned in the eight idea in Section 2.5, a school environment seemed to be the most appropriate environment. In a school there are not only teachers that can supervise the game session, children spend a lot of time at school and interact a lot with other children making a school environment a good place for practising collaborative behaviour. While a school environment is not a requirement for playing the game, the definition of a setting aided in the game development.

At the time of coming up with the idea the game was simply referred to as the laser game. However, later on the name of the game changed from Laser Puzzle to *Mirror Madness*, to *Block Bonanza*, and finally to *Laser Lunacy!*.

From this point on, the game will be referred to as Laser Lunacy!.

4.2 Iteration one

Iteration one resulted in two low-fidelity prototypes. These two prototypes were used to test out different functionalities for the user to interact with. The main focus of iteration one was to examine the basic concepts of Laser Lunacy!.

4.2.1 Step 1: Requirements and Planning

During the development of the idea for Laser Lunacy! certain requirements were defined. The list of requirements was updated through further development of e.g. functionalities throughout the development process.

- Clear start and goal for the laser.
- Direct the laser with stationary but rotatable mirrors or movable but one-directional blocks.
- A time limit to give the players a sense of urgency.
- The player has to actively hold the mirror or blocks in place to redirect the laser.
- Obstacles which forces the players to direct the laser along a set path.
- Some of the obstacles, such as walls, could be mobile and have to be moved to open the set path.
- Disruptive elements such as an enemy or bombs which destroy the mirrors or blocks.
- A requirement for all players to be part of the solution.
- An indicator that shows the participation of a player in the solution.

Initially, the idea of using mirrors in Laser Lunacy! sounded promising. However, it was decided that two prototypes would be developed and tested to determine which type of object to use for redirecting the laser. The idea for the game would stay the same for both prototypes with the only difference being the use of mirrors versus blocks.

Along with defining requirements and functionality for the game, personas were developed (see Appendix 3). The personas were created based on the perception of today's children to reduce any potential influences from the developers' personal preferences.

To keep a broad spectrum of end-users inside the target group, the personas were developed with varying personalities, family dynamics, gender, age, disabilities, and preferences. The personas had varying degrees of social interactions with friends and classmates, and varying degrees of experience with computers.

4.2.2 Step 2: Analysis, Design, and Implementation

Keeping in mind previously discussed game functionality, two initial designs were made. The first design that uses blocks is shown in Figure 4.2. This design was meant to be a tutorial with no obstacles and one or two blocks per player. The players have to reason together on how to solve the puzzle and drag and hold the blocks into the right position. For example, if they got the wrong block they would need to trade with each other. This could be done by using a teleportation device that each player has on their dashboard at the bottom of their tablet. Moreover, each player had to contribute to the solution for the level to pass, otherwise, they would not clear the level. This ensures collaborative play between the players. To make the players aware of this requirement an indicator on the dashboard was implemented. This indicator would light up if there was at least one block on the indicator's respective tablet.

A number of design patterns (see Section 2.3) had been implemented, and many of the choices regarding mechanics were made to use these design patterns. One

functionality is the fact that players start with blocks that might be needed by someone else. This implements the pattern *social interaction*, as the players need to communicate which blocks they have on their dashboard and which blocks they need. To trade blocks, the players need to use teleportation devices, which make use of the pattern *trading*.

Another design decision made was letting blocks reset their position once a player lets go of the block, forcing the player to hold the block in place to redirect the laser. Implementing the blocks this way counteracts any potential single-player gameplay in Laser Lunacy!. The resetting of blocks makes use of the pattern *concurrency* and creates interdependency between the players. Interdependency in Laser Lunacy! means that the players need each other to complete a level, and thus the pattern *gathering gate* is used as they advance together or not at all. The pattern *team play* was implemented to force the players to communicate about their game strategy. Lastly, the players also share the same goal of redirecting the laser into the goal, which incorporates the patterns *cooperation* and *mutual goals*.

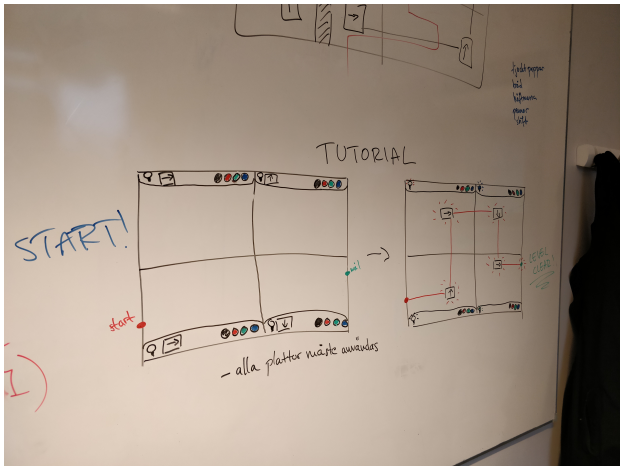

Figure 4.2: The first design of a game level meant to be a tutorial and using blocks to redirect the laser. The left shows the game map at the start of the game. The right shows the solution to clear the tutorial.

The first design featuring the mirrors is shown in Figure 4.3. At the start of a level the mirrors are placed in fixed positions on the game map. The users then need to rotate the mirrors to change the direction of the laser. To direct the laser the players have to hold the mirror. If the mirror is released it resumes its original angle. There is also an enemy that walks around and destroys the mirrors, that can only be defeated using the laser.

Many of the design decisions were similar to those that were made for the prototype involving blocks. Thus, many of the same design patterns were used as well. The aforementioned resetting of mirrors' orientation makes, like the block prototype, use of the pattern *concurrency*. The remaining design patterns used in the block prototype are also used in the mirror prototype in the same way.

One difference from the block prototype is that the prototype with mirrors has an enemy that disrupts and puts pressure on the players. The enemy, along with a timer that ticks down, was included mostly for the sake of helping to reduce the emergence of an *alpha player*. The idea is that the enemy will keep players busy, which hopefully means that they will not have time to focus their attention on other players - since they need to focus on themselves. Furthermore, the enemy appears at random times throughout the level, which makes use of the pattern *surprises*. Finally, the enemy can be defeated by the laser resulting in players defeating the enemy and rescuing other players which incorporate the pattern *eliminate and saviour*.

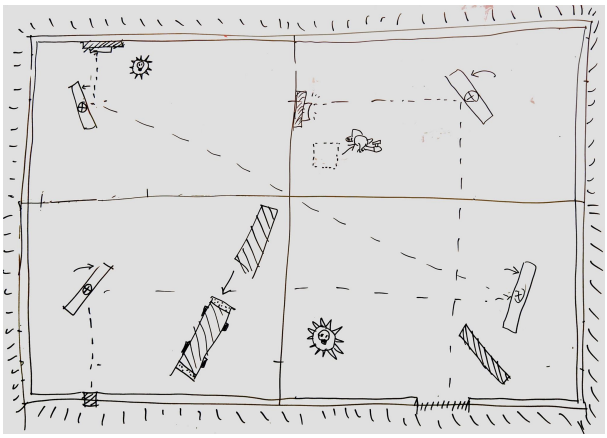

Figure 4.3: The first design of the game illustrating mirrors which is a more difficult level. Features illustrated are an enemy, bombs, movable objects and a teleport for the laser.

4.2.3 Step 3: Testing

The two ideas were made into paper prototypes. The original plan was to visit a school and let the target group test the two concepts. However, after the building process it did not feel appropriate to test the functionality at a school with the intended target group, as the purpose of the testing was to determine whether to use mirrors or blocks. Instead, the testing was conducted by the group members who took turns playing the two different versions of the game. After a few sessions it became clear that the blocks were the better-suited object for the game.

4.2.4 Step 4: Evaluation

The conclusion from the testing was that blocks were better suited since they enable the use of the pattern *trading*, but also because they would be easier for the players to interact with. Design decisions taken in iteration one were made to test general concepts for the game to ensure more specified functions in iteration two. In regard to the visual design of the game, none of that was incorporated into the paper prototypes, but ideas such as a temple environment were discussed to make the game look more appealing.

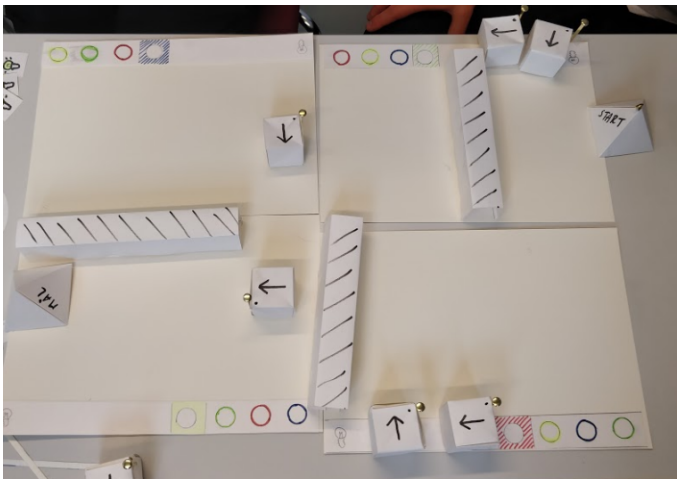

Figure 4.4: Image of the finished paper prototype with blocks for a potential first level. In the image there are obstacles, a dashboard per player, start and goal for the laser and blocks.

4.3 Iteration two

This section is the follow-up from iteration one and resulted in a high-fidelity prototype, i.e. a digital game playable on tablets.

4.3.1 Step 1: Requirements and Planning

A lot of the game's functionality was developed during the discussion sessions for game ideas but not all of this functionality was tested during the first iteration. Implementing all of the ideas in the game appeared to be too big of a task. Therefore, a set of basic functionalities and requirements were defined to ensure that by the end of iteration two there would be a form of minimum viable product (MVP). The MVP was decided to have at least one level, although more levels would probably not be that difficult to create once the first level was completed.

List of basic functionality and requirements of an MVP:

- The game should have at least one level.
- The level has to be able to be completed.
- To complete the level, the laser has to reach the goal and all players have to be part of the solution.
- The solution should not be obvious to the players at first sight.
- The laser has a starting position from which it shoots the laser in a set direction.
- When the laser hits a block, the laser is redirected in the indicated direction of the arrow on the block.
- The players can drag the blocks on the map.
- If a block is released it teleports back to the dashboard.
- The players receive the required blocks in a randomised order, located on the

dashboards.
- The players exchange blocks using teleportation platforms located on the dashboards.
- The game should be visually appealing.

In addition to these requirements, the MVP also has to fulfil the requirements mentioned in the introduction (see Section 1.2).

Depending on the time and effort it would take to develop an MVP, additional features could be implemented to heighten the game experience. These features are listed below in no specific order:

- Enemy
- Countdown timer
- Lose and restart a level
- Multiple levels
- Movable obstacles/doors
- Laser teleportation

The testing for iteration two was planned to be conducted at a school with children from the target group. It was decided that the test would start with an introductory questionnaire, followed by the play session in which the players' behaviour was observed, and completed by the players answering questions about the game. The questionnaires can be found in Appendix 2.

4.3.2 Step 2: Analysis, Design, and Implementation

To accommodate four players on four separate tablets, the layout of the game was divided into four equal parts, i.e. game zones. Each part corresponds to one tablet and one game zone equals one player. In each zone, at the bottom of the screen, there is a dashboard with room for blocks, teleportation platforms, identifying symbols, and potentially other functionally. Each player has three teleportation platforms, one for each of the other players. Each player's teleportation platform is represented by their symbol in order to know to whom the cube will be sent. When beginning a level, each player will receive one to three blocks. The maximum allowed number of blocks is three blocks per player.

To make the game visually appealing, a temple theme was decided upon. The game board, therefore, resembles rooms from an old abandoned temple where the floor, walls, and blocks are of a stone structure. To be able to tell the difference between blocks and walls, the objects have been assigned different materials. To achieve an appealing look, an environment package was used [32].

In total, three levels were designed. However, because of time constraints, only one of the levels was testable, which can be seen in Figure 4.6. In the level, there are two crystals; one purple and one yellow. The similarity of these crystals, which share the same mesh, subtly lets the players know that they are related. Hopefully,

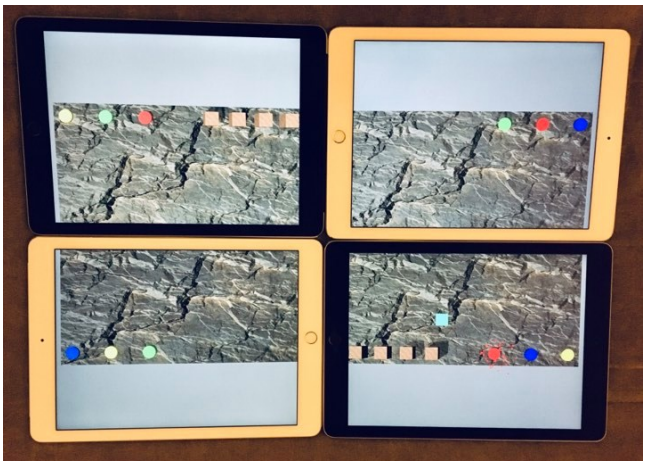

Figure 4.5: Early version of Laser Lunacy! consisting of a game map, teleportation platforms identified by colour, blocks, and testing of materials.

because of this, the players will realise that they need to lead and direct the laser from the purple crystal into the yellow crystal. The colours are also deliberate; the origin crystal is purple to match the colour of the laser, and the end crystal is yellow because it is a complementary colour to purple.

The look of the teleportation platforms was changed from coloured, flat cylinders to square platforms with coloured symbols. This is because one of the personas is colour blind. With the previous implementation, it might have been difficult to tell the red and green platforms apart. Now, it should be much easier given that the symbols are distinct and shaped differently.

The layout of the level, as seen in Figure 4.6, was designed to ensure that all four players are involved; the laser simply must pass through all tablets. The level design makes sure that everyone is part of the solution, which makes the indicator from iteration one redundant.

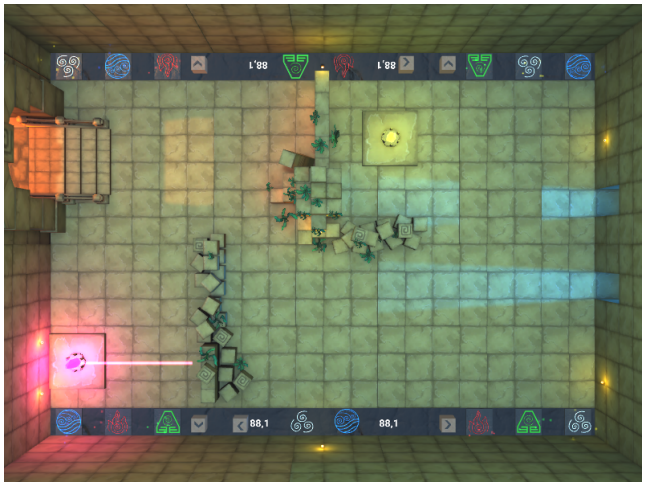

Figure 4.6: Later version of Laser Lunacy! with environment package in use.

Because it is a networked game, some objects need to be network-based. Static objects such as obstacles and the map do not need to be networked since they will not change during the course of the game. Game objects like cubes that move across tablets have to be networked. Since the cubes are being moved by the players, other players need to know if a player has moved any cubes. The cubes and dashboards are networked objects since they need to update their state to the other players. All networked objects are updated through the server and not the players.

4.3.3 Step 3: Testing

The test was conducted at Vasaskolan, an elementary school, with four students between the ages of 11 to 13. The students started by answering some questions about how much time they spend on various electronic devices, such as computers and mobile phones. The next step was to give each student a tablet and let them play the game, during which the group members observed their behaviour.

The players were quickly able to understand how to complete the level. They identified the laser's relation to the crystals; the laser needs to reach the yellow crystal to complete the game. Following their discovery of the crystals they now understood that they somehow needed to redirect the laser and started to look for ways to accomplish this. This step took a bit longer as the players searched for objects to interact with in the game. Through trial and error they soon discovered the movable blocks at which point they comprehended the directional symbols on top of the blocks.

They pulled out the blocks onto the map to interact with the laser and discovered that the laser changed direction. Their next realisation was that they did not have the correct blocks to direct the laser along the path and that they needed to exchange blocks. At first they tried to simply drag the block across the screens and immediately discovered that the blocks returned to their original position. It took a short while but soon enough one of the players made the connection with the symbols and announced this to the whole test group, to which they all agreed that this must somehow be a way to exchange blocks. They moved over a block to one of the teleportation platforms and discovered that it worked.

After this they started playing the game as intended, at which point their communication and interaction took a new turn. There was a lot of communication about exchanging blocks and relaying information about which blocks they needed and also which blocks they had and could give to another player. Some expressions they used are presented in the following list:

- "What block do you need?"
- "I need a [direction] block."
- "I'll send a [direction] block to you." or "I'm sending a [direction] block."
- "You need a [direction] block."
- "I have a [direction] block."

- “I have a block you need.”
- “You have a block I need.”
- “Which one are you?” or “What colour are you?”

The players also expressed very clear body language which they used to point out objects in the game or the direction they needed the laser to go. They started using more non-verbal communication as a result of discovering that saying ’up’ for one player could mean ’down’ for another. They, therefore, started pointing and gesturing to clarify the type of block they needed and also who was currently in possession of that block.

At times the players reached over to interact with the tablet of another player. However, the impression of this was that it was made with the intention to help. It was sometimes done upon request of the owner of the tablet when they felt that they were unable to do something themselves.

After completing the level, the players were asked questions on what they thought about the game, its features, and the functionality. Overall, they liked the game. They had a lot of ideas for future development, some of which have been discussed and considered for a later iteration. Some ideas included different types of blocks with different properties, a reward system, and the possibility to create custom maps that could be shared online.

The test participants were also asked if they felt like they could have completed the game by themselves or if they felt like they needed other players. They responded that they clearly felt that they could not have completed the game by themselves and that they won together through team effort.

4.3.4 Step 4: Evaluation

The user testing of the game went well. The players exhibited collaborative behaviour through communication, not only verbal but non-verbal. When asked if they felt if they had been part of a team to complete the game they answered affirmatively. There were a lot of bugs discovered in the game during the testing which hindered the players from trying all three levels, but despite this the results were still positive. The game seemed to indeed encourage collaboration. Based on the test participants’ suggestions and comments, the game could benefit from more mechanics being implemented in upcoming iterations.

4.4 Iteration Three - Final Iteration

Iteration three is the final iteration in the project and is built on iteration two.

4.4.1 Step 1: Requirements and Planning

Due to the length of iteration two, iteration three became a lot shorter than originally planned. It was not realistic to implement any new functionality in the time left. Also, from the test in iteration two it became clear that the game had a lot of bugs which resulted in only one of the three developed levels being tested. Therefore, the focus of this iteration became bugfixes in order to get all three levels to work.

The test of the prototype in this iteration was planned to be conducted in Denmark by the team members of CITE. The game was sent together with the questionnaire, which can be found in Appendix 2, used in the previous test at Vasaskolan. Therefore, the test would consist of an introductory questionnaire, followed by a game session.

In addition to the questionnaire, the members of CITE were asked if they could record while playing the game. A video would make it easier to evaluate the children's behaviour and communication, as well as whether or not the purpose of the game is accomplished.

4.4.2 Step 2: Analysis, Design, and Implementation

Aside from correcting bugs, two very minor changes were made. During the tests from the previous iteration, it became apparent that the blocks were sometimes difficult to tap on. Therefore, to amend this problem, the blocks have been made bigger, and the colour of the blocks have been made lighter in order to make them more visually distinct.

4.4.3 Step 3: Testing

The test was conducted in Denmark with four students from the ages of 7 to 10 years old. Because of the short length of iteration three, there was not enough time to test the game on the intended audience. Moreover, the test was conducted without a project member present. This was to some extent compensated for by the presence of an external test leader. However, a newly introduced bug since iteration two led the children to spend significant time playing the game in a way that should not be possible, before the test leader guided them in the right direction. Overall the test was similar to the test conducted at Vasaskolan. The students understood what the goal of the game was, but had trouble exchanging cubes between themselves.

In iteration two, invisible walls were mentioned to separate the tablets to hinder the blocks from being dragged from one tablet to another. Unfortunately they had not been implemented in iteration three, and the blocks could, therefore, be dragged to the tablet lying next to it. This was immediately exploited by the children, making the game much easier than intended. After approximately one-third of the test duration, however, the test leader gave them clues by asking whether they believed this was the way the game was intended to be played. The test leader also asked whether they had any thoughts on the meaning of the "icons", i.e. the teleporters.

After further explaining the concept of teleportation to the children, they started playing as intended; using the teleporters to transport cubes from one tablet to another.

The children used clear body language when communicating with one another. At times they pointed to let the others know who had the block they required. They also pointed to help the others in telling them to give away a block to the one that required it. There were some tendencies that one of the players could become an alpha player; dominating the other players and telling them what to do. At one point, it seemed like a pattern in the children's gameplay had materialised: first teleporting all cubes to the right place, then using them to direct the laser. At a later stage, however, the children were directing the laser with the cubes before having made sure all players had the right cubes. There seemed to be mixed results regarding whether the children found the game fun; some of them verbally expressed this sentiment while others meant the opposite.

4.4.4 Step 4: Evaluation

As mentioned, the testing was heavily impaired by the lack of invisible walls between the tablets, which makes concluding harder. It is uncertain whether the children would eventually have discovered the teleporting mechanism by themselves, as they had little incitement to do so.

The tests suggest that the teleporters may not be intuitive. One way to fix this would be constructing some sort of tutorial, ideally for the current first level (see Figure 5.10) or a level similar to it. The tutorial could include guiding text and indicators that explain how the game works.

Moreover, the aforementioned invisible walls between the zones should be implemented to prevent players from dragging cubes from one tablet to another. Ideally, these invisible walls will make the players keep experimenting and eventually find out how the teleportation platforms work, and then a tutorial would be redundant. However, further testing and research need to be conducted to check the necessity of a tutorial.

One final thing to note is that two of the players that tested the game were below the intended age of the target group. This could have an impact on the perceived clarity of the teleporters.

5
Final Prototype

This chapter gives a presentation of the game Laser Lunacy!, what it looks like, its different features, and the gameplay design patterns used.

5.1 Final Prototype: Laser Lunacy!

When starting the game, a splash screen as shown in Figure 5.1, containing the game's logo is shown.

Figure 5.1: The game's logotype, displayed on the tablets at start-up.

To be able to play together, the players are met with a screen in which they can choose room A or room B (Figure 5.2) which are waiting rooms for two different instances of the game allowing for two different groups to play the game simultaneously. Players wanting to play together need to choose the same room to end up in the same instance of the game.

Figure 5.2: People can choose between room A and B in order to join the game.

When everyone has connected to room A or B, they are met with a picture. The picture works as a puzzle for the players to solve so they can put each tablet in the right place (Figure 5.3). When all tablets are put in the correct place, all players need to hold a finger on their tablets simultaneously to make the game start.

Figure 5.3: The puzzle picture that helps the players to put the tablets in the correct order.

Laser Lunacy! is a game in which four players need to cooperate to get a laser from its starting point to a goal. The starting point is a purple crystal shooting out a laser, while the goal is a yellow crystal which can be seen in Figure 5.4.

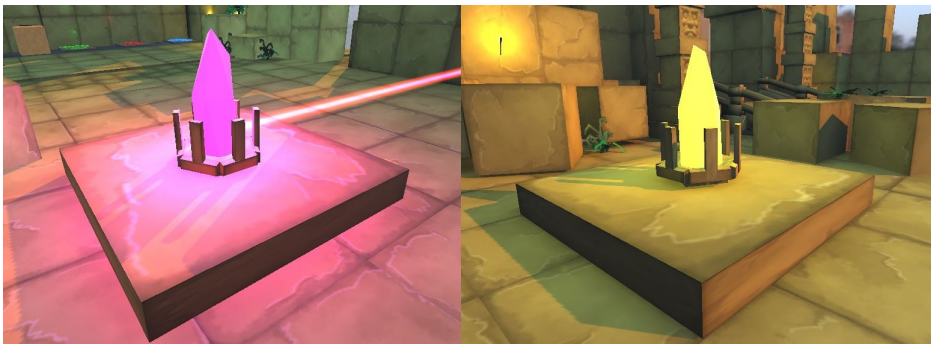

Figure 5.4: The purple crystal is the starting point which emits the laser, and the yellow crystal is the goal.

To reach the goal, players can forward the laser by moving cubes which has a set direction on them in the form of an arrow (see Figure 5.5). When the cube is activated, its arrow changes colour to white.

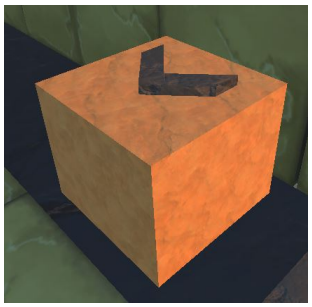

Figure 5.5: A cube which can forward the laser with a set direction represented by an arrow on top.

Each player has a dashboard on which all cubes are spawned (see Figure 5.6). The dashboard has symbols with colours that represent the players in the game. If a player needs a certain cube to forward the laser, other players can teleport the necessary cube to that player. The dashboard can hold a maximum of three cubes at a time, which means that players might need to give away a cube before they can be given the right one. The dashboard has a timer as well, which shows how long the players have left to complete the level.

Figure 5.6: The dashboard of player blue (or water), who has one cube.

The game features an enemy; a dwarf who destroys cubes if they are outside the dashboard (see Figure 5.7). The dwarf can be killed if hit by the laser.

Figure 5.7: The enemy that patrols the area.

When a cube has been destroyed by the dwarf, the player has to wait for the cube to respawn again. The time left to respawn is represented by a meter, as shown in Figure 5.8, that gets filled up with green colour. The cube becomes transparent to show that it is not usable.

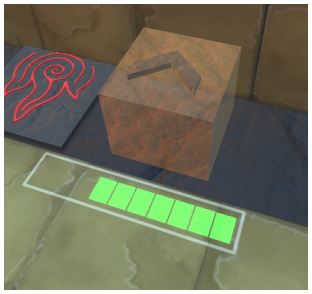

Figure 5.8: A cube that has been destroyed and is loading to be respawned.

The players also need to coordinate to remove obstacles. In level three, obstacles are blocking the way of the laser, and other players need to press orbs to remove the obstacle (see Figure 5.9).

Figure 5.9: An obstacle blocking the way to the goal, and the orb that has to be pressed in order to remove the obstacle.

The final prototype has three levels with incrementing difficulty. The first level has few obstacles and its purpose is to let the players learn how the basics of the game work (see Figure 5.10).

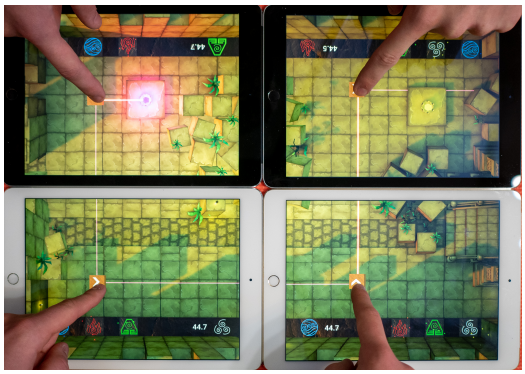

Figure 5.10: The first level which only requires one cube per person in order to be solved.

The second level introduces the dwarf and has a little bit more complex level layout (see Figure 5.11).

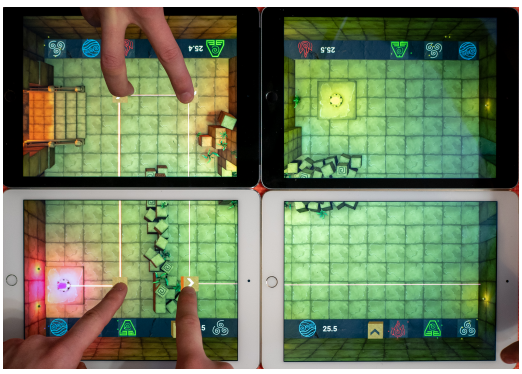

Figure 5.11: Level two with an example on how to start solving the puzzle.

The third level features the dwarf, the removable obstacles, and an even more complex puzzle (see Figure 5.12).

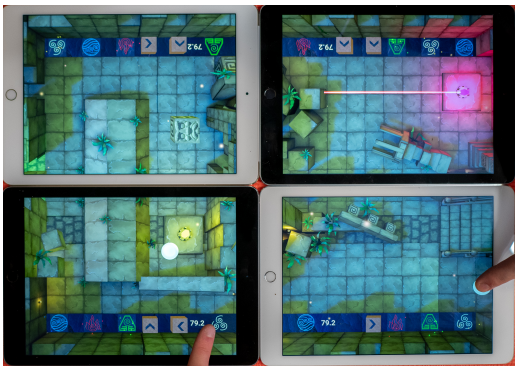

Figure 5.12: Level three is a more difficult level with a lot of features.

When a level is completed or the timer runs out, the players are met with a level complete screen or game over screen (see Figure 5.13). The players can press a button in order to go to the next level or restart the game.

Figure 5.13: The level complete screen and game over screen.

Sound effects were added to give players auditory feedback to their actions and make the game more immersive. In addition to sound effects background music suitable for the temple theme was added.

5.1.1 Gameplay Design Patterns

The following list consists of gameplay design patterns used in the game, the definitions can be found in Section 2.2, and explains how they are incorporated in the game.

Symmetric Information
The game board consists of four tablets and all players can see the entire map. Therefore, they receive the information at the same time and they all have access to the same amount of information.

Movement and Maneuvering
The blocks have predefined ways they can be moved as well as some of the walls.

The laser is redirected by the blocks, which have to be moved around not only to get the laser to the goal but also to defend players from the enemy walking around on the game board. When all cubes are on the dashboard, they are not visible to the dwarf and he instead patrols the map according to invisible waypoints. If a cube is on the map, though, he will instantly start walking towards the closest cube.

Asymmetric abilities or roles
Asymmetric abilities are introduced when a player has an ability that not all the other players have. An example of an asymmetric role is when one of the players has to use a lever to remove an obstacle for another player.

Symmetric abilities or roles
The players will mainly have symmetric abilities, meaning that all players can do all the same things. E.g. they can all move and teleport blocks.

Experimenting
In the third level of Laser Lunacy!, a new kind of obstacle is introduced. They are stones with a face that blocks the path for the laser (see Figure 5.9). In order to remove the obstacle, to let the laser through, one player has an orb that has to be pressed to remove the obstacle. They are implemented in such a way to make the player think and experiment on what works and how to remove the obstacle.

Surprises
The enemy is going to appear at random times to destroy the blocks, which thereby adds an element of surprise.

Cooperation
All players have the same main goal. The laser is supposed to be redirected to the yellow crystal. They might have subgoals in addition to the main goal, which could be the use of a lever to remove an obstacle for another player. All subgoals help the players to reach the main goal.

Team Play
To solve a level in Laser Lunacy!, four players have to collaborate. One player will not be able to solve the puzzle by themself.

Social Interaction
The players have to interact with each other all the time to know who has what block and where to direct the laser. They will also have to communicate in order to eliminate the enemy before it destroys any blocks.

Trading
Players receive one to three blocks, and not necessarily the right ones. If a player does not get the right block(s), they will have to trade with another player in order to solve the puzzle.

Eliminate and Saviour
This is used when the players kill the enemy, he will be eliminated but is going to reappear again when the players least expect it. A saviour is when one player helps another to kill the enemy before it destroys the blocks and thereby save the other

player.

Traverse
The goal is to direct the laser from a starting point to an endpoint. The endpoint will be located somewhere on the other side of the board with obstacles in the way.

Concurrency
Each player has one or more blocks that they have to hold in place in order to redirect the laser. Four blocks are the minimum amount of blocks that have to be used to solve a level, and there has to be at least one block on each iPad. This makes it impossible for only one player to manage alone and the players have to hold the cubes on the map simultaneously.

Mutual Goals
There is one goal in Laser Lunacy!, to redirect the laser to the yellow crystal. All players have to reach that singular goal together.

Gathering Gate
The laser starts at one point and one player at the time can change its direction. Therefore, the other players have to wait for the laser to reach their part of the game board before they can contribute their part of the solution.

6
Discussion

In this chapter, a discussion of the test results will be conducted based on the purpose of the project. The chapter starts with a short recap of the purpose of the project and continues to answer what gameplay design patterns encourage collaboration. Following, the tests, test results, and implementation are discussed from a reliability aspect. Ideas on how the game could be further expanded, what could be the next step, and what ideas, concepts, and mechanics that could be implemented and why follow the discussion of the test results. Together with this, there is a discussion on whether Laser Lunacy! can be used as a learning tool for the development of social and emotional skills in children. The discussion ends with a short overview of the work process during the project and mentions any problems in the implementation of the game.

6.1 A Collaborative Game for Children

The purpose of the project was to develop a tool for children to practice their collaborative skills in the form of a multiplayer game. To do this, a game was developed for a target group consisting of children between the ages of 10 to 12 years old.

6.1.1 Gameplay Design Patterns

Most of the gameplay design patterns have been implemented in such a way that they force the players to work together by relying on each other and by being incapable of completing the game on their own. Gameplay design patterns that exist in the game but which does not contribute to collaboration are *movement and manoeuvring*, *symmetric information*, *symmetric abilities*, *surprises*, and *traverse*. These patterns were instead pure functional in nature.

Two patterns mentioned but never implemented in the final prototype are *asymmetric information* and *rewards*. The reason for not implementing the pattern *asymmetric information* was due to the implementation of the pattern *symmetric information*. The implementation of one of these patterns automatically meant the exclusion of the other pattern. The pattern *rewards* is a pattern that was meant to be implemented but for which there was not enough time. A rewards-system could have been a good way to encourage children to clear a level faster and thereby improving their collaborative skills.

6.1.2 Designing for Children

The game's target audience is children, which means that it is important to have them in mind when making design decisions. The levels seemed to have an appropriate difficulty since the test participants completed all the levels and didn't lose interest. Though it is difficult to assess since the game only has three levels. The only complaint was that the enemy was a little bit too slow and did not really increase the difficulty. It seemed promising though that the test participants managed to figure out how to play the game mainly by themselves.

It is important that the game can be played by anyone so that no one feels left out. Implementing symbols along with colours to represent players is an example of how colour-blind children can play the game with their friends. However, further testing needs to be conducted in order to check if this is an effective solution.

The game is intended to be played in a school setting which means that adults will be nearby. Designing for a certain environment is important since it can influence how children play the game. The school environment provides scenarios where an adult is always nearby. Children look up to adults and often mimic what they do, so the possibility of having an adult around can benefit the game and how the children play it. The testing from iteration three showed that adults indeed affect how children play the game. An adult present in the testing pointed out that the test participants were not trading blocks in the intended way, after which the players began playing the game the way it was meant to be played.

Including children in the developing process is important to remove any personal preferences and biases. Looking at the feedback from the test results, there were not any unexpected answers, which indicates that the developed personas did not fail to represent the end-users. However, researching the end-user group could help improve the personas and solidify their accuracy.

Some of the ideas that are important for designing for children were not possible to implement into the game idea e.g. physical activities to improve learning, but the game covers most of them in different ways.

6.1.3 Exhibited Test Behaviour

The test results show that the players exhibited communicative behaviour. This was done in the form of verbal communication with the players exchanging information about available blocks they could give away, blocks they needed to complete their part of the puzzle, their player identification symbol, and the type of block needed. Physical communication in the form of body language through gesturing was also exhibited by the players, most clearly in the testing from iteration two, to clarify the direction of the block needed. The cause of this was the opposing positions of the players where 'up' for one player only meant 'up' for one of the other three players, and corresponded to 'down' for the other two. By using body language, the test group from iteration two ensured that they received the exact block that they

needed.

While communicative behaviour was exhibited in both test groups, it was much clearer in the test group from iteration two than it was in the test group from iteration three. There are several factors that could have contributed to this. One is that, while the testing from iteration two was conducted by the developers of the game, the testing from iteration three was conducted without the supervision of anyone from the development team. This resulted in the test participants from iteration two following the rules of the game much closer than in iteration three. When the test participants from iteration two discovered a bug in the game which allowed them to "cheat", the supervising developer could quickly correct the behaviour by imposing restrictions, something that didn't occur until significant time had passed in iteration three. Another factor that could have affected the results was that two of the test participants in the testing for iteration three were younger than the intended target group for the game. This might have affected the player experience of the two younger players, making the game more difficult for them and resulting in the players not engaging in the collaborative elements.

A problem that can hurt the collaborative element, especially if the children are not supervised, is that the game does not seem to currently provide enough functionality to keep each player occupied. This gives players an opportunity to tell others what to do in a larger capacity than intended, which can both be positive and negative. Positive in the sense that the team might have a leader that they follow, but negative in the sense that the leader prevents the other children to be a part of the solution more than just moving certain blocks.

6.1.4 Cooperative Learning and Development in Children

The game creates an environment for four people who have to work together to solve a task, similar to the environment of cooperative learning. The tests show that the players have pro-social and cooperative behaviours which is one of the key principles in order to achieve cooperative learning. One way Laser Lunacy! aims to achieve cooperative learning is by using the gameplay design pattern *asymmetric roles*; the players have to play their part in order to complete levels, which gives each player a specific responsibility.

Overall, the children seemed to have fun while playing the game which is an important motivating factor for learning. If the game is played in e.g. a school environment, a teacher can make sure that the children are behaving while playing the game. This gives a foundation for using Laser Lunacy! as a cooperative learning tool regarding social and emotional skills. The game promotes individual accountability and positive interdependence since it is impossible to complete the game if the whole group is not involved.

6.2 Societal and Ethical Problems

In the introductory chapter it was brought up that bullying amongst schoolchildren is an issue that needs to be taken into consideration when developing a game for children. This may be especially true if the game is mainly intended to be played in a school environment. While the issue of bullying is a larger problem than a simple game can handle, there are certain preventive measures that can be implemented into the game to prevent the emergence of an alpha player. An alpha player is not necessarily a bully, however, there are scenarios that may occur in team-based games in which one or several players become more dominant and assertive. Players may possess different traits and have different levels of experience. This can cause differences in their effectiveness as players, resulting in some players being faster and perceived as better at a game while other are slower and therefore perceived as bad players. A possible consequence of this is the faster players becoming impatient with the slower players which can result in e.g. the exclusion of the slower players or the faster players speaking ill of the slower players. To prevent such scenarios, Laser Lunacy! starts at a very low level of difficulty where all the players have time to learn the functionalities of the game. This gives an equal opportunity for the players to learn the game and to become equally effective at playing it, even at a more difficult level. The implementations of an enemy, obstacles, and having to hold the blocks in place were all meant to keep the focus of a player on their own tablet. The idea behind this was that if a player is occupied with their own tablet, they will not have time to impose on another player's tablet. Though attempts have been made to counteract bullying behaviour, these preventive measures may unfortunately not be enough. As an intended setting for Laser Lunacy! is a school environment, or otherwise educational, the presence of an adult, e.g. a teacher, can aid in curbing bullying behaviour and setting up the right learning environment.

6.3 Further Development

The final prototype is not a complete game. There are a considerable number of bugs in the game that have to be fixed in order to enhance the player experience. Additional features should also be added to give Laser Lunacy! a complete look such as a start menu. The game should also consist of a larger number of levels to engage players for a longer period of time. Other potential features that were discussed by the test players during the testing were a rewards-system consisting of currency which could be used to purchase upgrades, e.g. in the form of special blocks. Another possible improvement that could be made is to increase the movement speed and appearance rate of the enemy. Generally, the players not holding cubes were not busy enough, allowing unwanted scenarios like an alpha player to appear. Additionally, to make the function of the symbols clearer, i.e. teleporting cubes, a tutorial could be included that teaches the basics of the game. Another solution to this is to change the appearance of the teleporters or add visual effects or sound effects. In conclusion, there is a lot of room for changes and improvements in the game.

Further research could also go into collaborative elements which could be implemented in the game. Considering the large amount of existing gameplay design patterns, there are certainly more that could be implemented in a game like Laser Lunacy! or potentially in a completely new game. Moreover, it might be beneficial to keep a consistent method for testing throughout the project and to conduct further research into testing games on children. The test results might have been easier to analyse and compare had they been consistent between iterations. This would also make it easier to keep track of improvements and whether or not the game encourages collaboration.

6.4 Methodology and Issues

Two months into the project Sweden suffered an outbreak of the COVID-19 virus and the workflow had to be adjusted accordingly. All meetings and work were changed to take place via internet communication for the rest of the project duration. This caused challenges to the project that were not foreseen in the project plan.

As only one project member had access to the tablets, debugging got more complicated than was initially anticipated. It was hard to communicate precisely what occurred on the tablets without visual showcase. It also required the particular project member to be available for testing on proper hardware.

Due to a lack of general knowledge about networking, especially in game programming, a lot of time was spent figuring out how to implement functionality that would work between the tablets. Iteration two was heavily affected by this, which led to a very short iteration three. The combination of these problems led to the final prototype being less polished than expected.

7
Conclusion

The purpose of the project was to create a tool for children to develop collaborative skills. To achieve this, a four-player game was developed with the requirement that the players had to exhibit collaborative behaviour when playing. The collaborative elements in the game were implemented through the use of gameplay design patterns. The game was developed through an iterative, user-centred design process consisting of steps for planning, design, implementation, testing, and evaluation.

The behaviours exhibited in the test results seem to indicate that Laser Lunacy! is a game that can be used as a tool to develop collaborative skills. During tests, the players mostly exhibited collaborative behaviour through communication. The tests showed that the game may be suitable in an environment intended for cooperative learning. Though it may be a suitable tool for developing children's social and emotional skills, achieving a definitive answer might require broader and more extensive research and testing.

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A

Appendix 1

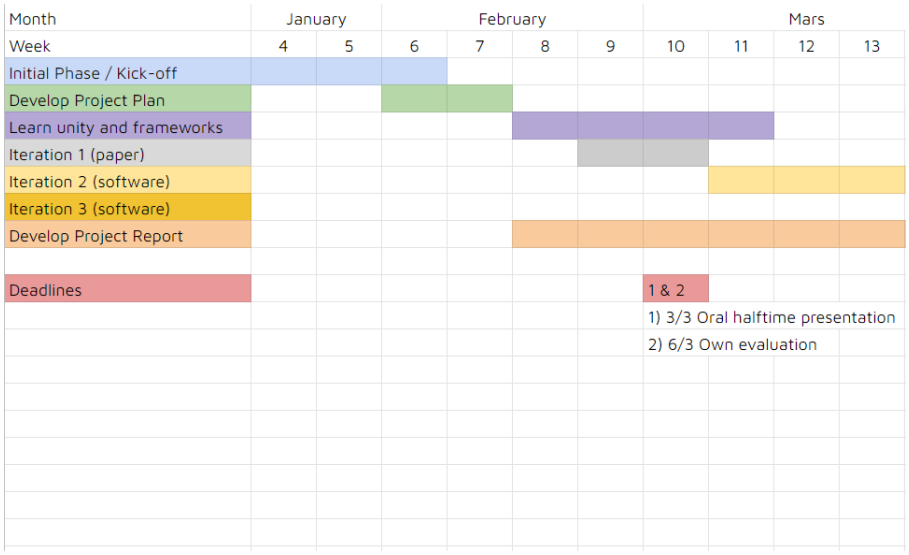

Figure A.1: Gantt chart over the planned timeline of the project (1/2)

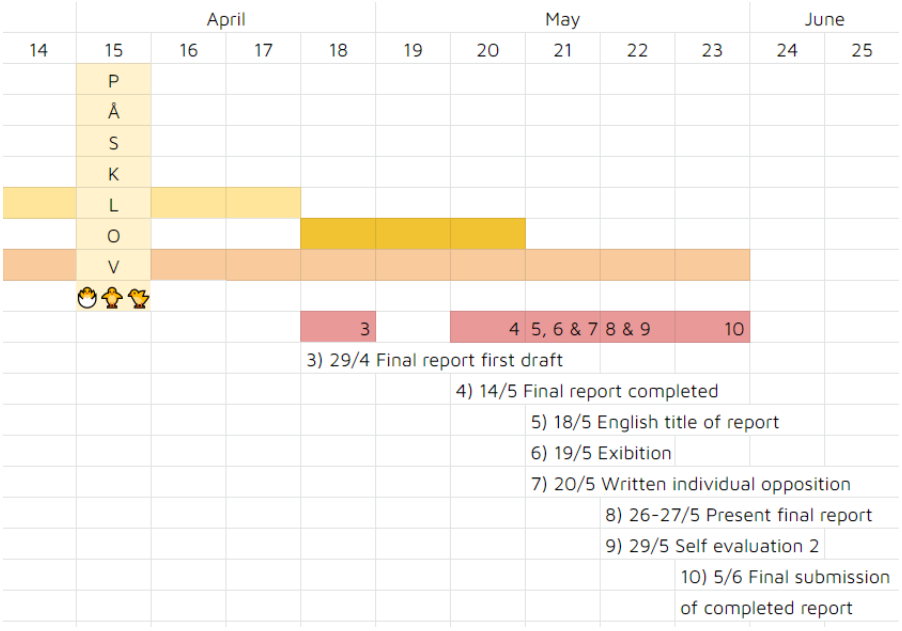

Figure A.2: Gantt chart over the planned timeline of the project (2/2)

B

Appendix 2

(this document has been translated from Swedish)

Initial form with background questions on the tester's digital usage

Execution (completed by a group member):

- How old are you?
- Do you have access to computer, tablet or smartphone?
- Approximately how much time do you spend on the computer in one day?
- Approximately how much time do you spend on the tablet in one day?
- Approximately how much time do you spend on the smartphone in one day?
- What are you doing while on the computer?
- What are you doing while on the tablet?
- What are you doing while on the smartphone?
- Do you spent a lot of your free time with friends? What do you do together?

(this document has been translated from Swedish)

Observation of the players and their behaviour during the test phase of the game.

Number of players:

- Does something seem hard or undefined, do they get stuck?
- What words or phrases are they using, how do they express themselves?
- Is one player the “alpha”-player and takes over or is the leadership even among the players?
- Do they cooperate with each other?
- In what way are they cooperating?
- Are they communicating, and how are they communicating?

(this document has been translated from Swedish)

Interview questions for after the testing of the game.

- Start of game
  1. Was it easy getting the game going?
  2. Did you understand how to play the game?
  3. Was it easy understanding how to play?
     (a) What was easy?
     (b) What was hard?
  4. Was it clear when the level started?
  5. Was it clear who had what symbol?
- Goal
  1. What is the goal of the game?
  2. Was the goal of the game clear or unclear?
     (a) If clear, what was clear or what could be done differently?
     (b) If unclear, what was clear or what could be done differently?
  3. How do you win the game?
     (a) Was it easy to understand what to do in order to win the game?
        i. If easy, what made it easy and is there anything that can make it easier?
        ii. If not easy, what made it hard and is there anything that can make it easier?
  4. How do you lose the game?
     (a) Was it easy to understand what to do in order to lose the game?
        i. If easy, what made it easy and is there anything that can make it easier?
        ii. If not easy, what made it hard and is there anything that can make it easier?
- Controls
  1. How did you find out how to interact with the game?
  2. Was it easy or difficult to understand how to interact with the game?
     (a) What was easy?
     (b) What was difficult?
  3. (How could the interaction be made easier to understand? More intuitive?)
- Block
  1. Did you understand the purpose of the blocks?
     (a) Was it easy or difficult to understand the purpose of the blocks?
        i. If easy, why was it easy and what could be done differently?
        ii. If difficult, why was it difficult and what could be done differently?
  2. Was it easy or hard to understand to use the blocks to change the direction of the laser?

3. Was it easy or difficult to understand in what direction the block made the laser go?
4. What's your impression of the blocks?
   (a) Is there something else that would work better than blocks?

- Teleport
  1. How did it work to send the blocks to each other?
  2. Was it easy or difficult to understand that you could send the blocks to each other?
     (a) What made it easy?
     (b) What made it hard?
  3. What did you think of the idea to be able to send the blocks to each other by teleports?
- Enemy
  1. What did you perceive of the enemy?
  2. Was he too quick?
  3. Was it clear what his purpose there was?
  4. What did you think of him destroying the blocks?
  5. Was it easy to understand how to kill him?
  6. Was it clear what to do when he destroyed a block?
     (a) What was clear and what could be done differently?
     (b) What was unclear and what could be done differently?
- Get rid of obstacles
  1. Was it easy to understand how to get the obstacle out of the way?
  2. Could it be done differently to be easier to understand?
  3. What did you think of this kind of obstacles?
  4. What do you think about the idea to have a obstacle where all four of you have to cooperate for it to get out of the way? E.g. all players have to hold down a button at the same time?
- Collaboration/Communication
  1. Did you think that you had to play together to finish the game?
  2. Did you experience that one of you took a leadership role?
  3. Did you feel like you were a part of the solution?
     (a) Why do you think that was?
  4. How did you communicate?
  5. How did it feel to communicate with each other?
- General
  1. What did you think of the game idea? Was it good or bad?
     (a) If good, what made it good?
     (b) If bad, what made it bad?
  2. In general - what was good?
  3. In general - What was less good?
  4. Was the game difficult or easy
     (a) What was difficult?
     (b) What was easy?
- Countdown
  1. What did you think about having the pressure of a countdown?

   (a) If good, why was it good?
   (b) If bad, why was it bad?
2. Do you feel you needed more time?
3. Would less time have been better?

- Feedback
  1. Was there something that could have been explained better?
     (a) If so, what?
  2. Was there a time where you felt that you did not get the response you were expecting?
     (a) If so, what was missing?

C

Appendix 3

(this document was originally written in Swedish and has been translated)

Alice

Age: 11 years old

Year (in Swedish school): 5

Description: Affectionately nicknamed 'Spralice" by her friends (a combination of the words "sprallig" meaning frisky in Swedish, and her name), Alice is an outgoing, happy and lively person. She lives with her parents and big brother fairly close to her school in the centre of the city. In her spare time she likes to spend time with her friends. Outside of school Alice can be found either with her friends doing whatever or playing floorball. She enjoys playing sports and practices floorball with her team two times a week. Alice doesn't really like school, she would rather spend time with her friends, and spends the least amount of time she can on her school work. In a group Alice enjoys being the centre of attention which results in her often talking over others and making most of the decisions resulting in her being perceived as bossy by others.

Bror

Age: 12 years old

Year (in swedish school): 6

Description: Bror is described by others as as someone that is calm, kind, has a lot of patience, but is the worst at colours. When he was small he was diagnosed with Protanopia, i.e. colourblindness. Bror has a tendency to be a bit lazy and this shows in his school work. Bror likes to play games of all kinds from board games, to video games, to role playing games; his favourite games are Super Smash Bros and DD. Bror lives with his parents and little sister. At home, he thinks that his little sister can be quite difficult. His little sister is six years younger than him and always demanding attention, especially his. Bror loves pizza and in his spare time he likes to draw and sketch comics and cartoon characters.

Ronny

Age: 11 years old

Year (in Swedish school): 4

Description: A few years ago Ronny was diagnosed with ADHD. Because of his ADHD, Ronny has difficulties concentrating and therefore receives extra help in school, Since he finds it difficult to sit still and concentrate, and is often scolded because of this, Ronny doesn't like school at all except for recess. During recess Ronny gets to hang with his gang, which are perceived as the cool gang at school. Outside of school Ronny and his gang often ride to the local hamburger place where they all pitch in to buy hamburgers and fries. Ronny lives with his dad who runs his own business. Ronny is a good motorcross driver and has won several competitions. He and his dad often go to motocross races and hang out together. His biggest secret is that he has a pet hamster which he adores and takes care of.

Elsa

Age: 10 years old

Year (in Swedish school): 4

Description: Elsa is the middle child and only girl in the family. Her older brother, Filip, is three years older than her, and her younger brother, Johan, is five years younger. Her greatest wish is to get a dog but since her mother is allergic it is not possible. Elsa is also greatly interested in horses even though she doesn't ride herself. The distance to the closest riding school is too great for her to be able to pick up riding as a hobby. Elsa does very well in school and likes to learn. She wants to be a veterinarian and is very interested in biology, animals and nature in general. She is a bit quiet and shy and only has two close friends she spends time with at school. Elsa likes to draw and often draws animals in different styles. When Elsa meets new people it takes a while for her to open up and feel comfortable in their company.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
CHALMERS UNIVERISTY OF TECHNOLOGY
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