Final Report

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Technobothnia's Escape Room in a Box

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Final report

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Abstract

The aim of this project is to improve the current Escape Room in Box for the Technobothnia laboratory complex by conducting multiple rounds of testing, redesigning, and potentially refabricating the puzzles based on the received feedback. A thorough investigation of previous work is also conducted to gather information. The report provides details about the project context, planification, and progress with an emphasis on project management. Lastly, the report concludes with a brief discussion of potential areas for improvements could the project be proceeded.

Language: English

Key Words: Technobothnia, Escape Room Game, Project Management

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Glossary

Escape room: An escape room (or escape game) is a game in which a team of players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal in a limited amount of time. The goal is often to escape from the site of the game.

Microcontroller: Compact integrated circuit that incorporates all the necessary components of a computer, including the processor, memory, peripheral units, and input/output (I/O) interfaces.

Arduino: Community of users, project, and company focused on open-source hardware and software. This group designs and produces microcontrollers and microcontroller kits that consist of single-board components. These components are intended for use in constructing digital devices.

Diode: Type of semiconductor device that primarily functions as a switch for current, allowing it to flow in one direction only.

Relay: Button that has two modes of operation: it can be controlled electrically or function as an electromagnetic component. Its primary purpose is to regulate the flow of inputs and outputs using a coil and an electromagnet. In addition, it is capable of amplifying electrical power to control a circuit with greater power output than input.

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Acknowledgments

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Josefin Slope was our supervisor and client we would like to thank you for your work and for the nice and effective meeting we had. Roger Nylund is the eps supervisor and is responsible for the eps programme. We would like to thank you for the opportunity you gave us.

Leah Ebert, Kiki Geurts and Albert Hernández where the previous developers of the escape room and where responsible for the design of the game. we would like to thank you all for the work you have don on this project. We would like to thank Leah Eberts and Albert Hernández because they always responded on our messages and helped us in the time of needs.

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Lastly, we would like to thank everyone who has played our game. Without you we couldn't get feedback and so we couldn't improve it. It was nice to see that you had fun playing the game.

1. Project Organization – European Project Semester

The project is completed in the framework of the European Project Semester (EPS) offered by several European universities. It offers the opportunity to explore project work in an intercultural team of students with a minimum of two scholastic years. These teams are established of three to six members of different nationalities using English as the main language. Supervisors from local corporations, research centers, or educational institutions were assigned to each team to provide guidance to the students.

The EPS was created to enrich engineering students' studied knowledge by offering a 15-week immersion in the modern, globalized workplace and working practices.

Moreover, students got training in teamwork, project management, cross-cultural communication, English academic writing, and the local language, in this case Swedish, in addition to project work. This benefited the students' education and laid the framework for their collaboration and successful project completion.

(European Project Semester, n.d.)

2. Introduction

2.1 Project Background

In 2021, the Technobothnia Escape Room project started due to Covid-19. During the crisis, Technobothnia could no longer be visited. As a result, students and other groups could no longer become acquainted with the work and research that is being carried out there. Interested parties could also no longer obtain information about possibilities for study or cooperation with Technobothnia. Due to other responsibilities of the previous team, consisting of Technobothnia employees in collaboration with teachers from local universities, the game and individual puzzles were left unfinished. The interactive escape room game originated from the desire to introduce the public and individuals to Technobothnia in a fun way. In addition, the requirement to be on site or in large groups was ruled out because the game is played in small teams.

The 25th anniversary of Technobothnia was celebrated in 2021. There was a large budget for this celebration. A large part of the money was left over from that budget due to Covid-19. Part of this money has been made available for the Technobothnia Escape room project. Before closing the project, it was passed on to a team of international EPS students. The previous EPS team mainly focused on further developing the escape room and making the puzzles. Now it is the task of the next group to test the escape room with users and improve it where necessary. More information are available about this process in the following chapters.

2.2 Technobothnia

The history of Technobothnia dates to the 1840's, when Finland was an autonomous part of the Russian Empire. The founding of the Waasan Puuvilla Manufakturi Oy cotton mill in 1857 was Vaasa-native industrialist A.A. Levón's most important undertaking. In 1980, the cotton factory stopped producing cotton. Currently, a technological research facility is housed in the abandoned factory and the mixing building next door.

The intended recipient of the Escape Room box is the institution Technobothnia, located in Vaasa, Finland. Technobothnia is a comprehensive laboratory complex established in 1996 by three local universities - the University of Vaasa, Vaasa University of Applied Sciences VAMK, and NOVIA University of Applied Sciences - with the aim of providing high-quality education and research opportunities in the field of technology, fostering collaboration between educational institutions, companies, and research institutes and technology centers, and offering measurement and testing services as well as research and product development to both public and private sectors (Technobothnia, 2022).

Today, Technobothnia accommodates 25 laboratories spanning nearly 8000 square meters, offering facilities for various fields such as Environmental Engineering, Electrical Engineering, and Automation (Technobothnia, 2022).

As the project supervisor for the Escape Room box, Josefin Stolpe, who serves as the coordinator of Technobothnia, oversees all aspects of collaboration among the three universities, including organizing events at Technobothnia and hosting visitor groups. In addition, Stolpe holds a seat in the Technobothnia steering group, which represents all universities, and provides input on budgetary issues.

Of particular importance is Stolpe's involvement in the project since its inception, as she played a crucial role in conceiving the concept of the escape room together with the former team of lecturers.

Figure 1: Technobothnia pictures.

2.3 Escape Room Background

Escape rooms are themes adventure games. Players are immersed into the story ranging from light-hearted Christmas themes to action-packed prison breaks. In real-life escape rooms, players choose a room and meet their guide. This guide will keep a close look on the players and assist players with hints when it is required. (Ascalon, 2022). In escape room boxes this is often a video or papers with generalized hints.

Once the players are ready to start the game, they usually get to watch a mission video, in escape room boxes they get to read a paper that describes the objective. These forms of media explain the world the team will be entering, what they are trying to achieve, and why the team only has limited time. In real rooms, the players must search the room and look for patterns and connections between clues to escape the room. Through teamwork and communication with one's teammates, one can find the solutions to the puzzles and the way out of the room. (Ascalon, 2022)

When playing an escape room in a box players do the same. The difference is that players only have the box and its contents to rely on. The team must again find clues, solve the puzzles, and decode the game.

2.4 The Team

The rest of the Technobothnia Escape Room in a Box project is taking charge of the team member: Nynke BOUMA, Pepijn NIJBOER and Noé MONPOINT from the Netherlands and France respectively.

In the goal to build an effective project team, the entire team have done individually the Belbin test.

Nynke BOUMA studies Industrial product design at Hanzehogeschool Groningen. She is in the third year of the bachelor.

Figure 2: Nynke

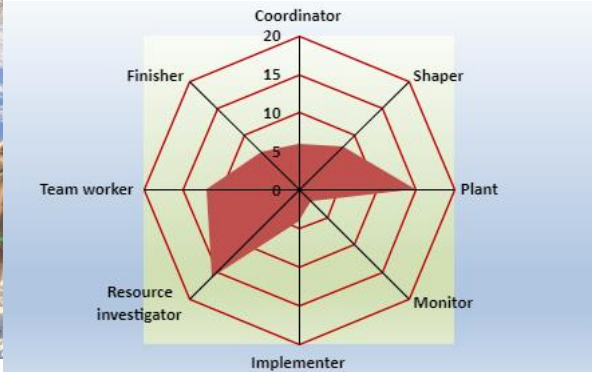


Figure 3: Nynke beblin test results.

Following the Figure 2, Nynke Bouma has 2 main roles in a team. She is a resource investigator and a plant.

She has a natural inclination towards creativity and unconventional problem-solving, which are her strong suits. Her strengths include being imaginative, free-thinking, generating ideas, and solving complex problems. However, her weaknesses may include disregarding small details and struggling to communicate effectively when she is too engrossed in her work. (Bebelin Limited, s.d.)

In the role of a resource investigator, she leverages her curious disposition to discover new ideas that can benefit the team. Her strengths lie in being sociable, enthusiastic, exploring possibilities, and establishing connections. However, she may have some weaknesses such as being overly optimistic and losing interest once the initial excitement fades. (Bebelin Limited, s.d.)

Pepijn NIJBOER is a third year student applied geo information sciences at the HAS university of applied sciences in Den Bosch, the Netherlands. In his studies he learns how to visualize and analyse geodata (data with a location component).

Figure 4: Pepijn

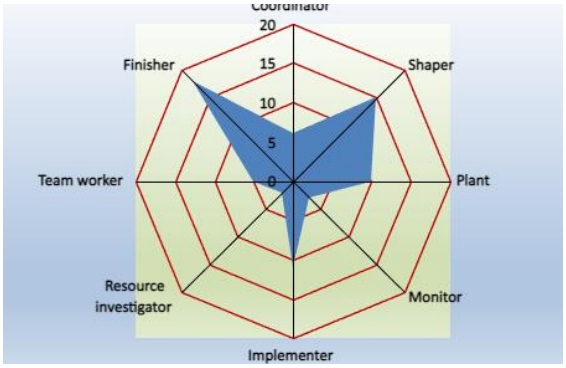


Figure 5: Pepijn's Belbin test

In figure 5 the results of the Belbin test are presented. The main roles are the finisher, shaper, and plant. The finisher is someone who wants a project to be finished in the highest standers as possible. This person is most effective at the end of a task. The strength of these role is that he is perfectionistic and that every project requires to finish. One weakness that is acceptable in this role is that the individual may tend to worry excessively and have a reluctance to delegate tasks. (Bebelin Limited, s.d.)

The role of a shaper involves keeping the team driven and on track towards their goals, even in difficult situations. The primary strength of this role is the ability to excel under challenging circumstances. However, an allowable weakness is that in prioritizing the success of the project, this individual may occasionally inadvertently hurt others' feelings. (Bebelin Limited, s.d.)

Noé MONPOINT studies general engineering oriented in Mechanical and Industrial fields at École Nationale d'Ingénieurs de Tarbes (ENIT) in France. He is in the fourth year, equivalent of first year of MEng, and has taken industrial engineering as an option of specialization.

The results of Noé's Belbin test are shown below. Following the Figure 6: Noé

Figure 7, Noé MONPOINT has 2 main roles in a team. He is a coordinator and a shaper (like Pepijn). As a coordinator, his primary responsibility is to ensure that the team stays focused on achieving their objectives, by drawing out the potential of team members and assigning tasks accordingly. His strengths include being mature, self-assured, recognizing talent, and establishing clear goals. However, there are some weaknesses that come with the role, such as being perceived as manipulative and possibly shirking his own share of the work. He may also tend to assign too much work to others, the result is that is having very little work for oneself to do. (Bebelin Limited, s.d.)

Figure 6: Noé

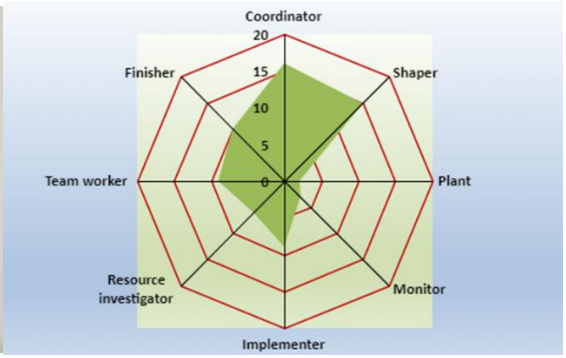


Figure 7: Noé's Beblin test.

For this project, he is the project manager (as Belbin test shows), might carry on the responsibilities of project leadership (if required). He has the greatest organizational and managerial skills and already existing experience in project management. With a mechanical background he may participates in design as Nynke. Being a more creative person, she may be more able to enhance the responsibility of the puzzle's execution.

2.5 Game presentation

The escape room is composed of multiple events that collectively establish a plotline from a singular story. The various puzzles and their sequence are integrated into a cohesive storyline, which constitutes the general theme of the escape room. The premise of this particular escape room involves a scenario where students have confined teachers within the Technobothnia facility, and the game players are enlisted to facilitate their escape. Through this process, the participants are guided through diverse Technobothnia departments.

In order to provide the reader with an initial overview of the game and facilitate orientation in subsequent discussions, a concise description of the puzzle essentials is presented below. The puzzles are presented in the same order as they appear during gameplay.

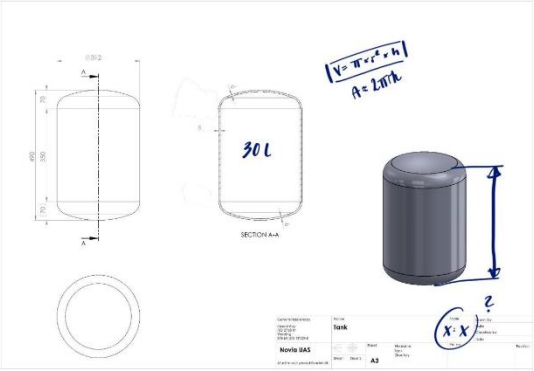


Figure 8: Technical drawing.

The participants receive a technical drawing, presented in Figure 8 depicting a water container with an estimated capacity of 30 litters. The drawing contains added handwritten annotations, such as formulas. Moreover, the top-left portion has been torn away, depriving the players of the tank's height dimensions. The players are tasked with determining the drawing's scale.

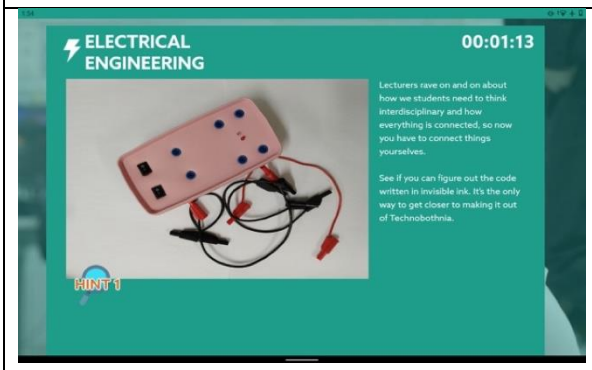


Figure 9: UV Circuit.

The participants are presented with a plastic container, as presented in Figure 9, which they must secure by completing an electrical circuit. When they accomplish this task, a UV light bulb will illuminate and display a code written in ink that responds to UV light. However, if they improperly connect the circuit, either the bulb will not light up at all, or a red LED light will turn on instead.

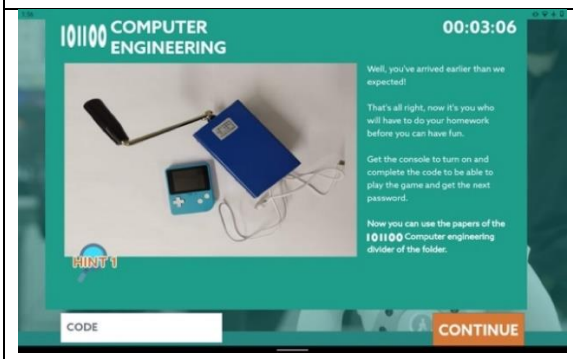
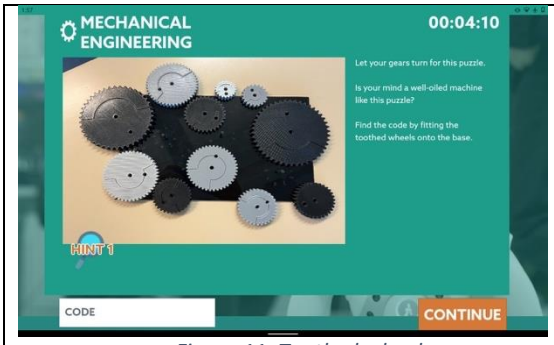
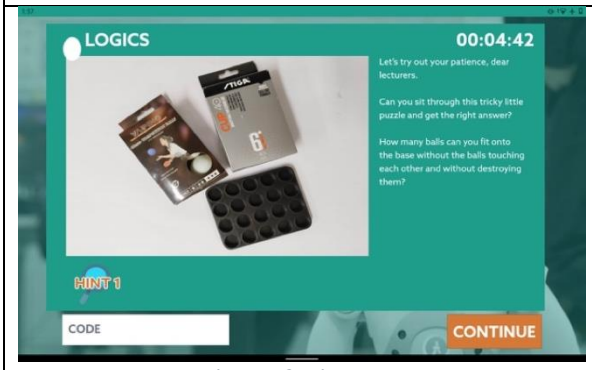
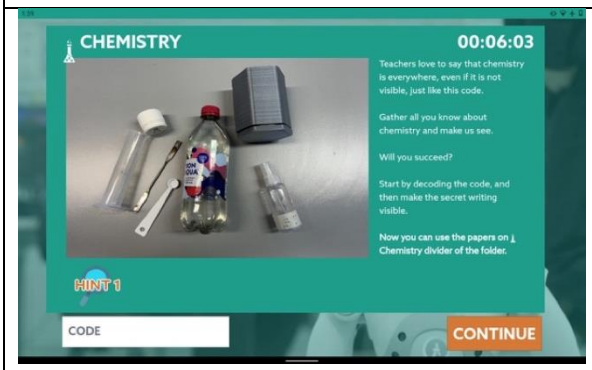
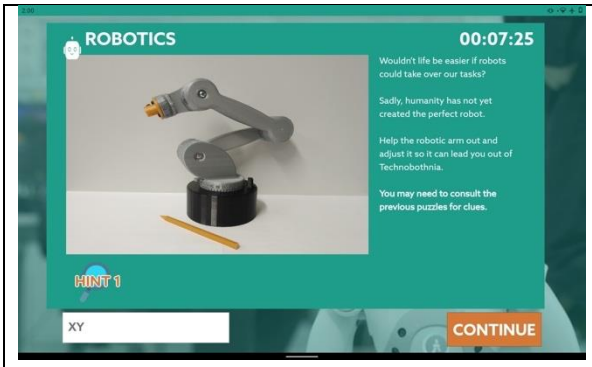


Figure 10: Console game.

To play this game, the players must initially link a handheld gaming device to a manual crank and determine the ideal rate to generate the necessary voltage. Then, another participant must complete the game's code with the assistance of a secret message. Following this, they need to participate in the game and earn sufficient points to uncover the code required to access the subsequent level. The Figure 10 expose the material of the puzzle.

 *Figure 11: Toothed wheels.*	In the Toothed Wheel puzzle, the participants are presented with a collection of toothed wheels exhibiting diverse shapes and dimensions, as well as a base plate featuring unchangeable hooks (as presented in Figure 11). Their objective is to properly affix the wheels onto the base plate by linking the embossed lines on the wheels. Upon precise alignment, the players can observe the code by peering through the provided apertures on the wheels and onto the base plate.
 *Figure 12: Ping pong.*	In this game, participants are presented with a base plate and Ping Pong balls and are tasked with placing the maximum number of balls on the base without any of them encountering one another. A screenshot of the application is stated in Figure 12.
 *Figure 13: Cone.*	This puzzle requires the players to examine a model comprising a cone and an attached cylinder, as well as several papers depicting potential outlines of the cylinder's inner surface. The participants must identify the accurate surface drawing that matches the cylinder's actual inner surface. A screenshot of the application is stated in Figure 13.
 *Figure 14: Invisible ink.*	The players are presented with numerous papers that contain a concealed code, which they must discover and decode. This process leads them to concoct a visibility mixture that will reveal an invisible code. The players are required to determine the appropriate volumes for the mixture using various methods. Furthermore, a chemical substance will be concealed within a puzzle box. A screenshot of the application is presented in Figure 14.

 *Figure 15: Robotic arm.*	The Robotic Arm puzzle (Figure 15) serves as the focal point of the game, whereby the participants acquire the code to unlock a pre-built robotic arm that is enclosed in a safe box. The players must scour the prior games for hidden codes and adjust the individual scales on various components of the arm accordingly. Once the adjustments are made correctly, the arm will point to the appropriate code on a base plate. Only through precise calibration of the arm on the base plate can the players ascertain the correct code.

Screenshots of the entire updated game is in Appendix 10.

2.6 Playing the game

The team first played the escape room as an introduction to the project. Without prior knowledge, the team was able to properly experience and evaluate it.

Points for improvement found while playing the game:

- For entering the game, a nickname was required. The name EPS 2.0 and EPS wasn't working. But "…" was working. So maybe the system only wanted to see punctuation marks.
- Video's, the subtitle must be in the video instead of at the side of the page.
- The game was taken to much time.
- **First puzzle – technical drawing:** the missing piece on the paper and the formula were confusing. Those made the puzzle more difficult what took times.
- **Second puzzle – UV circuit box:** when the blue light players could not see directly the code.
- **Third puzzle – console puzzle:** The team found difficult to finish the game when users were too bad at video games.
- **Fourth puzzle – toothed wheel:** the pins were not good fix on the board, it was difficult to read the code, pins on the board should be more proof making, making numbers on the board easier to read, clearer begin and end of the code.
- **Fifth puzzle – ping pong puzzle:** the O before the code on the ball was confusing.
- **Sixth puzzle – cone puzzle:** the design of the cone could be improved.
- **Seventh puzzle – invisible ink:** The team found that the puzzle could be more sustainable.
- **Eighth puzzle – robotic arm:** the code given was not correct and the right crane position was difficult to find on the board.

After this the decision of what improvements must be done before next tests were made. This can be seen in the WBS in Appendix 1 and chapter 4.1.1.

3. Project management:

3.1 Mission and vision:

To ensure the success of a project, have clear goals, tasks, and timelines was crucial. This involved defining the mission and vision of the project.

- **Mission**: Getting school kids interested in science and math, representing different fields of Technobothnia, and using the game as a tool to showcase and market technology education to Children.
- **Vision**: To increase interest in technical careers and engineering studies, ultimately benefitting the energy sector of Vaasa and universities through increased graduates. Overall, the project aims to engage and familiarize children with Technobothnia.

3.2 Goals:

To make the missions and vision achievable, SMART goals have been developed for the project. In total five SMART goals were written down the main point of these goals.

1) Design and develop a fun, interactive, and challenging escape room game.
2) Figure out how to shorten overall game time using scientific testing methods.
3) Making the game future proof.
4) Develop an educational, interactive, and entertaining escape room game for high school and middle school children.
5) Design and create an interactive escape room game that will increase awareness and enthusiasm.

There is in Table 1, a summarize of the goals. In this table the goals are visualized, how to measure them and when the goal is achieved.

Smart Goals for the project	Measurement	Achievement
Fun	Feedback with questionnaire at the end of the game. And/or analyse behaviour during the game.	Minimum of 50% of player find that it's fun, interactive, challenging
Interactive		
Challenging		
Increase awareness and enthusiasm towards technical careers among 15/16-18 years people	Enquire the teacher or players directly.	Minimum of 50% demonstrating increased interest in pursuing a technical career
Proof	Check the way of puzzles and see if anything is broken	0-5% of components break
Duration of the game	Directly on the application	1h to 1h30
Time to do the project	4 months	Game achieves before 4 months
Budget	Available: 1000€	Stay in the budget

Table 1: Smart goal table.

3.3 Stakeholders

Stakeholders in the escape room project included:

- The team working on the game.
- The project supervisor Josefin Stolpe
- The previous EPS group who developed the gam
- The involved teachers who created the puzzle concepts
- EPS coordinator Roger Nylund
- The individuals who tested the game and provided feedback.

The team was responsible for the project and the project supervisor aids in coordination and client representation. The involved parties were responsible for raising awareness for Technobothnia and enhancing the cognitive skills and knowledge of high and middle school children. The stakeholders had varying levels of involvement, with some actively participating and others having completed their role.

3.4 Requirements:

The team planned to improve the Escape room game to make it more playable for 15/16-18 years people. Based on their experience from the first test, a list of several actions to be taken has been created, such as making the game usable without WiFi, designing their own packaging, and reducing the game time to between 60-90 minutes. The team has prioritized these actions into must have, should have, and nice to have, as the Table 2 presents. Must have, were essential for the game to work properly, should have make playing the game smoother, and nice to have, were extra features that may be added. The team plans to further improve the game by letting another student's playtest it.

1. Must have	2. Should be included	3. Nice to have
Plan and execute product testings on target group with scientific testing method.	Produce material for the user interface.	Design a game presentation page for the Technobothnia webpage.
Report the results of the product testing and suggest possible improvements or adjustments.	Perfect game instructions.	Online booking system for the game.
Figure out how to shorten overall game time.	Add/change game hints.	Pack everything puzzles wise.
Improve/remake puzzle/game props.	Put the symbols on the package.	Trying an escape room Boardgame with the team.
The game must be usable without WiFi.	Design new packaging.	Make time trackers it in the application, per puzzle, for scoreboard.
Puzzles was required to be as effortless as possible to replace.	Perfecting the game instructions.	
Reduce the game to between 30/45 minutes and a maximum of 1 hour and 30 minutes, preferably an hour.	Give a penalty in the game for using the hints.	
Make sure the puzzles work properly.	Reading books about escape room games.	

Table 2: should have, must have, and could have structure.

3.5 Deliverables:

To successfully complete the project, several deliverables have been provided, these included.

- Playable escape room with improved materials and durability
- An improved escape room application with a better user interface and experience
- A midterm report detailing the project's progress.
- A final report explaining all project decisions and providing recommendations for future development.
- Testing reports to detail playtest results and areas for improvement
- A test design report to ensure consistent testing methodology.

These deliverables have aided in understanding project decisions, providing recommendations for further development, and ensuring consistent testing.

3.6 Work Breakdown Structure

The project was divided in four main categories; these are.

- Improve the puzzles.
- Testing the game
- Improve the application.
- Reports and presentation

Each category has different subtasks. Figure 8 presents the subtasks for each category. The entire work breakdown structure is presented in Appendix 1.

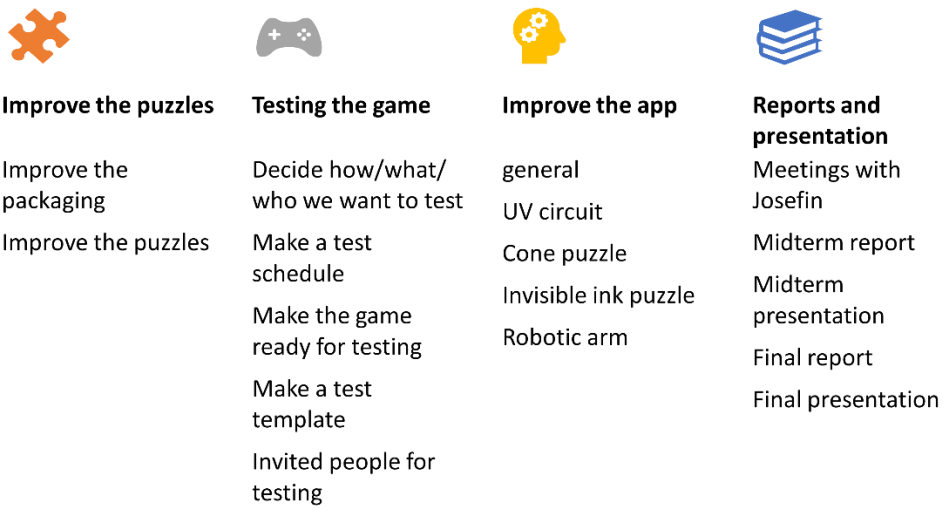


Figure 16: Work breakdown structure.

Improve the puzzle.

The previous group had made a workable escape room game with eight different puzzles. However, the puzzles still required to be improved. For example, make the materials more durable and make the puzzles clearer. These improvements have been done based on the feedback got from the testing rounds. Based on these feedbacks the puzzles and the packaging will be improved.

Testing the game

Probably the most important part of this project were the testing rounds. In these rounds students and children got the possibility to play the escape room game and given feedback. Based on this feedback the puzzles and the application had been improved. To effectively compare those tests, they all have been done in the same way. In total five test rounds have been held in our project. The first two of these are with students and the last to are with children in the age from 15 till 18 years old.

Improve the application

Besides all the physical components of the escape room there was also an application. This application guided the player though the escape room. The previous group had already stated developing the application but there were still some improvements that should be made.

Reports and presentations

To inform our client and other stakeholders two reports and presentations were made. The first report was the midterm report. In this report the project definition and the way the project will be done is discussed. This was done therefore that the client and the project team are on the same pace, and it is clear what there is going to be done in this project. To supplement this, there was a midterm presentation. This presentation was a short version of the report. At the end of the project an end report was made. In this report all the decisions that were made in this project are discussed. This report forms also the first reference for future development of the escape room and other people who are interested. This report is also supplement by a presentation.

3.7 Gantt schedule

The total duration of the project was three and a half months. That means that there were fifteen weeks to on the project. To make this possible there was weekly planning made. In this planning the main tasks of those weeks are descripted below. The entire Gantt chart is put in Appendix 3.

February

Month	February			
Week	30 January	6 February	13 February	20 February
Task	Introduction	Introduction	Project introduction	Improving puzzles

Table 3: Gantt schedule February.

In table 3 the weekly planning of February is sown. February was the introduction month of the project. In the first week there was an introduction in the EPS (European project semester) program, in which this project was a part of. In the second week the project teams were formed and there was decided who is going to do which project. In this week there were also some teams building activities with the project group and with the rest of the EPS group. In the week from 13 of February the first meeting with the client was held and there were discussions about what there is going to be done in this project. In the last week of February, the project work started by improving the puzzles. Only the necessary improvements were made.

March

month	March				
Week	27 February	6 March	13 March	20 March	27 March
Task	Holidays	Testing students	Midterm report	Improving puzzles	Testing on students

Table 4: Gantt schedule March.

In March there were two testing rounds between those rounds the game was improved, as the Table 4 sown. The first testing round was in the first week of march this testing round was with students and was our base measurement. The second testing round was in the last week of march. In the second week the midterm report was written. In the third week of march the game was improved. In the last week of march, the second testing round was held this is again on students.

April

month	April			
Week	3 April	10 April	17 April	24 April
Task	Improving puzzles	Improving puzzles	Improving puzzles	Testing on schools

Table 5: Gantt schedule April.

As the Table 5 is sown, in April the game was improved and at the end there is a testing round. In the first three weeks of April the game was improved based on the feedback from the previous testing rounds. In the last week there was a testing round with our target audience, Children between 16 and 18 years old.

May

Month	May		
Week	1 may	8 may	15 may
Task	Final report	Final report	Final Presentation

Table 6: Gantt schedule May.

The main topic may be the completion of the project. In the first two weeks of May the end final report was made, because the deadline is on the 12th of May. In the last week the final presentation was held.

3.8 Risk management

Risk management in a project is a crucial part of project management, involving the identification, analysis, and response to potential risks that may impact the project's objectives.

The scope of probability and impact risks are between 1 to 5. For the probability one means that it is unlikely to happen and five is the most probable. For the risk impact one represents a minimal impact and on the contrary five demonstrates a significant impact. Red means an intolerable zone; this was when the ranking is around 3/4 to 5 and the sum is between 7-10. To avoid those risks, a solution for the highest risks was found. The orange signified a medium

zone, when the ranking was around three and the sum is about 5 or 6. That points out risks that the team could not ignore.

Finally, green means a tolerated zone. In this case it was not required to find a solution to avoid those risks. The Figure 17 bellow sums up what is said.

Probability / Impact	1-2	2-3	3-4	4-5
1-2	Low	Low	Low/Medium	Medium
2-3	Low	Medium	Medium	High
3-4	Medium	Medium/High	High	High
4-5	Medium	High	High	High

Figure 17: Risk matrix legend.

In table 7 are the ten risks with the highest scores. Those are ranking from the higher to the lower score (sum of the two parameters).

	Risk	Risk probability	Risk Impact	Score	Plan made for the worst risks
1	Technical equipment does not work	4	4	8	Enquire help from teachers/colleagues, research information
2	Too bad work organization	3	5	8	Make a WBS, Gantt, communication in the team, daily/weakly meetings
3	Lack of team worker or help by experts	3	5	8	Make reminders before appointment, he organizes, try to be independent.
4	Not prioritizing tasks	3	4	7	Make a prioritize list, meetings with the team, WBS, planification in short term (weekly), create milestones.
5	Inferior estimation of the time spent in design	4	3	7	Take feedback from players, clients, previous team and still WBS and planification long term and short term.

6	Players not enjoying the game	3	4	7	Take feedback from previous testing rounds
7	Game does not finish before testing	3	4	7	Weekly schedule, prioritize list, daily/weekly meetings, make sure that the game is ready 2 days before.
8	Spending too much time on details	3	3	6	
9	Not enough players finding to play the game	3	3	6	
10	Game is too long	3	3	6	

Table 7: Risk matrix.

Present in the last column of the matrix is a little explanation to avoid the risk. Made modifications was in the puzzle improvement phase. Therefore, if the 3D print was not working, it would not be able to create new parts and improve the puzzles. The probability that the 3D printer did not work was high, and the impact even higher. Thus, there requires to be assistance from the teacher to use the equipment or learn it.

Moreover, a low-quality work organization, and not prioritizing tasks could be dangerous and probable. To avoid those problems, crafting a work breakdown structure to know the amount of work was necessary. Another solution was to design a planification with the resources affected (such as dividing the tasks in the team). Also, improving communication in the team and organizing daily or weekly meetings should help to prevent those risks.

Estimate the amount of time dedicated to the design phase without receiving input from players was unsure. Thus, it was of interest to ensure the completion of the game's improvement, as players may not enjoy the game if it is unfinished. Additionally, inadequate design may arise, which highlights the need for weekly planning, milestone setting, and consideration of feedback to mitigate associated risks.

Furthermore, potential risks may be classified into two categories, with medium impact and probability, respectively. The first category comprises risks where both the impact and probability were equivalent, while the second category includes risks where the probability could be low, but the impact could be high.

Notably, the unavailability of appropriate materials may have a significant impact since it was akin to a lack of equipment. However, the likelihood of this scenario was low due to the availability of materials in the laboratory. Additionally, the puzzles were designed to prevent injury and breakage during gameplay, resulting in a low probability of occurrence. Nonetheless, if such an event were to transpire, it would have critical implications.

3.9 Budget management

The budget allowed to the project was about 1000€. As the most part of the puzzles were already made, not a high number of materials were ordered. However, the materials ordered were more expensive than expected. In spite of that, the team stayed in the initial budget.

Thus, the total budget consumed, Table 8, was about 542,52€. Nonetheless, 3 consoles were ordered in case of broken one or for replications. With only 1 console, the cost would be about 374.69€. The Appendix 4 gives the links to buy the products ordered on internet.

Budget consumed	Price	Item	Total
Case	22,65 €	1	22,65 €
Screen protector	9,17 €	1	9,17 €
Papers	21,12 €	1	21,12 €
Box S	21,95 €	1	21,95 €
Box M	39,95 €	2	79,90 €
Console	83,92 €	3	251,75 €
LED	0,45 €	4	1,80 €
Plastic	10,00 €	1	10,00 €
Electronics	5,03 €	6	30,18 €
Bottle	4,00 €	1	4,00 €
Application	90,00 €	1	90,00 €
		Total	542,52 €

Table 8: Budget consumed.

Nevertheless, the team had free access to machine as 3D printing and materials for printing. Hence the real cost of the project is more expensive than the number calculated.

Finally, in addition of the first EPS project, the total cost of the game is about 1180,44€.

4. Testing and improving the game

Testing the game consists of having the game played by students from Vaasa. The goal is to detect issues of the game both in the application and in the puzzles.

4.1 Round 1: Tests preparations

For the first test the client desired to test the game on 5 groups of national and international students. To defy the test more, it was necessary to have at least one Finnish group play the game. Indeed, the final game will be played only by Finnish people.

As appointed with the client, the group size for the first testing round was between 2 and 4 people. Therefore, the most playable size group is contained between 2 and 4 people. Indeed, with one person the game would take too long, and too difficult to handle. Then with five people, some would wait too long on each other.

Before testing, the game also required to be improved because the game was not working as expected. It was decided to only improve the absolute must have, therefor the game was playable.

4.1.1 Improvements on the game before testing

The team had to prepare the puzzles before testing the escape room game. The team test round revealed that there were still ambiguities in the puzzles. The escape room game could also not be played without issues. Without making significant changes to the puzzles, the team wanted to make the escape room game playable for the test rounds. The test rounds that were scheduled then showed what her significant adjustments we could make to the game. Below is a list of the changes we made for the test rounds, along with explanations.

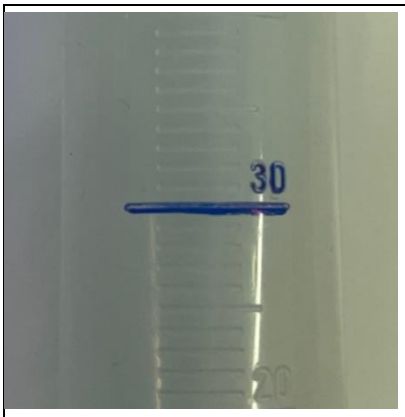
 *Figure 18: Cylinder marked.*	During the test by the team, some difficulties were met to see the measuring cup's line. Then, this line was more distinct after the improvement. As a result, it would be simpler for the gamers to understand the necessity of using water as well as the appropriate amount. A permanent marker was used to draw the line clearly so that it does not degrade in the presence of moisture, as the figure on the left illustrates.

Figure 19: New toothed wheels pins and board.

While the team played the tooth wheel game, one of the pins broke. The strengthened of the pin connections is improved and the players were warned of the pins' fragility.

At the top left corner of the board, the arrow and the word up were added. This assisted players understand how to place the board and which direction the code should be read, as the Figure 19 is demonstrating.

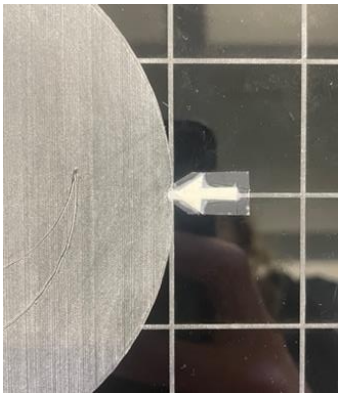


Figure 20: Robotic arm arrows.

Arrows have been added to the robotic arm (Figure 20). The arm and board had small white stripes that were barely visible. To place the robotic arm on the board, the players require the arrows. The code of the puzzle in the application has also been updated. When the team tried to complete the game themselves, the programming was wrong. Changing the code allowed the players to complete the game.

Figure 21: Generator code.

All puzzles contain numbers for solving the final puzzle. It was challenging to find this number for the console game. Players must replay the Gameboy game or crack the binary code to discover the number. Too much time was spent on this. The number required for the final puzzle has been added to the console game's dynamo (Figure 21).

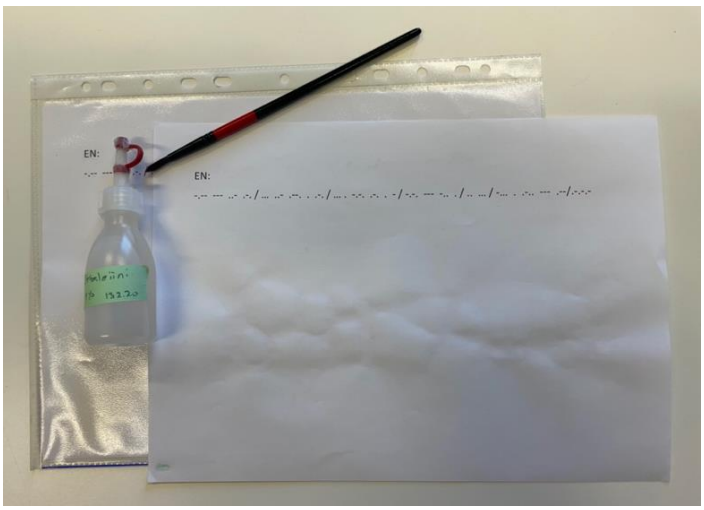
 *Figure 22; New ping pong code.*	One of the ping pong balls also includes a number that can be used to solve the final puzzle. This number was initially written as O - 22. As a result, the initial digit, which was a circle, appeared to be a 0. This circle can be seen by players on the robot's arm. By colouring the circle, it no longer looked like a 0 but like the circle it should have been (Figure 22).
 *Figure 23: Puzzle numbering.*	The puzzles were not yet numbered when the team played the game by itself. Even though they were in order, the team still had to search. For the test rounds, it was decided to number the puzzles because of this. This would make the ordering of the puzzles simpler for both the players and the team. Tape was used to attach the numbers to the packaging (Figure 23).
 *Figure 24: Invisible code.*	Few elements were necessary to prepare for the invisible ink puzzle. Creating the invisible code using a liquid on the paper was needed to prepare the game before testing (Figure 24). A brush was used for this. This required the printing of new papers first. To guarantee there were enough papers for all the test rounds, there was made a stock of them. Every time, the spray bottle and measurement cup also needed to be cleaned.

 *Figure 25: New folder.*	For the papers in the folder, insert sleeves were added. This improves the folder's organization and makes it more obvious to which tab the papers belong. The papers were arranged under the correct tabs because the program lets you know which papers the players need at what time (Figure 25).

4.1.2 Tests advertisements and registrations

To make sure people are going to play the game there requires to be advertising and the possibility to register. This process started to decide when to play the game. Then was decided to have 4 testing times in the week from 6 march till 12 march. These testing times were:

- Tuesday 7 march from 9:00 till 11:00/ 12:00
- Tuesday 7 march from 13:00 till 16:00/ 17:00
- Thursday 9 march from 9:00 till 11:00/ 12:00
- Thursday 9 march from 13:00 till 16:00/ 17:00

To fill these timeslots a poster Figure 26 and a google forms document was made to register and to advertise the test.

Figure 26: the test advertisement poster

This poster was distributed the EPS group and different engineering student societies were contacted to distribute this poster. These student societies were:

- Filicia r.f. (Novia's tech students associations)
- VIO ry (VAMK's tech student association)
- Tutti.RY (The university of Vaasa tech student association)

The Tutti.RY student association reacted on this mail and posted the poster on their social media channels. The testing schedule is shown in Table 9.

Timeslot	Group size	Finnish or international
Tuesday 7 march from 9:00 till 11:00/ 12:00	3 people	Finnish
Tuesday 7 march from 13:00 till 15:00/ 16:00	2 people	International
Thursday 9 March 9:00 till 11:00/12:00	4 people	International
Thursday 9 March 13:00 till 15:00/16:00	3 people	International

Table 9: final testing schedule

All groups had at least one member with a technical background.

4.1.3 Tests Proceedings

4.1.3.1 Introduction

Test groups were formed by various sizes and nationalities, as was already mentioned in the previous chapter. This purposeful decision was taken to have as many distinct groupings as possible.

A brief introduction was told to players before they began the game. As well the team members introduced themselves, provided game history, and described the working of the game. The explanation was intentionally as brief as possible to expose the less possible to the players.

The team tried to avoid giving the gamers too many hints while they were playing. This would influence too much the test results. The last test rounds went more smoothly than the first in this regard. Also, the team learnt from tests to tests. As a result, the team was able to apply this knowledge in the upcoming test rounds.

Players were given free coffee or tea and a patch as a thank you for testing the game. That was very effective.

4.1.3.2 Feedback: Moderated method

To collect feedback from the players or from the team member about the run of the game in general or by puzzle, a process of testing was managed.

Based on the previous EPS group work, the Moderated method from Adobe was used: the purpose of user testing is to provide developers with feedback on their ideas and concepts from the perspective of users. It also aims to provide detailed insights into how users interact with the product, revealing any inconsistencies or issues that require to be addressed. By doing so, the testing process helps in optimizing the product. (Babich, 2019)

Moderated usability testing is a usability testing approach that requires the active participation of a moderator (a real person who will facilitate the testing). The moderator will have extensive expertise in usability testing and user research, and they will work closely with the test participants, leading them through the testing process. (Babich, 2020)

This method was used following this way:

- Enquire questions to players only at the end.
- Encourage them to take notes.
- 1 of the team members lead the game.
- 2 takes notes of behaviours. The Pepijn notes are setting in Appendix 6.
- Request the players to fill in the **google form** feedback.

A picture which shows the testing is presented in Figure 27.

Figure 27: Testing with moderated method.

The feedback was collected by enquiring questions to the players after testing then request them to fill in the form.

The google form was composed of 4 parts: the introduction with the name of the players, and especially enquire which age the game is suitable for, then a part about the application/tablet (instructions...), afterwards questions about the game (playing time, complexity...) and finally about the puzzles (materials, hints...).

This one is also based on the feedback procedure of the previous group (Leah Ebert, 2022). The questions about this are in Appendix 5.

4.1.4 Results of testing

4.1.4.1 Time tracker statistics

The time spent on each puzzle for each team has been recorded. There is below a table about all the time records as well as the average for each puzzle and for each team. The chart Figure 28 illustrates those data with a graphical manner.

Puzzle	Team 1	Team 2	Team 3	Team 4	Average
1 (Technical drawing)	14	16	11	11	13
2 (UV Circuit)	3	6	6	7	5
3 (Console)	18	6	12	19	14
4 (Toothed wheels)	13	11	15	19	14
5 (Ping pong)	2	1	3	2	2
6 (Cone)	3	8	12	8	8
7 (Invisible ink)	19	16	22	16	18
8 (Robotic arm)	16	16	14	9	14
Total	88	80	95	91	88

Table 10: Time tracker in min.

The average of the testing time was about 88 min. Compared to the goal, gather around 1-1h30 (60-90min) this time respect the objective.

The chart of the average time spent in function of the team players (**Error! Reference source not found.**) demonstrates that the time spent in the puzzles was not regular. Indeed, the time spent on the ping pong puzzle, number 5, was nine times lower than the invisible ink, number 7, for example. Moreover, the time spent by puzzle was about 11 min.

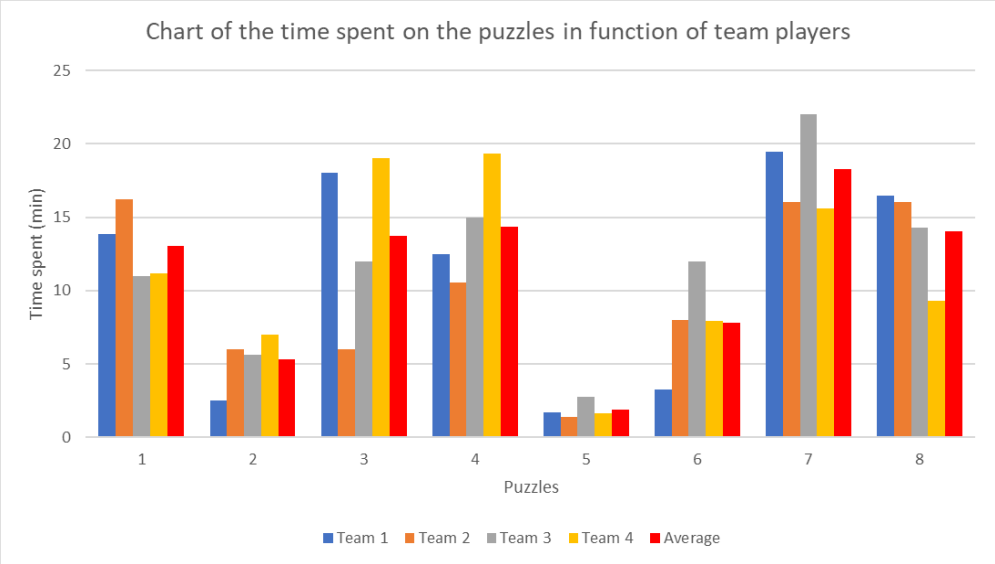


Figure 28: Chart of the time spent on the puzzles in function of team players.

The chart of the time spent on the puzzles in function of team players (Figure 28) demonstrates that the irregularly spent time on each puzzle could be found on each team player.

The trends between the 4 teams are quite the same about the time spent on the puzzles. However, the results were not the same. It could be explained with the background of the players. Indeed, team 1 was constituted of electrical engineering students, therefore, the electrical puzzle was solved very quickly.

4.1.4.2 Feedbacks from players

According to the google form and the oral question after testing, players were happy to play the game. The game was found interesting, fun and challenging. A picture which gathers those three aspects is stated in Figure 29. Improvements about puzzles and the application or the timeline were suggested.

Figure 29: Picture of team 4 during the game.

One of the most important areas of the feedback was the age suitable for the game. The figure below highlight that the game is suitable for 12-15 to 16-18 years old people. The Figure 30 presents this result.

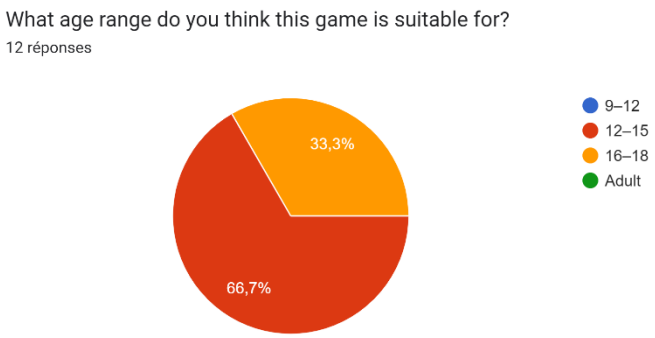


Figure 30: Chart of age suitable for the game.

4.1.4.3 Application/tablet feedback

The tablet feedback was excellent. The average mark is around 8,1 out of 10. Globally the result was very promising, but some improvements were still necessary. There are below 2 extra feedbacks about the graphics/illustrations of the tablet application.

“Graphics were simple and nicely done. In this type of game there is no need for flashy and very interactive graphics.”

“No sound and doesn’t really add something.”

The most important problem said by the players was that they did no longer pay attention to the video and only focus on the text nearby. Otherwise, the interface was friendly and instinctive.

Finally, some grammatical mistakes have been founded in texts.

4.1.4.4 Game in general feedback

In this part, the players evaluated the game in general like noticing the difficulty of the game, the instructions, if the game is too short, too long or just great. The average mark in this part was about 7.8 out of 10. All players judged that the difficulty is just right as the time to solve the game. For only the question “How much did you like this game in general?” the average was 8,8 out of 10 (0: hated 10: loved).

A main content was that players have difficulties understanding all the story. Some instructions were not very clear, difficult to understand, as the comment demonstrates: “It's difficult to understand all the story, and not very interesting”.

4.1.4.5 Puzzle feedback

For the last part, players assessed the quality of the puzzle like the materials, the difficulties finding the codes, the hints, and their puzzle preferences.

For the question “How much did you like the materials and/or game pieces?” the average was 8,2 out of 10.

One of the puzzles was not working very well and the materials were weak, therefore, that was the least liked (toothed wheels). Indeed, the pins were very weak, and the gears are not always good fitting: “They were very fragile” said one player. Otherwise, all the puzzles were liked by the players. The most prefer one was changing in function of the player, but the chemical puzzle was more liked than the others.

4.1.4.6 Feedbacks from the team

The test proceedings went as expected, and everyone involved, including the players and organizers, relished to be present. Promising general feedback was received, indicating that the players were genuinely interested and enjoyed. When the players encountered difficulties lasting more than 10 minutes, the team provided hints. The same hints were given to every group. It was also realized that the hints provided in the application were often not very useful.

However, several significant issues were encountered. For instance, the console puzzle required restarting the console after a game session, and the battery required to be drained before the next testing session. Team 2 was exceptionally fast in this puzzle as the game was already loaded, making it instantly playable. Additionally, several bugs were identified in the application during testing. Finally, the toothed wheel puzzle presented problems due to the weakness of the pins.

4.2 Improvements after first round

4.2.1 Puzzles

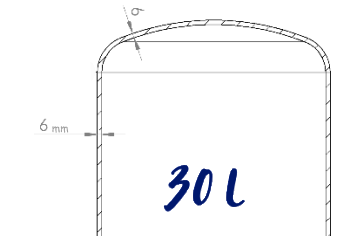
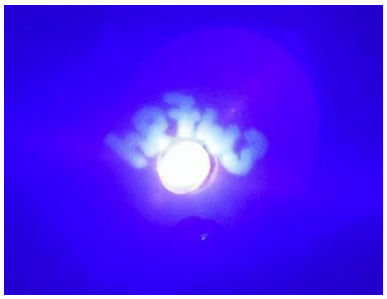
 *Figure 31: Technical drawing improvements.*	**Technical drawing:** Some difficulties were meet for escape room players to figure out the technical drawing's answer. To provide players with an additional suggestion for the answer, the mm designation was included to the drawing (Figure 31).
 *Figure 32: UV code.*	**UV circuit box:** Some challenges were found for escape room players to read the UV code. The ultraviolet LED light and UV ink were not powerful enough. As a result, the UV ink has been repainted and the LED light has been replaced (Figure 32).
Console puzzle: A solution to the battery problem started to be built but it was not finished before the second round.	

Figure 33: New toothed wheels pins.

Toothed wheel: The pins were still insufficiently strong in the first test round. Because of this, new pins have been 3D printed, such as the Figure 33 is presenting. The new pins were attached to the original board by drilling holes in it and gluing it from below. Additionally, white sticker sheets for the wording on the board have been ordered. The wording has been temporarily whitened with a chalk marker until the stickers are delivered.

Ping pong puzzle: After the first round of testing, the ping pong puzzle was determined as extremely simple. The suggestion to switch the following puzzle from effortless to complicated was made during the midterm presentation. Finally, it was decided against doing this. Which puzzle the participants see as being the most challenging varies greatly. The ping pong puzzle offers a boost for the escape room game in the middle as well. Players are reminded that in certain escape rooms, the solution can be obvious.

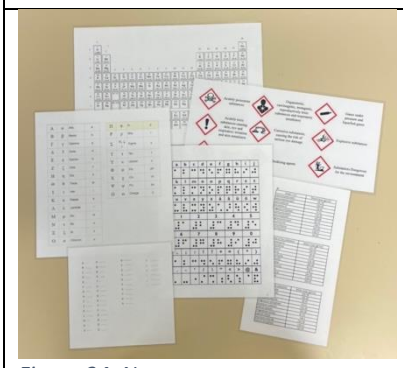


Figure 34: New papers.

Invisible ink: Papers were once again created with invisible ink for the invisible ink puzzle, just like they were for the first test round (Figure 34). The sheets without the code have been plasticized as well. This keeps the papers intact and gives the players a tiny tip on which paper to utilize for the code.

4.2.2 Application

After the testing round there were a few things that required to be improved in the application. The two most important things where the hints were not always useful, and the text of the cone puzzle was not clear enough. To improve the hints notes has been taken during the testing round. After the testing round in a collaborate meeting it was decided what the hints would be. After that the hints were put into the application. For the cone one sentences required to be changed. Because this sentence was grammatically incorrect and did lead players into the wrong direction. Beside the whole text of the application was checked for grammatical and Orthographical mistakes. It was tried to publish the changes on the tablet, but it would not work. Because the free version of web into application was used. In this version it is possible to change a website or zipfile (max 3 mb's) to an application for the tablet. But the file size was larger than 3mb's and for the website and the domain the information was not given. For the tablet case and a screen protector were ordered to make the tablet more durable.

4.3 Round 2: Test preparation to results

4.3.1 Preparations

For the second test round the client required to have not that many modifications compared to the first test round. Moreover, 2 testing groups were decided to be tested according to the clients and the team. Because the team was busy and the end of march, the tests took place in the stating of April.

Otherwise, the rest is like the first testing round.

The Table 11 presents the 2nd test round schedule.

Timeslot	Group size	Finnish or international
Tuesday 4th of April 8:00 to 10:00	4 people	Finnish
Tuesday 4th of April 13:00 to 15:00	3 people	International

Table 11: Round 2 organisation.

Team 1 was constituted by students at university of Vaasa. They did not have any technical background.

Team 2 gathered students from different studies, mostly with technical backgrounds.

4.3.2 Results

4.3.2.1 Time tracker statistics

As the first test round, the duration of time spent on each puzzle by every team was documented. In Table 12 is presented the results of the spending time on each puzzle for each team. The Figure 35 illustrates that in a chart.

Puzzle	Team 1	Team 2	Average
1 (Technical drawing)	21	9	15
2 (UV circuit)	17	12	15
3 (Console)	8	31	20
4 (Toothed wheels)	15	10	13
5 (Ping pong)	2	3	3
6 (Cone)	4	15	9
7 (Invisible ink)	11	25	18
8 (Robotic arm)	8	12	10
Total	87	117	102

Table 12: Round 2-time results

The average time was around 102 minutes, 1hour and 42 minutes. That is close but a little too high compared to the goal (1-1,5h).

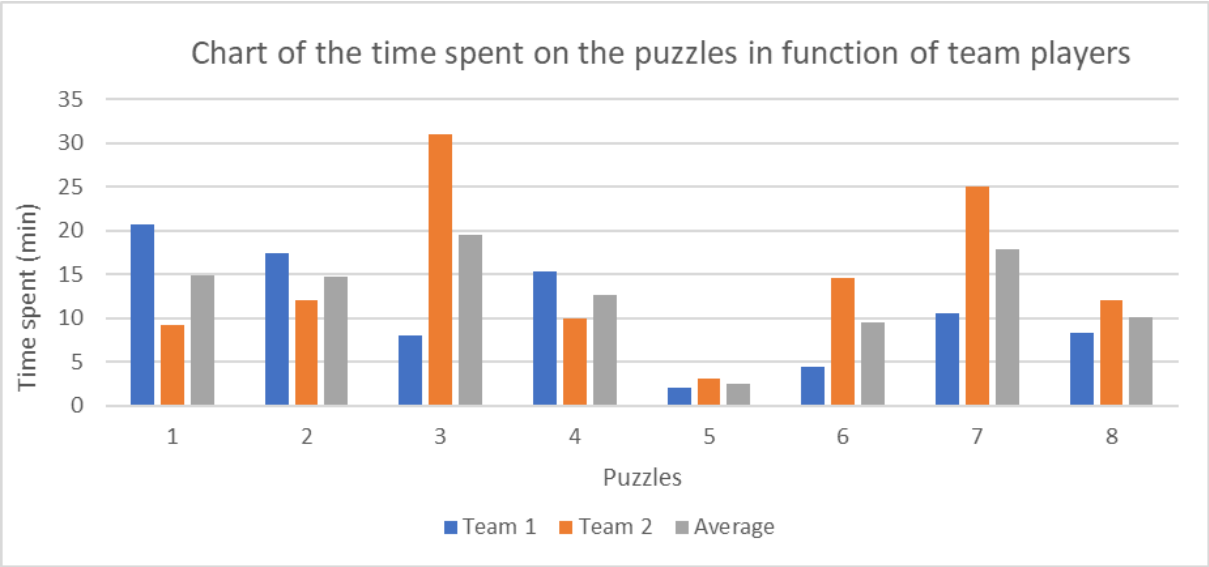


Figure 35: Chart of the time spent on the puzzles in function of team players of round 2.

The chart of the time spent on the puzzles in function of team players (Figure XX) demonstrates that the irregularly spent time on each puzzle could be found on each team player. The time spent in the puzzles was still not regular.

Team 1, without technical background had difficulties on the puzzle 1 and 2 because they had zero mathematical notion. However, the players became very fast from the console game to the end.

Team 2 was fast at the stating, but they had enormous problems to collect the 90 coins. Then they were slow on the cone and the invisible ink.

The results are quite the same as the first test. Compared to 1 test round:

- Puzzle 1: The average time spent was a little longer (13 min for the 1st round and 15 min for the 2 round) in the 2nd round. It may be explained by the fact that players had not any technical background. Maybe that without the modifications before testing this difference would be much higher.
- Puzzle 2: Same as the puzzle 1, but the difference was bigger: the average of time spent was around 5 min for the 1st round and 15 min for the 2nd round. So, the 2nd round is 3 times longer than the first one. It could be explained by the fact that players had not any technical background.
- Puzzle 3: The time spent was longer (14 min against 20 min for the first) because of the team 2 that had to many difficulties to finish the game. Otherwise, the team 1 was one of the fastest groups.
- Puzzle 4: It was solved faster in the second testing round (13 min against 14 min) certainly because of the modifications brought.
- Puzzle 5: The time spent was equal to the first test.
- Puzzle 6: Same as puzzle 5.
- Puzzle 7: Same as puzzle 5.

- Puzzle 8: It was finished faster in the second round (10 min against 14 min) than the first round certainly because of the modifications brought.

Moreover, the time spent by puzzle was about 13 min.

4.3.2.2 Feedbacks from players

As the first round, players enjoyed the game. It was found fun, challenging and interactive. A picture which assembles those three points is presented in Figure 36. Suggestions about puzzles improvement about puzzles and the application, or the timeline were also provided by the players. Some comments may be a proof: “It was fun to solve the puzzles.” “I liked it very much; it was entertaining and fun experience”.

Figure 36: Happy players of round 2.

For this round, the age suitable for has been estimated mostly for 16-18 years old people:

- 57% estimated that is suitable for 16-18 years old people.
- 29% evaluated that is made for 12-15 years old children.
- 14% noted that for adult.

In summary, the target group was suitable for the game.

In addition, the application/tablet feedback was barely the same as the could not be uploaded in the tablet before testing.

Furthermore, the game feedback in general was completed by players. The average mark was about 7.9 out of 10. Then, for the question “How much did you like this game in general?” the average was 8,6 out of 10 (0: hated 10: loved). Those results were barely the same as the first round. That demonstrated that the improvement before the game were not negative. All participants deemed the level of difficulty of the game appropriate and fitting for the time that they spent to solve it.

Finally, for the last part, the quality of the puzzle like the materials, the difficulties finding the codes, the hints and their puzzle preferences were noted.

For the question “How much did you like the materials and/or game pieces?” the average is 8,4 out of 10. That was higher than the first round (8.2). That could demonstrate that the improvements which has been done are useful. However, the hints were found not helpful as the comment presents: “I think some of the hints were just more confusing and didn't give more information”.

Therefore, both most liked puzzles were composed of the robotic arm and the invisible ink. Indeed, the combination of all the puzzle at the end of the game was really appreciated by the players. As the first round, the chemical puzzle was highly liked.

Nevertheless, the less liked puzzle was the first one, technical drawing. Since the players did not have any knowledge in this field, the puzzle was not liked.

4.3.2.3 Feedbacks from the team

As the first round of testing, players and organiser enjoyed the tests. Therefore, when players were in troubles some instruction has been given such as “You can use a hint”.

The target time goal was not respected by the team 2. That might be explained because of the console game, where they spent 30 minutes. A solution to reduce this amount of time could be to decrease the number of coins required to complete the puzzle. However, the client desired to keep this until the next testing round and then see if the modification is required.

Moreover, players of team 2 were mostly waiting for solution instead of searching for. An escape room may do not fit with everybody. Another explanation could be that players have been perturbed by the organiser in a way that they were watching them, and players might be scared about organiser reactions.

Furthermore, although the toothed wheels pins were changed, the puzzle did not work as expected. Indeed, the gears did not fit as required to unlock the code. A solution would be to move the position of one pin.

Difficulties to solve the electrical puzzle showed that hints could be improved before next round. Then, uploading the modifications in the application was also something to do before the next round.

Finally, videos were not working at the starting of the test of the team 2 because of internet connection bugs.

4.4 Improvements after second round

4.4.1 Puzzles

- **Console puzzle:** A solution to the battery problem started to be built but it was not finished before the next round.

Figure 37: Led

UV circuit box: Ultraviolet LED lights were ordered. Indeed, LED lights lose their quality after a specific number of usages. These are added to the first aid kit of the escape room (Figure 37).

Console puzzle: A solution to the battery problem started to be built but it was not finished before the second round.

Ping pong: The conclusion following the second test game was reaffirmed that the game of ping pong was simple. The subject of whether the game is too simple was raised once more. This generated the idea of combining the cone puzzle and the ping pong puzzle. After testing, it was determined that merging is ineffective and that the ping pong puzzle should continue to be a boost to players of the escape room game. The ping pong balls were left loose within the package to still provide a little additional complexity to the puzzle.

Figure 38: Invisible ink improvements.

Invisible ink: There were still some unclear passages in the invisible ink. As a result, the puzzle has undergone several changes. First, a spatula was added. Players will find it simpler and more obvious to mix a liquid as a result. Second, an English translation of the Finnish version of the icon paper was made. To make the game simpler, the team thought about removing additional papers from the game. That was ultimately avoided because the client wished to wait for the outcomes of the next testing round with the teenagers. And last, a new, fancier water bottle was bought for the backpack. Because of this, using the bottle is made simpler and more integral to the game. All the improvements are in Figure 38.

4.4.2 Web application

After this testing round the hints of the application changed again, because the hints were straightforward. Then, the work started on adding a picture in one of the hints. However, this did not work out. The last thing was the continue to work on a way the application could be uploaded though the tablet. The solution was finally found. The code was uploaded though github in github the html file was transformed in though a webpage. In the webinto application the website is loaded and transformers it in tough an apk and the apk is loaded in the tablet as an application.

4.5 Test with a class of teenagers

4.5.1 Organisation and proceedings

The third round of testing was conducted with a group of teenagers who came to Technobothnia for a tour. The escape room was played by the teenagers after getting a tour of Technobothnia. The class consisted of fifteen teenagers. In collaboration with the client, the class was consequently divided into four groups. The escape room was divided into four different areas as well:

1. Physics laboratory --> toothed wheels puzzle and ping pong puzzle
2. Electrical and IT laboratory --> UV-circuit puzzle and console game
3. Science laboratory --> Invisible ink puzzle
4. Mechanics laboratory --> Technical drawings puzzle and cone puzzle

Each of these areas has its own "island." Every island had a game supervisor. A fourth EPS student showed up to assist. The puzzle's preparation was overseen by the game master, who also made sure that the puzzles' completion times were recorded. A winning team was selected based on the playing times, and as a prize they got to play the robotic arm puzzle.

This method for playing the escape room worked as expected. The escape room cannot be played with a considerable group. Therefore, it makes sense to divide the group and the escape room.

For the test results, a new, more compact version of the initial Google form has been made for the players and another one for the teachers.

For the instructors who participated in the test round, a new Google form has been made to collect test feedback. This is because the escape room would be used in classrooms in the future, and teacher feedback would be very helpful for testing in school.

4.5.2 Results

4.5.2.1 Time recording

The duration of time spent on each puzzle by every team were documented at each part by the members of the board. In Table 13 is presented the results of the spending time on each

puzzle for each team. The Figure 39: Chart of the time spent on puzzles in function of team players in round 3. , illustrates that in a chart.

Puzzle	Team 1	Team 2	Team 3	Team 4	Average
1	9	12	10	9	10
2	9	7	7	6	7
3	8	7	7	6	7
4	14	16	21	12	16
5	2	1	1	1	1
6	1	7	4	6	5
7	13	12	22	16	16
Total	56	62	72	56	62

Table 13: Round 3 time results.

The average time is around 62 minutes, 1 hour and 2 minutes without the last puzzle. For few seconds, team 1 was the fastest one. Thus, they played the last puzzle. The time spent on the last puzzle was about 15 minutes. Finally, the fastest total spending time was comprised around 77 minutes, 1 hour and 17 minutes. Compared to the goal, gather around 1-1h30 (60-90min) this time respect the objective. In addition, the average time spent on each puzzle was gathered around 8 min. That was lower than the first and second round.

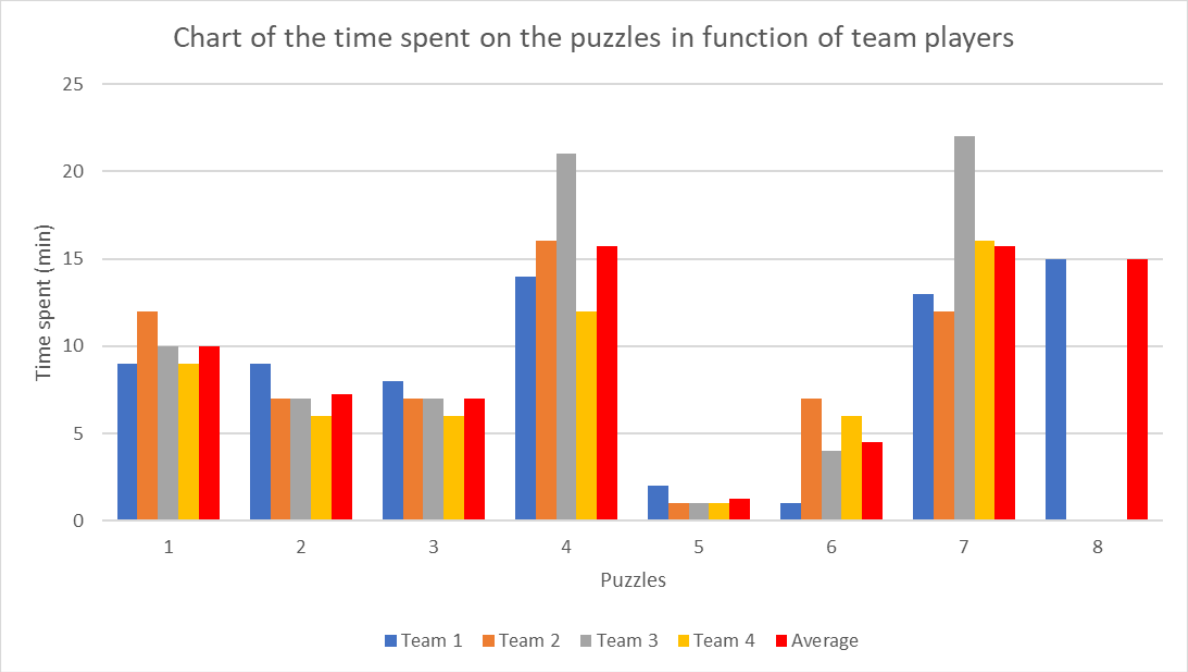


Figure 39: Chart of the time spent on puzzles in function of team players in round 3.

The chart of the time spent on the puzzles in function of team players Figure 39 demonstrates that the irregularly spent time on each puzzle could be found on each team player. The time spent in the puzzles was more regular than the other testing rounds.

The table below gather the average of time spent on each puzzle depending on the testing round.

Puzzle	Average (teenagers)	Average (round 2)	Average (round 1)
1	10	15	13
2	7	15	5
3	7	20	14
4	16	13	14
5	1	3	2
6	5	9	8
7	16	18	18
8	15	10	14

Table 14: Time comparisons.

Results demonstrates that the children were quicker than students in the first and second rounds. That may be expound on the competition created between them. Another explanation could be that they saw a part of the solution for other puzzle while they were waiting for the next puzzle.

4.5.2.2 Feedbacks from players

As said in 4.5.1, a new google form feedback was made for this testing round. It was a reduced version of the other one. The reason was that the configuration of the game was not the same as the others (laptop against tablet). On 15 players, 9 feedback responses have been received.

Most of the players had a pleasure to be here, as well as the previous testing round. The game was found fun, challenging and interactive as the comments and the Figure 40 presents: "As said before it was fun" "I thought it was fun". 90% of the responses said that the game was fun and more than 50% demonstrated interest in pursuing a technical career.

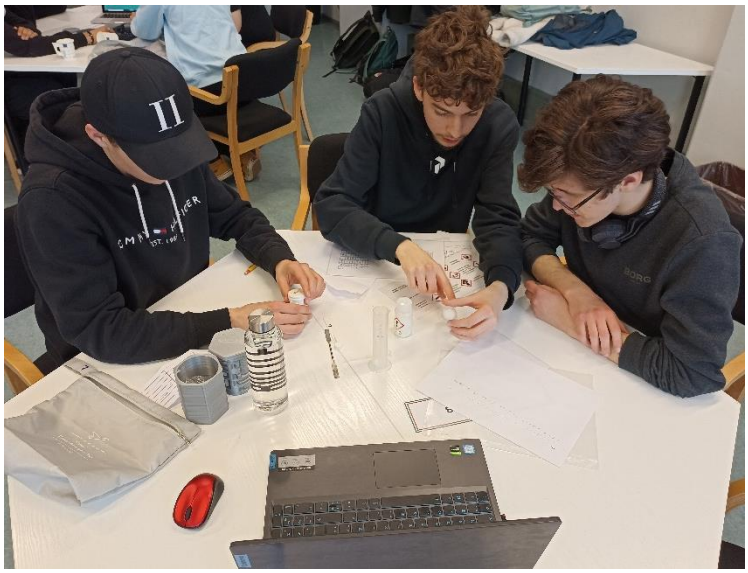


Figure 40: Players of round 3.

The class was formed by teenagers who are 16-18 years old. Thus, the target group of the project played the game.

The age suitable for has been estimated mostly for 16-18 years old people as the Figure 41 is presenting:

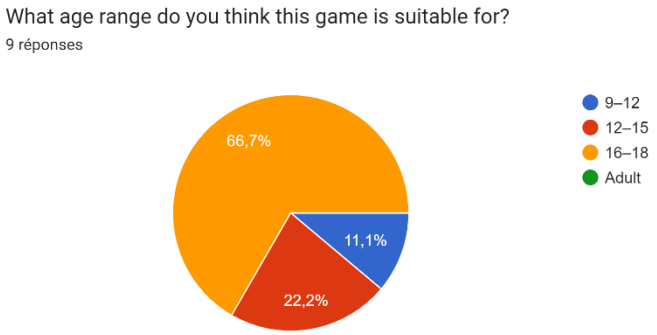


Figure 41: Age suitable according to round 3 players.

- 66.7% estimated that is suitable for 16-18 years old people.
- 22.2% evaluated that is made for 12-15 years old children.
- 11.1% noted that for 9-12 years old children.

Thus, the target group was suitable for the game.

Moreover, the application feedback was less liked than the other testing round. Indeed, the average was 6.89 out of 10. That might be explained by the fact that the game was run on laptop and not the tablet, the screen fitting may be more adapted in the tablet.

In addition, feedback of the game in general was filled in by players. The average mark was about 7.39 out of 10. Also, the average was 8,22 out of 10 (0: hated 10: loved), for the question “How much did you like this game in general?”. All participants evaluated the game's difficulty level and time duration as appropriate and suitable.

Therefore, the final section highlighted the quality of the puzzle, including the materials used, the challenges encountered in finding the codes, the effectiveness of the hints, and the players' puzzle preferences.

Finally, the average was 8 out of 10, for the question “How much did you like the materials and/or game pieces?”. The hints were not used that much. However, for players who used them, they were balanced about the hint's effectiveness.

Furthermore, the most liked puzzle was composed of the invisible ink and the toothed wheels. The printing part were really appreciated by the players. As the previous round, the chemical puzzle was highly liked.

Despite the results meet expectations, the marks were lower than the previous testing rounds. That could be explained by the test organisation. Indeed, split the game in 4 parts, run the application with laptop could be parameter that players less like than before.

4.5.2.3 Feedbacks from teachers

A special feedback form was created especially for the three teachers who accompanied the teenagers (Appendix 7).

The Figure 42 presents that the age range suitable for the game is mostly for 16-18 years old people.

- 66.7 % estimated that is suitable for 16-18 years old people.
- 33.3 % evaluated that is made for 12-15 years old children.

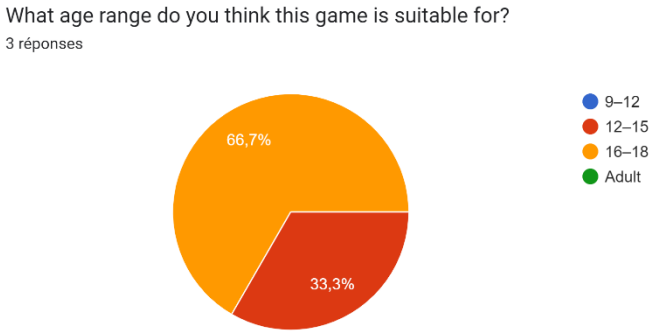


Figure 42: Age suitable according to teacher.

The minimum age estimated by the teachers was about 14 years old. Moreover, the suitable duration time for the game was evaluated around 1 to 2 hours. Thus, the game duration was just right, as the answers of the teachers.

Therefore, the game in game was really liked as the average mark in for the question “How much do you like the game in general” reveals: 8 out of 10.

Furthermore, the materials were also really liked. Indeed, the average mark about the materials was around 8.3 out of 10.

In addition, there are some comments written by teachers about the game:

“Great work, it was fun taking part!”

“Good work, keep developing, finetuning; game was appreciated”

The game will be recommended for other schools.

Nevertheless, the average mark was around 6.9 out of 10 for the story of the game. This result was similar to the players of the same round. The reasons why the mark was lower than the rounds before was the same as for the players (4.5.2.2).

4.5.2.4 Feedbacks from the team

The game session took around 2h, from the welcoming, introduction to the leaving of the class. However, the puzzle solving time was around 1h and 17 minutes. Thus, the goal was respected.

Furthermore, following teachers' opinion, the length of time to setting up/introduction/end of the game of 2h was suitable.

Moreover, in case of next testing round in the same settings, the masters of the game should train again to build a more interactive introduction.

Nevertheless, using laptop to run the application was not optimal. Indeed, some illustrations were not fitting on the screen as expected.

Therefore, the console broke during the last round. Indeed, an inside component of the console melt. It might be explained because of a battery overload: the generator supplies 5V, but the rated voltage of the console is about 3.7 V.

In general, this test demonstrated that the escape room could be played in two ways. In the case of one testing one entire class within only 2 hours (15 or 20 players maximum), only the second setting is possible (split puzzles in 4 parts). Another setting is plausible with 25 players. Indeed, one group could wait, and someone might show the studies available in technical sector or they could read the possibilities of studies in printed papers. This experience will be an example when the game will be advertised beside schools.

Finally, before lending the game to school, teachers could solve the escape room. Then, the game will be explained with effortless by the leaders. Otherwise, the team wrote instructions for teachers/leaders of the game.

4.6 Improvements/actions

4.6.1 Puzzles

- **Console puzzle:** A solution to the battery problem started to be built but it was not finished before the next round. Moreover, 3 consoles were ordered. However, the reception was after the 4th round. Thus, an old console was used only in the next round.

- **Toothed wheel:** Throughout the third test round, the toothed wheel continued to have issues. The gears did not operate smoothly because one of the pins was still out of place. Additionally, gamers occasionally got confused by the arrow and the word "UP." In addition, some pins that were hot glued into place were dislodged. Because of this, it was decided to create a brand-new board for the toothed wheel puzzle and use 2-component glue to make the pins fit. For the last test round, work was begun on the new board. However, this was not completed before the final test round because it was too risky. For this, the old board had to be taken apart. It was uncertain if the new board would be ready on time. The new board's readiness would not certainly be ready in time. As a result, most secure way was chosen to ensure that the puzzle could be used.

- **Invisible ink:** Any documents after testing with the teenagers were deleted. The puzzle was simple enough to be solved. The client also mentioned that having a few confusing side paths is part of the escape room experience. When an escape room becomes too simple, it is not enjoyable anymore.

4.6.2 Packaging

Alternatives have been considered for the puzzles' packaging. There required to be a replacement for delicate puzzles. Additionally, the customer handed us the task of creating more polished packaging. In the end, fabric packaging instead of all the packaging was decided to be used. Finally, it was agreed to put the toothed wheel, console, and chemical problems in boxes, as presented in Figure 43.

Figure 43: New packaging.

These puzzles were picked because of the price and the weakness of the pieces compared to the other puzzles. Additionally, the boxes give off a professional and "scientific" impression. It enhances the experience of an escape room. Other options, which are detailed later in the paper, have been investigated for the fabric package design.

4.6.3 Web application

After the testing round the packaging as was changed. With the names was changed. Then, the puzzle got a logo. Therefore, it was decided to do this change everywhere. In the folder the names of the folders changed, and in the web application. In the application, for the puzzle names changed and for each puzzle name the logo of the puzzle came. Also, when revering though the divider the names changed though the puzzle name and a logo was sown. This version of the application was published on the tablet.

4.7 Test with a group of teenagers

4.7.1 Organisation and proceedings

As school did not response to the team, Josefin enquired children of friends of her to play the game. Then, at least one player group of the target game played the game as the initial gaming way.

Organisation and proceedings were the same as round 1 and round 2. It took place on the 26th of April.

The team players were constituted by 3 Fins aged around 16 to 18 years old.

4.7.2 Results

4.7.2.1 Time recording

The chart of the average time spent in function of the puzzles is presented in Figure 44.

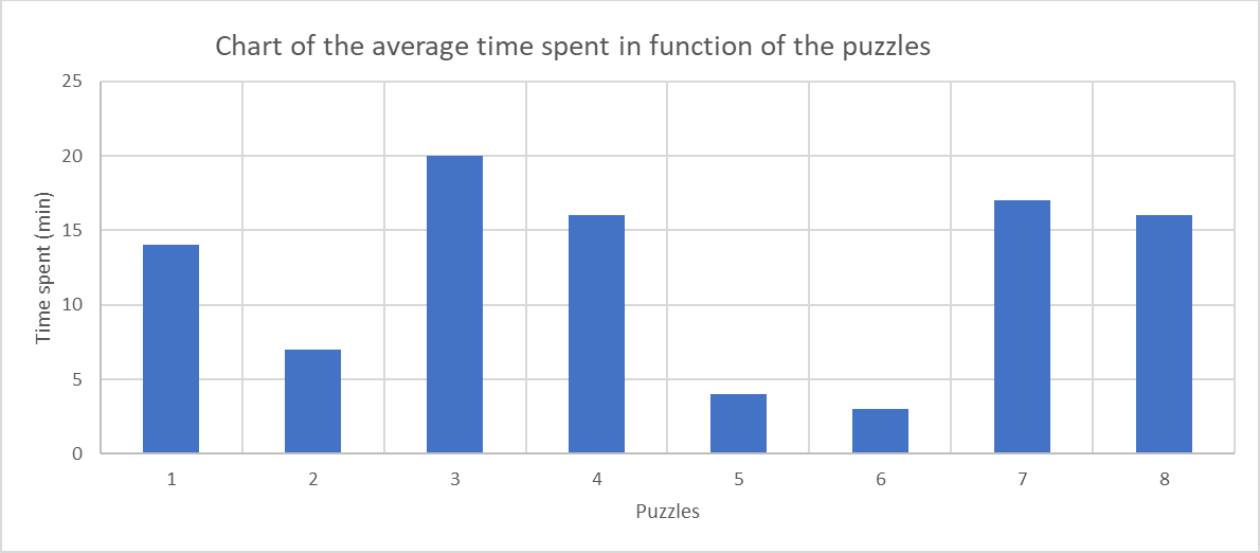


Figure 44: Chart of the average time spent in function of the puzzles in round 4.

The time spent in the puzzles was still not regular. The average time was around 97 minutes, 1 hour and 37 minutes. That was close to the goal (1-1,5h). In addition, the average time spent on each puzzle was gathered around 12 min.

Moreover, the time spent on the second (UV circuit) and the fifth (cone) puzzle was very fast compared to the other rounds. Otherwise, the rest of the spending time on the puzzle was in the average of the other testing rounds.

Nevertheless, the players had difficulties to solve the console puzzle. Indeed, players did not use the double jump and collect sufficient coins to finish the game. Once used, players solved the problem very fast.

4.7.2.2 Feedbacks from players

The escape room was relished by the players. That was found fun, challenging, interesting and interactive as presents the Figure 45. There are below some comments about the game:

“It was fun to play and was a good way to test your knowledge” “It was fun”.

Figure 45: Players round 4.

For this round, the age suitable for was evaluated mostly for 16-18 years old people:

- 66.7% estimated that is suitable for 16-18 years old people.
- 33.3% noted that for adult.

In summary, the target group was suitable for the game.

In addition, the average mark about the application/tablet was around 7,9 out of 10. It may show that the application improvements were useful and effective.

Furthermore, the game feedback in general was completed by players. The average mark was about 7.4 out of 10. Then, for the question “How much did you like this game in general?” the average was 7.7 out of 10 (0: hated 10: loved). All players judged that the difficulty is just right as the time to solve the game: “Easy to understand knew what to do”.

Finally, for the last part, the quality of the puzzle like the materials, the difficulties finding the codes, the hints and their puzzle preferences was noted.

For the question “How much did you like the materials and/or game pieces?” the average is 8 out of 10. The hints were judged as helpful. The comment below may proof that: “The hints were easy to understand and well made”. That may be because of the hints’ improvements.

Therefore, the most liked puzzle was the UV circuit as the comment shows: “The electric one because it was easy”. Indeed, it was solved very fast without any difficulties.

4.7.2.3 Feedbacks from the team

All the puzzles run on as excepted. The game was playable without problems. Therefore, this goal was completed.

Josefin considered that the goal time was also completed even if the result was higher than the initial goal.

Depending on the skills in playing videogames, players may solve the puzzle in very different time duration. This round and the older ones demonstrated that the console game took a long time to be solved. Thus, reduce the number of coins required to complete the game was decided (for next rounds).

Some little improvements/finishing touches were still required. Such as changing pictures in the application, delete the mathematical way to solve the invisible ink, remove unnecessary instructions in the console game, finishing the packaging and changing the end of the game.

Usually, the escape room games end after unlocking a safe. Therefore, a puzzle before the robotic arm chest was decided to be made.

4.8 Last improvements

4.8.1 Puzzle

Console puzzle: Solution for "empty the battery between tests"

Problem:

In the case of several tests in a same day, the console battery could be charged before the subsequently test. Indeed, players charged the battery of the console, with the hand generator, and solved the game. However, after solving the game, the battery was full. Then, the next group had the console game already charged.

Goal:

The goal was to "empty" the battery when the game was solved. In other words, the goal was to have automatically the battery empty for the next test, even if it was directly one after the other.

3 solutions were discovered to solve the problem. The solution 3 was the most adapted. Therefore, that was the solution made. The solution 1 and 2 are standing in Appendix 8.

Solution 3:

This solution derived from the solution 2. Indeed, instead of using an electrical way to build the system, the way was electronical. The second solution was to charge a little battery with the hand generator in between the console and the generator, and disconnected the console battery. Then when the intermediate battery would supply the console.

In the retained solution, the goal was to false the console battery charging by using a microcontroller (Arduino) which controlled the energy supplied from the intermediate battery to the console. Indeed, the console would be always plugged with the microcontroller. That one would supply the console in function of the builder requirements by using programming (language: C++). There is below a picture of an Arduino board.

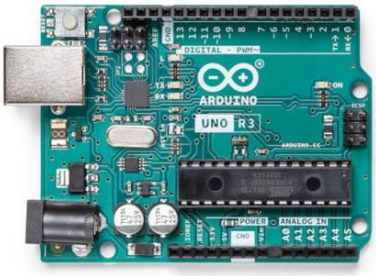


Figure 46: Arduino board.

In addition, to make the players more interesting in the puzzle, or in electronics, a display would print the level of energy available in the false console battery (percentage of the battery left).

To avoid that player, plug directly the generator to the game, a special wire strategy was made. The figures below present the circuit in schema then in real.

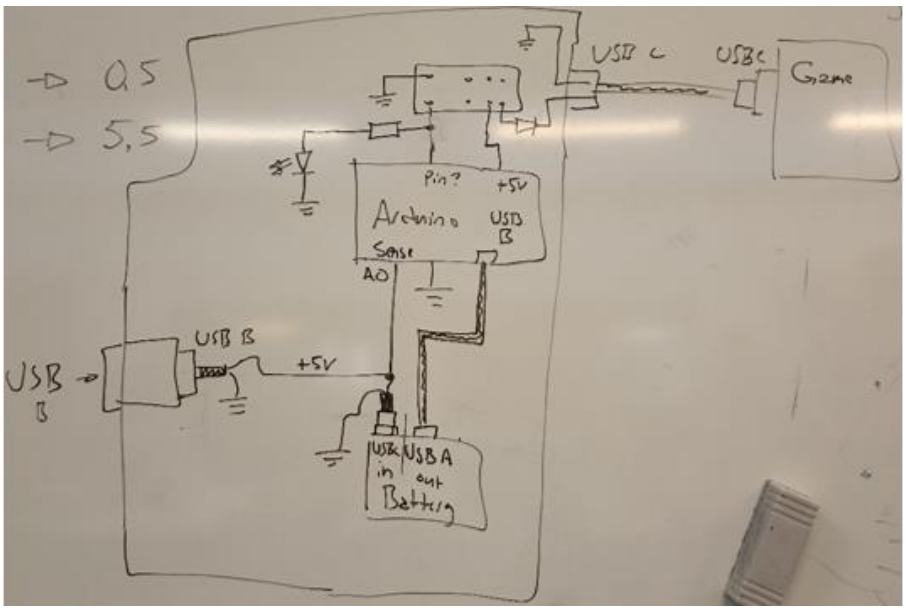


Figure 47: Schema of the circuit.

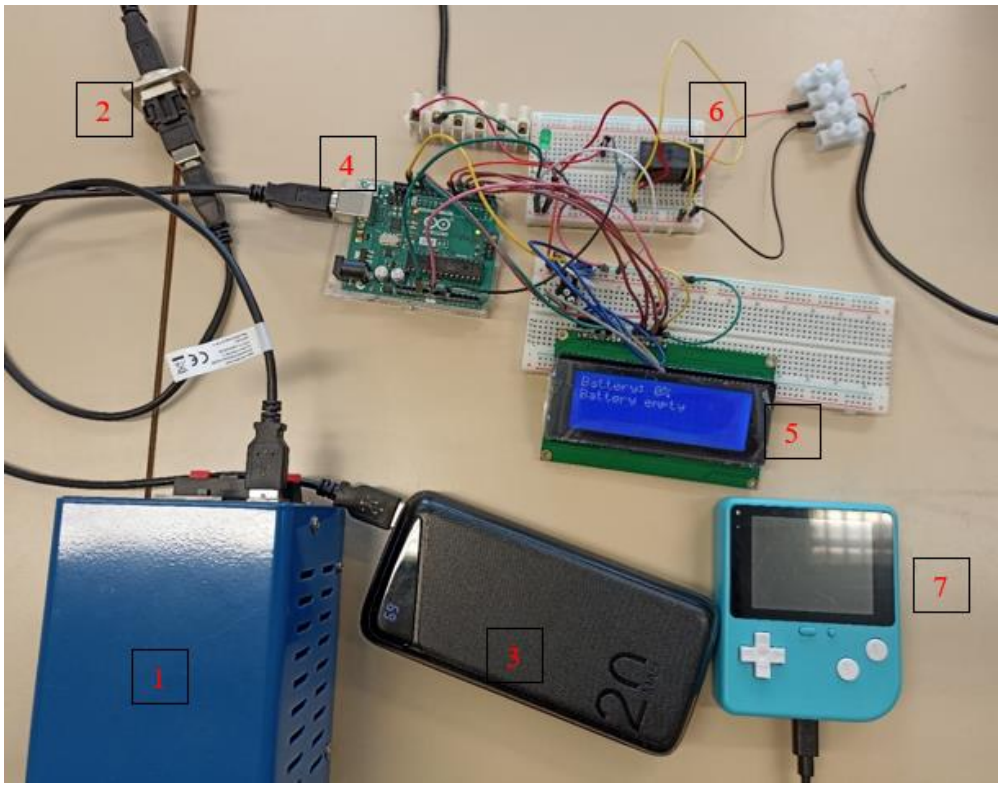


Figure 48: Picture of the circuit.

From the left, from the USB B- USB B (2) adaptor there is a hand generator (1). Then a box would contain all the component required for the system.

Initially, a wire from the USB B-USB B (2) adaptor would relate to the battery (3) and the Arduino (4) (microcontroller). That implied to charge the battery while turning the generator. However, the battery was used to supply the Arduino at the same time. But the battery could not be recharged and supplied current at the same time.

Therefore, the battery (3) was only plugged with the Arduino (4) to supply power and the wire from the earlier USB B was directly connected to the Arduino at the A0 input (Analog input 0).

Then the voltage produced by the generator was measured by the Arduino. While the voltage was equal at 5V the Arduino implemented by 1% each second of the fake battery. That means that while the generator was turned, each second gave one percent more in the fake battery.

Also, while the percentage of the battery was superior at 0%, the Arduino supplied the console (7). The picture below illustrates that (5).

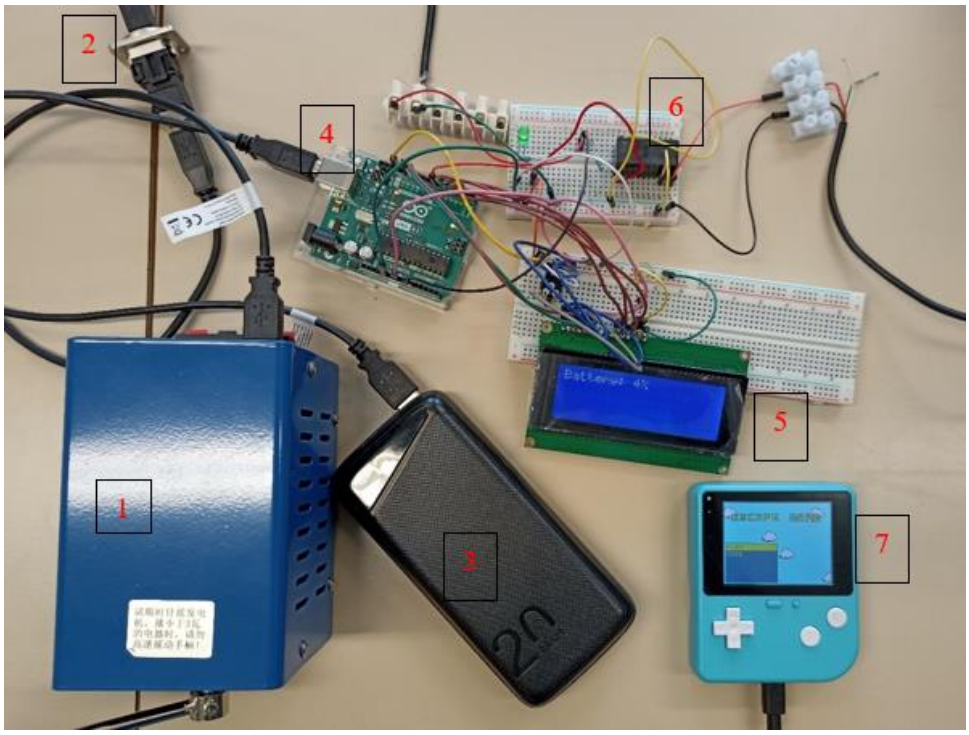


Figure 49: System on, with console supplied.

However, the fake battery percentage went down by 1% each 3s while the generator was not turned. Moreover, the display was not represented in the schema and the diode was not used in real for this version of the system.

Furthermore, a relay (6) was employed after Arduino and before the console because the current supplied by the Arduino was not sufficient to turn on the console.

Finally, the output of the box went to the console game. The box was not represented in real. All the system was operated as expected.

Nevertheless, the battery owns a clock that it was turn off automatically if it was not employed. The current consumption of the system was small. Therefore, the battery was turned off automatically while playing.

Furthermore, this was only a prototype. Indeed, the solution was not durable. Thus, the work should be continued as making the game durable such as creating a special board for all the system and delete all the Arduino wires. Then, another person may install all the component in a box, may place a switch to turn on/off the battery bank and might create a hole in the box to charge the battery before testing. The Appendix 9 details the Arduino wiring and the code employed.

Console: The console puzzle was simpler by making it optional to go up and collect 90 coins. It is still possible to go up and though collect 90 points. This will give a hint code for the safe in the robotic arm puzzle. Either way the code is given. It was only difficult to add this thing because it was not possible to edit the console puzzle without an error. The error was removed but this does mean that there are less animations and the jumping action is a little bit slower.

Toothed wheel: Further work was done on perfecting the toothed wheel board after testing with the teenagers. A black plexiglass plate was first cut to size and finished with no sharp edges remaining. The new board, Figure 50, has holes precisely positioned for the pins. After that, two-component glue was used to attach the pins to the board. The board was tested several times with the gears on it after the pins were adjusted. The result was that the gears now fit properly on the board and work smoothly.
The plastic sticker sheets for the lettering had also been delivered in the meanwhile. Using the Brother ScanNCut SDX1200, the letters and numerals were cut from the plastic sticker sheets. After that, these stickers were applied on the new board. The code was considerably simpler to read through the holes in the gears since the board is black and the text is white.

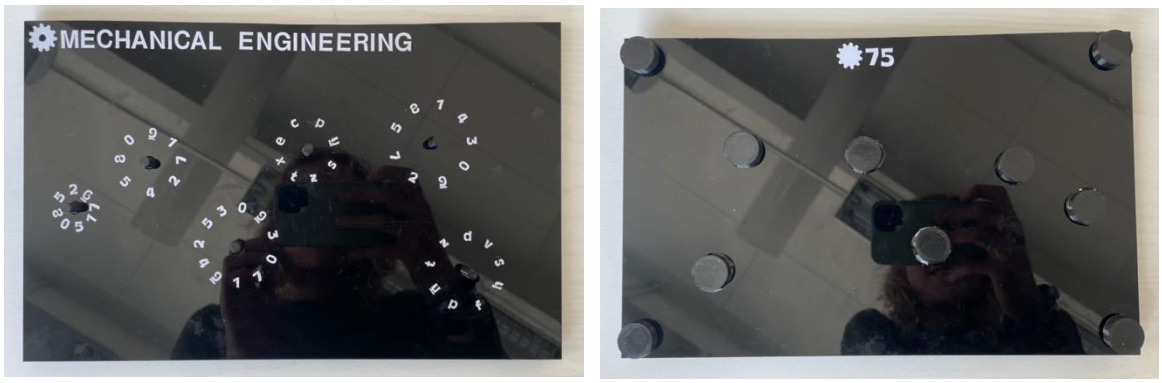


Figure 50: New toothed wheels board.

 *Figure 51: New spray code.*	**Invisible ink:** The little bottle's code has been modified for the invisible ink game. The original code was changed since it was unclear. The previous code provided a calculation-based solution to the decoding. As a result, the players lost focus on the easier solution. H2O has replaced the previous code of 2 mol/l. The water, that players are required to add to the mixture to make the invisible ink visible is referred, Figure 51, to as H2O.
 *Figure 52: New arrows.*	**Robotic arm:** For the first testing round, arrows were attached to the robotic arm using paper and tape as a temporary solution. These arrows could be changed with the stickers of the arrows now that the plastic sticker sheets had been delivered. This looks more professional and is more durable, as the Figure 52 is presenting.

4.8.2 General

- **Puzzle on safe:** First, the last safe could be opened with a code that was displayed in the application. Then, a small puzzle on the locker instead was added. This puzzle doesn't take much extra time but makes opening the locker more challenging.
- **Hint words more obvious:** The text for the two lovers in the console puzzle has been modified to make the text hints more obvious. The last word did not stand out sufficiently because the initial clue words were just in bold. The text's words are now more noticeable because they are underlined.
- **Remove cheat code:** In addition, the console game contained an extra page in the binder that was confusing for players. Because of this uncertainty, players waste a lot of time, and the console puzzle was already challenging enough. For this reason, the extra paper has been removed from the binder.
- **Paper for notes:** It turned out during the test rounds that players required paper to take notes while playing the escape room game. As a result, Technobothnia writing paper has been added to the backpack.

4.8.3 Packaging

The names of the games were printed on labels for the packaging. This makes it simple to identify the puzzle that is within the packaging. The puzzles' names were also modified. The original names of the puzzles already had suggestions about what the games were about. For instance, the name of the puzzle with invisible ink already implies that the game contains invisible ink.

The names were changed to:

1. Technical drawing --> Technical drawing
2. UV-circuit --> Electrical engineering
3. Console game --> Computer engineering
4. Toothed wheel --> Mechanical engineering
5. Ping pong --> Logics
6. Cone --> Physics
7. Invisible ink --> Chemistry
8. Robotic arm --> Robotics

The names also reveal which Technobothnia department the puzzle belongs to. This inspired the idea to put a map of Technobothnia on the package as well.

On the fabric package, the map was placed using transfer paper. The picture was fused to the packaging by printing it on transfer paper and heating it in a heat press.

The floor layout was put in the packaging boxes, as the Figure 53 reveals. When the players open the boxes, the map will then be seen. The boxes outside now include the names of the puzzles. As a result, the puzzle's presence in the box is still visible from the outside. The maps and names were first printed, then laminated and attached to the boxes with strong double-sided tape.

The folders' design was modified. Initially, these were just numbered, which confused players. Each problem has a folder in the updated edition, although not all of them are filled. This makes it simple to identify with which puzzles need the use of the binder's sheets. The same design was used for the folders as for the packaging

The folders' design has also been modified. Initially, these were just numbered, which confused players. Each problem has a folder in the updated edition, although not all of them are filled. This makes it simple to identify with which puzzles need the use of the binder's sheets. The same design was used for the folders as for the packaging.

Figure 53: Printed labels and floor on packaging.

4.8.4 Web application

Finally, for the web application the instruction for the locker before the robotic arm where change. Because now the code isn't given any more. A start was also made to add an extra slide in the end with information about opening another locker in which the prices were. Unfortunately, it was not possible to add this information because there was not sufficient time. The team change the first hint to include small or capital letters in the UV circuit puzzle and add a picture in the technical drawing. The entire updated application is presented with screenshots in Appendix 10.

4.9 Last testing round

4.9.1 Organisation and proceedings

During the last week of the project, after that the improvements were finished, a last testing round was run to trial the improvements and to write recommendations for a next group.

The proceedings were the same as round 1 and round 2. It took place on the 9th of May.

The team players were constituted by 2 international students with a technical background.

4.9.2 Results

4.9.2.1 Time recording

The chart of the average time spent in function of the puzzles of the last testing round is presented in Figure 54.

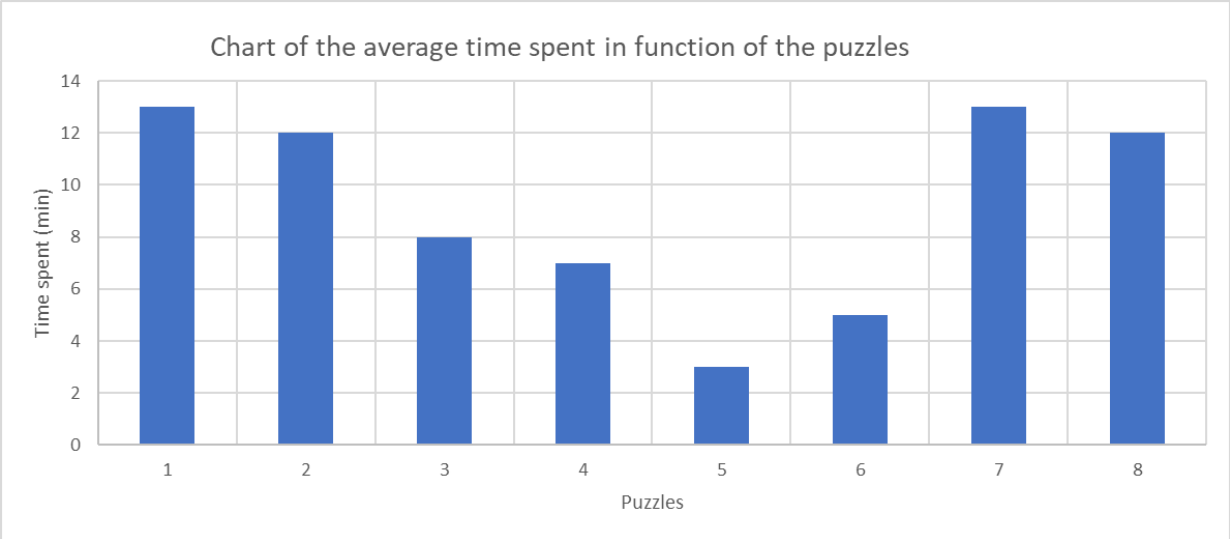


Figure 54: Chart of the average time spent in function of the puzzles of round 5.

The time spent in the puzzles was still not regular but more homogenous. The average time was around 73 minutes, 1 hour and 13 minutes. That was into the goal (1-1,5h) and faster than all the other testing rounds. Thus, the improvements made may be effective. In addition, the average time spent on each puzzle was gathered around 7.3 min.

Moreover, the time spent on the third (console) and the fourth (toothed wheels) puzzle was very fast compared to the other rounds. Indeed, the number of coins to reach the console game was decreased, then players had less difficulties to solve it. Otherwise, the rest of the spending time on the puzzle was also faster but closer to the average of the other testing rounds.

Nevertheless, the players spent a little more time than usual in the electrical puzzle (UV circuit (2)) but the solution was found fast. The code was found after several minutes.

4.9.2.2 Feedbacks from players

The escape room was appreciated by the players. That was found fun, challenging, interesting and interactive as presents the Figure 55. There are below some comments about the game: “I liked the videos and that the teachers are locked up, that makes it fun” “It what fun to play games you usually don’t play”.

Figure 55: Players of round 5.

For this round, the age suitable for was evaluated mostly for 16-18 years old people:

- 50% estimated that is suitable for 16-18 years old people.
- 50% noted that for 12-15 years old children.

Moreover, the application/tablet received an average rating of 7.5 out of 10, suggesting that the recent improvements made to the application were effective. Participants also reported that the illustrations/instructions were easy to read.

Furthermore, the feedback received from players regarding the game was comprehensive. The game received an average rating of 7.6 out of 10, with a rating of 8 out of 10 for the question "How much did you like this game in general?" (0 indicating dislike and 10 indicating love). All players agreed that the game's difficulty was appropriately set, as the time to solve it: "I enjoyed the videos and the fact that the teachers were locked up; it made the game more entertaining."

Finally, feedback was collected regarding the quality of the puzzle materials, difficulty in finding codes, hints provided, and player preferences. Participants rated the materials and game pieces highly, giving them an average score of 9 out of 10. The hints were deemed helpful, with one participant commenting: "They were useful, but you still had to think afterwards, which made it more enjoyable. There was also a second hint option available." This improvement in the hints may have contributed to their effectiveness.

As per the participants' comments, the most popular puzzles were the toothed wheels and the chemistry puzzle, with participants noting that "The gears were well-designed and easy to understand" and "The chemistry puzzle was fascinating; it had many components, and it was enjoyable to examine all the elements required."

4.9.2.3 Feedbacks from the team

This test was the occasion to test all the improvements made both in the entire semester and in the last part of the project, especially to trail the battery simulation for the console puzzle.

Indeed, the electronic system presented in 4.8.1 was utilised for the first time in real conditions. The figure below was taken while players employed the system. Because of the battery bank turned off directly, the Arduino was supplied by a laptop.

Figure 56: New console puzzle tested by players.

The puzzles functioned as intended, and the game was fully operational without any issues, thus allowing the objective to be achieved. However, minor enhancements or final adjustments may still be necessary, as outlined in the recommendations section of the report (6.1-6.3).

5. Results comparisons

In total, 39 players and 3 teachers in total were involved in the testing rounds. The Table 15 gathers all the average time in total and by puzzle on each round.

	Round 1	Round 2	Round 3	Round 4	Round 5	Average
Average time spent by puzzle	11	13	7,7	12	7,3	11
Total average	88	102	77	97	73	87
Standard deviation	5,4	5,4	5,5	6,3	3,9	4,6

Table 15: Comparison of the total time spent by testing round in min.

The results were included between 73 to 102 minutes (1 hour 13 minutes to 1 hour 42 minutes). The four rounds average time spent in total is about 87 minutes (1 hour and 27 minutes).

The chart of the time spent on the puzzles in function of testing rounds, Figure 57, demonstrates that the irregularly spent time on each puzzle can be found on each round.

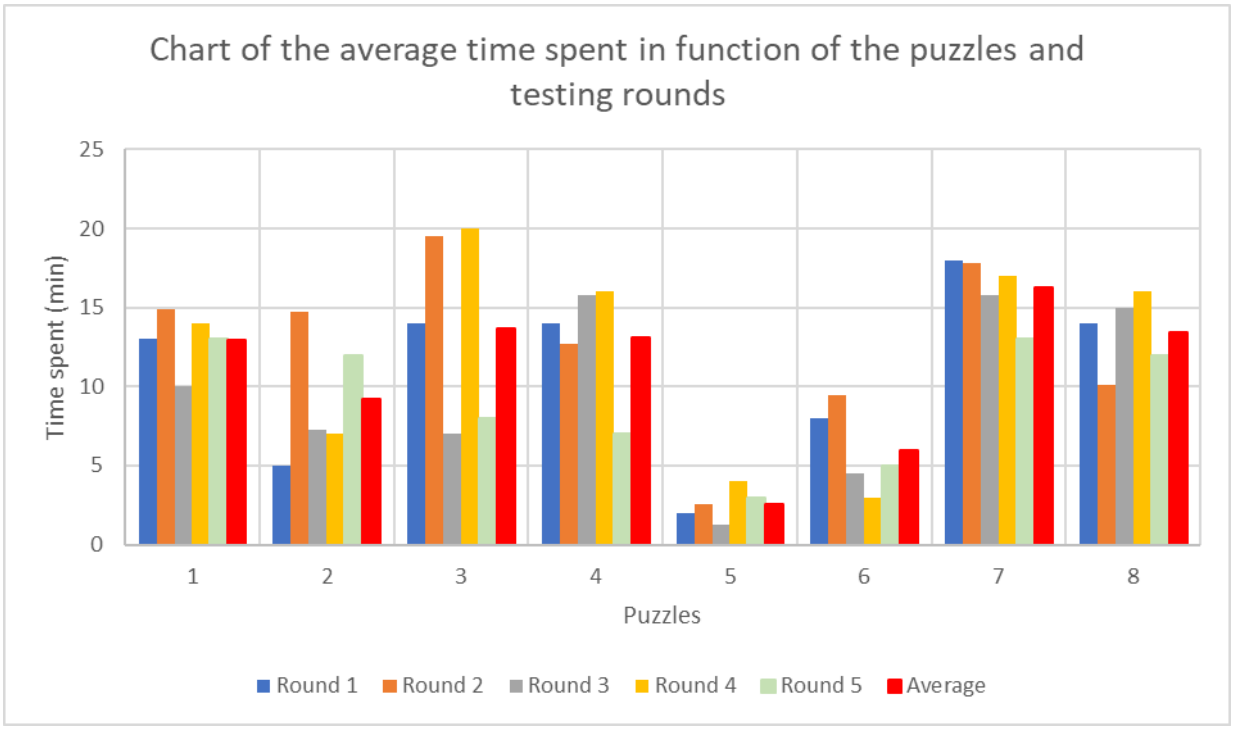


Figure 57: Chart of the average time spent in function of the puzzles and testing rounds.

Other than improvements, the time spent on each puzzle was depending on the age, background and motivation of the participants. That is why it is difficult to see the effects of the improvements by the time spent on puzzles. For example, the round 1 was faster than the second one in 5 puzzles. However, regarding the last round, number 5, is one of the fastest one 6 puzzles. In addition, the standard deviation of the last round is the smallest, meaning that the time spent was more uniform than the other rounds. Thus, the improvements made may be effective.

Moreover, about the feedbacks of players (and teachers), the Table 16 gather the responses for the question of the age suitable for the escape room.

Adult	2	6%
16--18	20	56%
12--15	13	36%
9--12	1	3%

Table 16: Final result of the age suitable for the game.

Most responses were 16-18 years old people. However, still 36% of the respondents believed that the game was suitable for 12-15 years old children. That could be explained because the team said that the game is made for "children/teenager" and could have influenced players. Then, the game is suitable for 15/16-18 years old people.

Furthermore, the table below gathers the marks given in all the rounds in function of the features.

	Round 1	Round 2	Round 3	Round 4	Round 5	Average
Application/tablet feedback	8,1	8,1	6,9	7,9	7,5	7,7
General feedback	7,8	7,9	7,4	7,4	7,6	7,6
How much do you like the game in general?	8,6	8,8	8,2	7,7	8,0	8,2
How much do you like the materials?	8,2	8,4	8,0	8,0	9,0	8,3

Table 17: Result of the players feedback of all the rounds.

The total average is 8 out of 10. That was calculated with the average in each round, but the number of players were not equals. Therefore, that is not the real average.

In addition, marks are equivalent between rounds but the first and second rounds gave higher marks in 3 features. Even after the improvements the game was liked as the marks of the round 5 demonstrates. Therefore, the round 5 gave 9 out of 10 for the materials, that may be through the puzzle's improvements.

Nevertheless, the sensitivity about evaluating something is up to each person. For example, for a same game, same enjoyment, two people could not evaluate the same.

Finally, the game was always found fun, interactive and challenging. Teenagers demonstrated interest in a potential technical career. The game is playable in 1 to 1,5h or 1,5 to 2 hours with the settings and introduction. Any materials were broken during the last testing round. The team utilise only a little part of the budget as thee most of the puzzle were already make and the materials in the laboratory was for free. Therefore, all the smart goals (3.XXX) were respected.

6. Recommendations

6.1 For the game

The game is payable, and people like to play the game but still there can be some improvements. In each puzzle there something that could be improved.

- **UV-circuit:** making the code more readable because now is difficult to find the code. This can be done by changing the hints.
- **Console:** There are two things that could be done in this puzzle. The first thing is adding a box around the Console supply circuit with holes for the two cables and for the battery percentage display. This will make the circuit more durable, and it is not required to be extra corsage with the circuit. The second thing that could be improved is to add the animations back from the character in the game and remove the lack. This will make the game easier, and it will look nicer.
- **Invisible ink:** In the invisible ink puzzle, it is not always clear that people need to use the water bottle. To make this clearer add a picture of the water bottle in the application, change the text in the application, or add a logo of the puzzle on the water bottle.
- **Robotic arm:** In this puzzle the code on the locker is confusing because it uses the same symbols from the puzzle. Those symbols are also used later in the puzzle. This could be improved by changing the symbols on the puzzle on the locker.

6.2 For the application

There are also some improvements that could be made for the application in general. The first improvement is to add background music into the application. By adding background music, the players are more into the game and feel more pressure from the game. The second thing that could be improved is the end of the game. Now there is one slide that congratulates the players, but it is not ferry fun to see. What could be add is an additional slide with confetti and a code for the last locker. In the locker there could be a little gift for the players. The Third thing to add is to make it so that after each third try the players must wait one and a half minutes before entering the new answer. This will make sure that players are not trying endless codes before finding the right code. The last thing is that player is automatically getting one hint if they are stuck add a puzzle for more than 10 minutes.

6.3 For the packaging

There are also some improvements that could be made for the packaging. The first improvement could be to remove all the company logos from the bags. On the bags of the packing are company logos from a travel company. This does not look professional so needs to be removed. The simplest way is to buy new bags without logo's and put the games in it and put the puzzle logo on it. The second thing that could be improved is the suitcase, because that is an ordinary suitcase. It would be more professional and nicer if the suitcase is specially designed for the escape room with storage places for each puzzle. It would then be simpler to pack the game. The last thing that could be improved is to add pages on the school back. This makes the school back look nicer and makes it more a part of the game.

7. Discussion

To make sure this project reaches his goal of teaching children about Technobotnia and a technical career there are still some elements that could be done. The first aspect is to research and market the game. This consist of contacting schools and enquire if there is interest in playing the game. Another important part of marketing is making a website. In this website school have the possibility to lend the escape room and let children play it.

Another thing that could be done is testing on schools. In this project there were only test in Technobotnia and only where the group has setup the game. In the final version the teacher would set-up the game. To look at how this is done there requires to be testing rounds at schools. Therefore, it is possible to prefect the system.

The last aspect that could be done is producing duplications of the game. If the game is duplicated, it would be possible for more children to play the game and learn more about Technobotnia. If this game is duplicated than children could still play the game if something breaks in one game.

8. Conclusion

As part of the European Project semester, the team worked on the rest of the project: Technobothnia's Escape Room in a Box. The escape room was first developed by the previous EPS an Escape Room in a Box is a game consisting of eight interconnected puzzles and a webapp that leads the play through it. The final puzzle serving as the culmination of the game. Originally, the puzzles were categorized into four smaller and four larger ones, but this categorization was abandoned due to varying user responses and the difficulty of distinguishing between "big" and "small" puzzles in terms of effort and time required. The game was initially designed to be completed successfully within 45 minutes to an hour without the need for hints. However, after testing, it was found that players required more time, resulting in the game length being extended to approximately two hours. Each puzzle presents a unique challenge.

The Technobothina escape room was improved based on testing rounds. Indeed, 39 people tested the game in five testing rounds. The first two testing round were with students. The two-testing round after it where with children form 15 till 18 years old and the last testing round was with students. In between those testing rounds the development of the game was done. Therefore, the project started with a testing round and ended with a testing round.

During the testing rounds, the escape room game underwent various improvements based on feedback and observations. Several specific puzzle modifications were implemented to enhance the overall experience. Overall, these modifications aimed to address specific puzzle issues, enhance packaging and presentation, and update the web application accordingly. The improvements seemed to have a positive impact on gameplay, resulting in a more consistent and efficient solving experience. The average time spent on the escape room game during the final testing round. fell within the target range of 1-1.5 hours, indicating the success of the implemented changes.

Overall, the feedback from players was positive, with participants finding the game fun, challenging, and interactive. The game was considered suitable for 16-18-year-olds, with some suggestions that it could also be suitable for younger age groups. The puzzle materials, game pieces, and hints received positive ratings, although some feedback indicated that the hints provided were not always helpful. The application, which was run on a laptop instead of a tablet in some rounds, received lower ratings compared to previous rounds.

In summary, the testing rounds provided valuable feedback and insights for the escape room game's development. The game was well-liked by participants, with positive ratings for its entertainment value, interactivity, and puzzle design. Adjustments and improvements were identified for specific puzzles, the application, and the game's overall setup.

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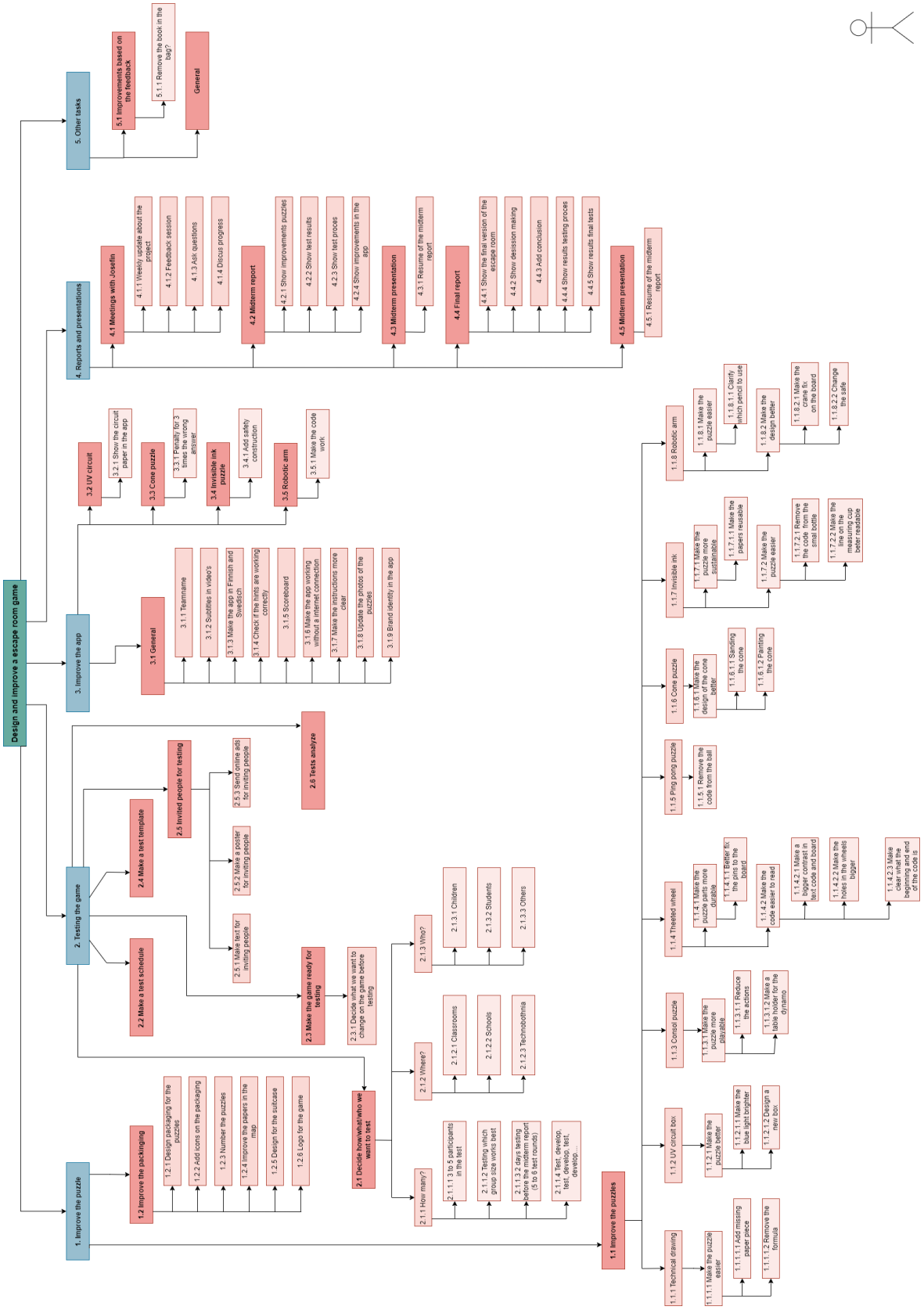
Appendix table

Appendix

Appendix 1: WBS (Work Breakdown Structure).



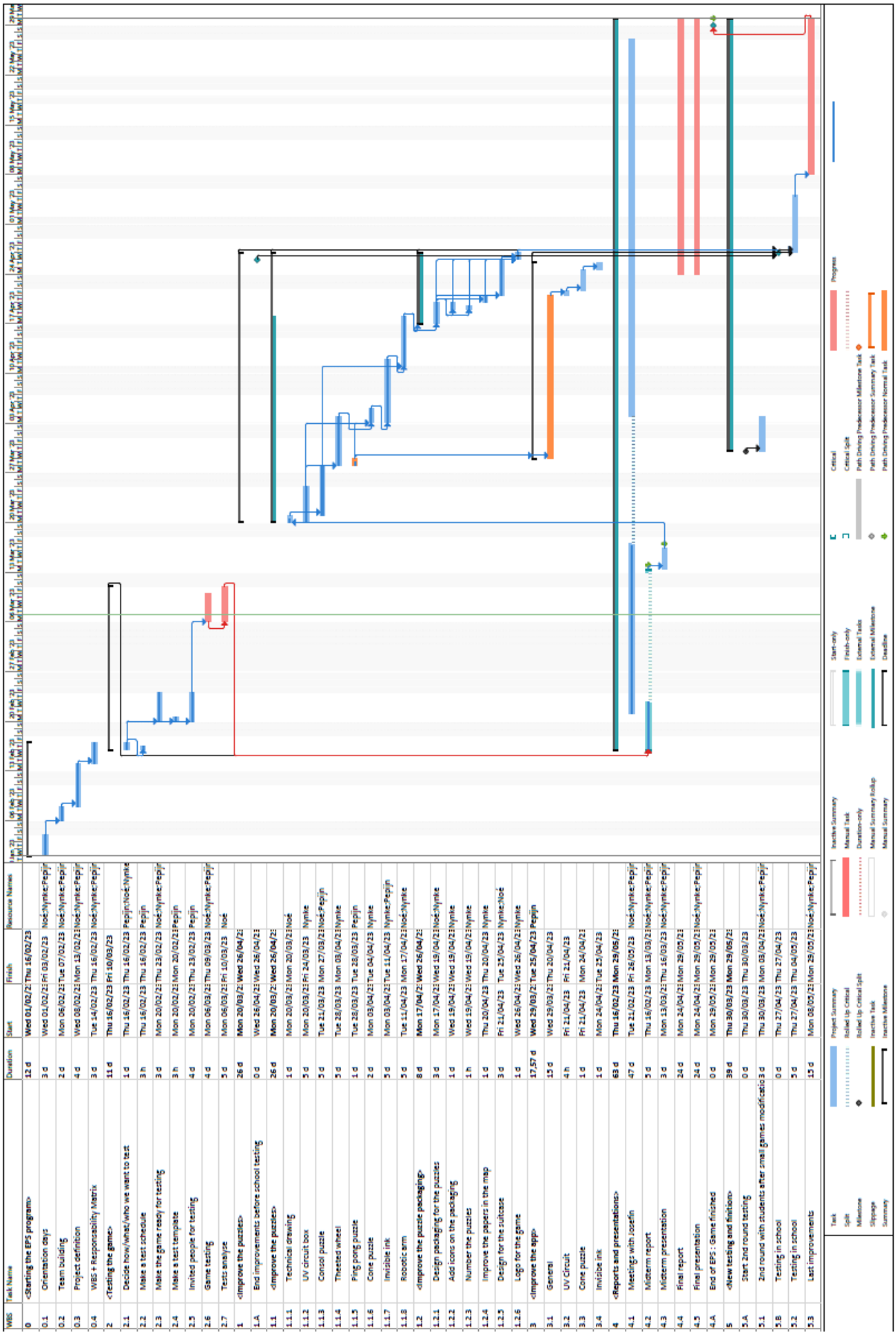
Appendix 2: Responsibility-Matrix

Person WBS-package	Pepijn	Nynke	Noé	Comments
1.1.1 Technical drawing of puzzles	I	A	R	Nynke is driving puzzles improvements.
1.1.2 UV-Electricity box	I	A/R	C	
1.1.3 Consol puzzle	R	A	I	Pepijn responsible for “code” part and Noé/Nynke for design
1.1.4 Weels puzzle	C	A	R	
1.1.5 Ping pong	R	A	I	
1.1.6 Cone puzzle	I	A	R	
1.1.7 Invisible ink	R	A	C	

1.1.8 Robotic arm	I	A/R	C	
1.2 Improve packaging	I	R	C	Improvements of puzzles and packaging should have the same “driver”
2.1 and 2.5 Contact people for test	A/R	I	I	
2.2 Schedule test	A/R	I	I	
2.3 Make the game ready for testing	C	A/R	C	
2.4 Make test templates	I	I	A/R	Noé is responsible and accoutable for feedbacks from tests.
2.6 Tests analyze	I	I	A/R	
3 Improvement of the application	A/R	I	I	Pepijn is accountable and responsible for the IT.
4.1 Meetings with Josefin	C	R	C	

4.2 Mid-term report	C	C	A/R	Noé is responsible and accoutable for reports and presentations.
4.3 Mid-term presentation	C	C	A/R	
4.4 Final report	C	C	A/R	
4.5 Final presentation	C	C	A/R	

Appendix 3: Gantt Chart.



Case:

https://www.amazon.com/dp/B08VBWK115/ref=twister_B08VC2VBLH?_encoding=UTF8&th=1

Screen protector:

https://www.amazon.com/ProCase-Protector-TB-X306X-TB-X306F-Tempered/dp/B08N4NR93P/ref=sr_1_4?crid=1JT5Y8RNJQ0HZ&keywords=lenovo+tab+m10+hd+10.1%22+tablet+screen+protector&qid=1679485784&sprefix=Screen+protector+lenovo+tab+m10+hd%2Caps%2C227&sr=8-4

Boxes as packaging:

https://www.clasohlson.com/fi/p/41-1729
S-Size: 23x19x11 cm
M-Size: 34x29x15 cm
L-Size: 41x32x18 cm
XL-Size: 54x43x22 cm

Console : https://www.robotshop.com/

LED: https://www.starelec.fi/product_info.php?products_id=9590

Papers for board:

https://www.amazon.de//nl/dp/B099MSS8Q2/ref=sr_1_52?crid=10A13GK1PP0UA&keywords=vinylfolie%2Bplotter&qid=1680244190&sprefix=vinyl%2Caps%2C104&sr=8-52&th=1

Appendix 5: Testing feedback form, inspired by last EPS group (Leah Ebert, 2022).

User testing — Game in general: Moderated method

Name of the player:

Nationality of the player:

Name of the team:

Date and time:

What age range do you think this game is suitable for?

9–12 12–15 16–18 Adult

How many minutes did it take you to finish the game?

Under 45 46–60 61–90 91–120 Over 120 min

1 Application (app) /Tablet questions:

1.1 Appearance:

How much did you like the graphics/illustrations of the tablet app?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Did not like Loved

Why?

1.2 Interaction with app

Was the interface easy to understand and to work with?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Difficult OK Easy

If difficult, why?

1.3 Tablet Quality

Was the table (quality/screen etc.) sufficient?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Not sufficient Sufficient

Why?

1.4 Text size

Was the text on the App, puzzles or instructions too small or just, right?

Too small just right too big

1.5 Instructions

Are the instructions for the game easy enough to understand? Yes NO

Would you have preferred a paper version of the instructions to look back on during the game? Yes No

2 Game questions

2.1 Game idea (concept) or theme:

How did you like the Theme/story of the game?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Boring or weak OK Very good

Why?

2.2 Interest:

How much did you like this game in general?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Hated it It was OK Loved it

Why?

2.3 Complexity:

How complex was the general game, especially for your age group?

Very simple Average Very complex

Why?

2.4 Game instructions/rules:

Were the instructions for the puzzle sufficient?

Very simple Average Very complex

Why?

2.5 Playing time:

Was the game too short, too long or just, right?

Too short Just right Too long

Why?

2.6 Waiting time:

How much waiting where you as individual were not busy?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Too much Normal amount Very little

2.7 Interaction:

How much did the game play cause you to interact with other players?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Never All the time

2.8 Hints:

Are the time penalties for hints or the solution too long/short/right?

Too short Just right Too long

Why?

2.9 Uniqueness/ Game mechanics:

How different was this game from other Escape Room games?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Very different Not much different

I have never played an Escape Room game:

3 Puzzles

3.1 Hints:

How were the codes hidden?

Very simple Average Very complex

Why?

If used, were the hints sufficient? Did they help? Yes No

Comments:

Do you have comments about one game in particular? Did you experience problems in one/several of the games?

3.2 Order:

Was the mix of 'hard' and 'easy' games good? Yes No

Why?

3.3 Materials:

How much did you like the materials and/or game pieces?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Did not like Average Loved

Which one did you like best and why?

Which one did you not like at all and why?

3.4 Graphics

How ones did you like the graphics/illustrations of the puzzles?

0 – 1 – 2 – 3 – 4 – 5 – 6 – 7 – 8 – 9 – 10

Did not like Loved

Which ones did you like the best and why?

Which one did you not like at all and why?

(Leah Ebert, 2022)

Appendix 6: Pepijn 1st round testing notes.

Group one (3 people)

Now audio in the video they though the video had audio.

Puzzle 1 (13:15)

Directly picked the good back and picked directly the good puzzle game.

They were thinking to

They were looking in the binas but you don't need it. They didn't figure out the. Make more copies of the first puzzle.

There first try was in the good direction by they didn't fill the good number in.

Had no picture.

Puzzle 2 (3:31)

This puzzles the figured out fast and soon. But then the mixed it up.

It was not clear that you need to see the invisible ink so make the ink brighter.

Puzzle 3 (18:00)

They didn't look in the book because it wasn't written clearly in the app.

It is much work to put the power on the tablet.

And they didn't get it in the first try.

It is not clear how to use solve the puzzle.

The dynamo takes a lot of time and isn't fun to use.

The game goas black in the middle of playing.

It is not clear that you need to use the extra root.

The game is too difficult.

you need to fill in the quiz correctly to unluck double jump make that clearer and make the quiz clearer.

Puzzle 4 (12:30)

The pin was broken so the puzzle couldn't fit so the game doesn't work.

The big ones are not ferry realistic

You need to make clear which pizes are the end and beginning pizes

Make the holes in the wheels bigger.

Make it clear what up and what down is.

Puzzle 5 (1:44)

This puzzle is fast solved.

Puzzle 6 (3:16)

In the app is written divider three but it needs to but six.

He knew the code

Puzzle 7 (19:27)

They first did try to get all the puzzles good but not looked at the papers.

They did get the mores code.

And started by translating the code.

They were thinking below the table, but it accurately is on the paper below.

The game sudently restared so

It isn't clear that you need to use the water bottle.

They did use to much of the material they didn't look

Puzzle 8 (16:28)

They didn't get the clou that you need to use material from the other puzzles.

They did put the wrong pencel inside.

They needed a hint.

They were afrate of opning and using material from other puzzles.

They didn't get the pinpong balls.

Group two (2 players)

Puzzle 1 (16:14)

Slide three

- Log in
- They were writing all the slides and all the information well.
- Picture puzzle one is not working
- Write through the text once and look at typos.
- They did use the book but not for ferry long.
- They tryde before they knew the answer.
- They were.
- Make a limited amount of anweser
- The book is confusing.
- They were calculation too much.

- They were thinking too much, and they feel they don't know

Puzzle 2 (5:57)

- They did use the woring while they didn't need to use it
- They didn't open the box.
- They did use the light to see on the box.
- Make the code brighter.

Puzzle 3 (5:56)

- They did try the game before writing the clue.
- They did try the code before using the code instruction.
- They did directly go above.
- There is a lot of battery in the gameboy.

Puzzle 4 (10:32)

- They didn't know what the beginning and end pices where of the puzzle.
- The big ones are not logical to use.
- They can't seed the letters.
- They though up were a clou.
- The puzzle doesn't fit.

Puzzle 5 (1:25)

- Puzzle was too easy.

Puzzle 6 (7:59)

- Text was not clearly written.
- They are though too difficult.
- They tried everyone so

Puzzle 7 (16:04)

- They stated good.
- They opend also the little decoder
- They started decoding the text on the bottle and though to diffuclut
- They predicted the words.
- They understand what they need to do after decoding the code on the paper.
- Then they understand what they needed to do but they were then thinking too difficult.
- Make a sturing megansime
- Write down on the scoop how many scoops they need.

Puzzle 8 (16:00)

- They directly used the write pencil.
- They were using the book.
- After a while they did know the clou and then it went fast.
- They did look on the package of the ping pong balls but not at the balls itself.
- Last game is not good it is YX instade of XY.

Group three (4 people)

Puzzle one (10:55)

Slide one

- Fog a better experience,
- There is no time penalty for using hinsts so cut that sentence out.

Slide two

- No audio in the video's
- They didn't press continue in the slide before the puzzle.

Puzzle one

- They were thing about using the formula.
- They didn't understand that you need to use only paper one
- There was one person not doing anything.
- They were thinking too difficult.
- They said the answer and wort the answer Directly and figure it out fast.

Puzzle two (5:38)

- They made a picutere of the circuit board, add the picture in the app
- The y directly put their hand over it and made it black, but it was not clear written.

Puzzle three (12:00)

- They did look at the voltage and but didn't rotade the dynamo.
- And directly started writing the papers in the diffider.
- I hadn't reset the game.
- The screen went constantly with.
- They picted the scrow drive and wanted to scrow things open.
- The first tree they didn't have enough points and filled in the code in the app.
- You could directly click on the code with using the other paper.
- The consol needs to have a less battery.

Puzzle for (14:58)

- The numbers weren't readable.
- They put it the wrong way up.
- They are though the first one needs to be pointing up.
- They tough the n was a u.
- Put in the code how many of the numbers you put in are good and fault.
- They tried the same code a copple of times.
- The letters are the wrong why up.

Puzzle five (2:45)

- They though to hard but did give it a try.

Puzzle six (12:00)

- They didn't understand the text in the app.

- They understand the puzzle directly, but they tried it for both ones while you only need one. But they tried the good answer.
- They did make a cone from
- They did try both ones.
- The text is difficult to read.

Puzzle seven (24:22)

- The big maze was easy to solve.
- The paper with the invisible ink wasn't in it.
- Everyone was involved in this game.
- Make it clear on which papers you are allowed to write.
- The little maze was difficult to solve.
- They did look at the wrong paper.
- One person was one her phone.
- They did try the wrong code and didn't mix.
- They were thinking too difficult.
- Make the water more a part of the puzzle.
- They stared decoding the bottle in the middle.
- We need to put a sterr in it.
- They didn't understand the hint use the code below.
- Put also the bottle in the picture in the app.

Puzzle 8 (14:19)

- In the video they sowed the wrong safe.
- They did understand the crane and how to get the good code.
- They didn't put a pencil in the crane.
- They did find out the pencil by using the smallist pencil.
- They put the read code but they than they did use the wrong code.
- Make a back button in the in the app.

Group three (three persons)

Puzzle 1 (11:12)

- They directly started the app without an introduction.
- They didn't communicate and read the first slides in slices.
- They directly understand that they needed to search for the scale.
- They direcely picked the roller and measured the good distance and had the right answer.
- They have the right answer but didn't fill it in.
- They were really stressed and wanted to complete the game fast.
- Make a x:x in de app as code so that everyone knows how to write.

Puzzle 2 (7:00)

- They directly put label from the box.
- They note the code for the robotic arm down.
- They directly started by connecting the qeruit without looking at the qeruit at the back.
- They didn't put their hands over it held it in the lights.

Puzzle 3 (18:53)

- They started by reading the papers and not power on the consol.
- They write down the clous
- They understand the second hint.
- Then they started to rotad the dynamo.
- They were really focesed.
- They put the dynomo of.
- They put down code without completing the game.
- But then the console went of and they didn't the dynamo back on, then they started to rotate the dynamo.
- Then thy understand the hints that were given.
- They weren't good at playing the game.
- They put the dynome of.
- They did write any code down.

Puzzle 4 (19:21)

- They did start by trying the big ones.
- They broke one pin.
- They did put the wrong site up.
- They though they needed to use other things.
- They find it hard with three people.
- They don't want to use a hint.
- They final understand to connect the lines.
- They asked is the two first numbers.
- They tried the n again.

Puzzle 5 (1:38)

- They were fast

Puzzle 6 (7:28)

- They started thinking in the good way
- They are combining again.

Puzzle 7 (15:37)

- The great puzzle was the wrong way around.
- They first decode the codes.
- After decoding thy directly understand the whole game
- But they neede to decode the maze first the big maze then te small one.
- They played with the powder.
- They directly opened the bottle.
- But then started decoding again.
- They directly spread it on the good paper.

Puzzle 8 (9:20)

- They write everything down.
- They put directly the robitic arm in the good way.
- Now they used the information they wrote down.
- They were thinking too difficult.

User testing — Game in general: Moderated method

Feedback from teachers

Name of the teachers:

What age range do you think this game is suitable for?

9–12 12–15 16–18 Adult

What is the minimum age suitable to play the game?

What is the goal duration of an escape room session?

Would you have preferred a paper version of the instructions to look back on during the game?

How did you like the Theme/story of the game?

Boring or weak : Around 0

Ok : Around 5

Very good : Around 10

How much did you like this game in general?

Hated it : Around 0

It was ok : Around 5

Loved it : 10

Why?

How complex was the general game, especially for your student age group?

Why?

Was the game too short, too long or just, right?

Why?

Was the game too short, too long or just, right?

Why?

Do you have comments about one game in particular? Did you experience problems in one/several of the games?

How much did you like the materials and/or game pieces?

Did not like: Around 0

Average: Around 5

Loved: Around 10

Which one did you like best and why?

For you, what can still be improved?

Will you recommend the game to colleagues, like others schools, others teachers ?

Yes No

Do you have something else to add ?

Inspired on (Leah Ebert, 2022).

Appendix 8: Console solutions details.

Solution 1:

The first solution was to employ a resistor. Indeed, that would consume the current of the console game directly. Some calculations were made to determine the value of the resistor. However, empty the battery in a short time and repetitions of that would destroy or burn the battery.

Solution 2:

The second solution was to charge a little battery with the hand generator and disconnected the console battery. Then when the intermediate battery would supply the console. Some calculations were made to sizing the battery with those features:

Current	0.011 A
Voltage	5,1 V
Power	0.579 W
Autonomy desired	100 seconds

The current, voltage and power were measured directly from the console with a usb tool, as the picture below presents.

Figure 9: Console power Measurement.

Nevertheless, the capacity calculated was too low that no battery fit with. Another solution was to employ superconductor. However, the level of the electrical complexity to build the system was declared to difficult by Hans.

Appendix 9: Replication instructions for the console game battery.

Instructions to remake or understand the system:

A. Wires connections

Display:

1. Look at https://docs.arduino.cc/learn/electronics/lcd-displays and find the instructions to build the first part of the system.

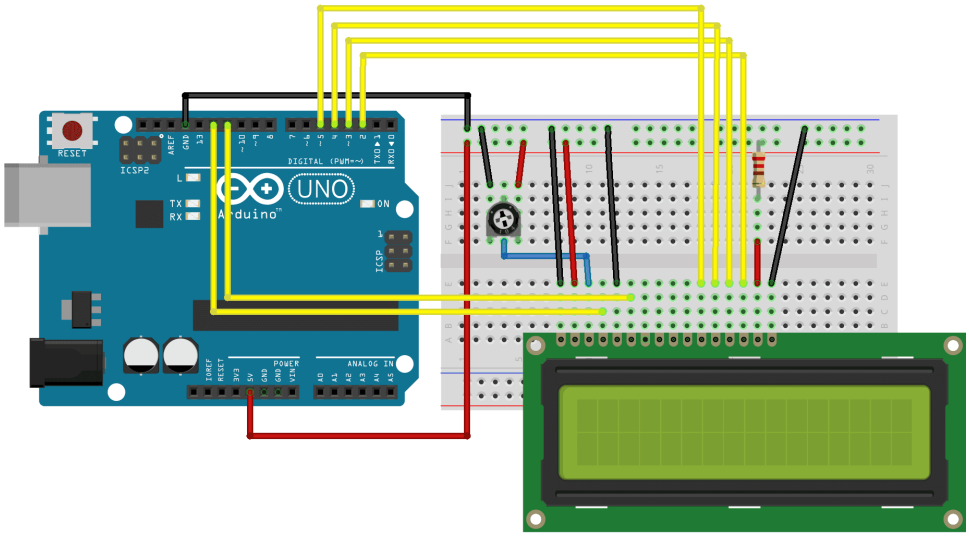


Figure 5: Display connection, picture from (Arduino, s.d.)

For real:

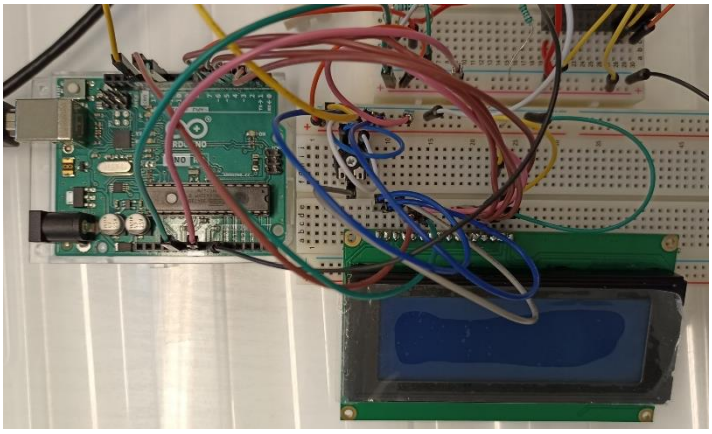


Figure 6: Real circuit.

2. Component required:

- 10 kilo ohm potentiometer
- 220 kilo ohm resistor
- Arduino Board
- Wires
- Breadboard
- LCD screen (ref: LCD2004B or compatible Hitachi HD44780 driver)

(Arduino, s.d.)

LED:

There is below the Arduino LED connections.

Further explanations are available to: https://docs.arduino.cc/built-in-examples/basics/Blink

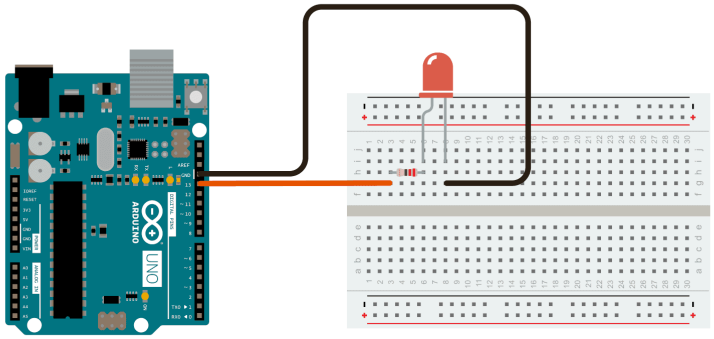


Figure 7: Led connections from (Arduino, s.d.).

For real:

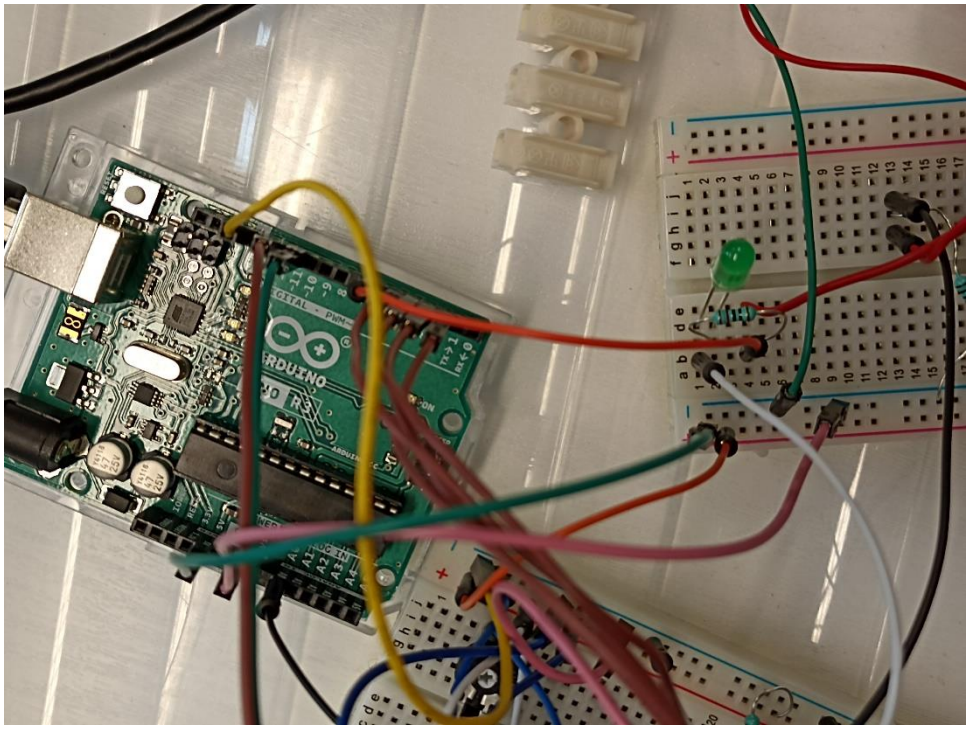
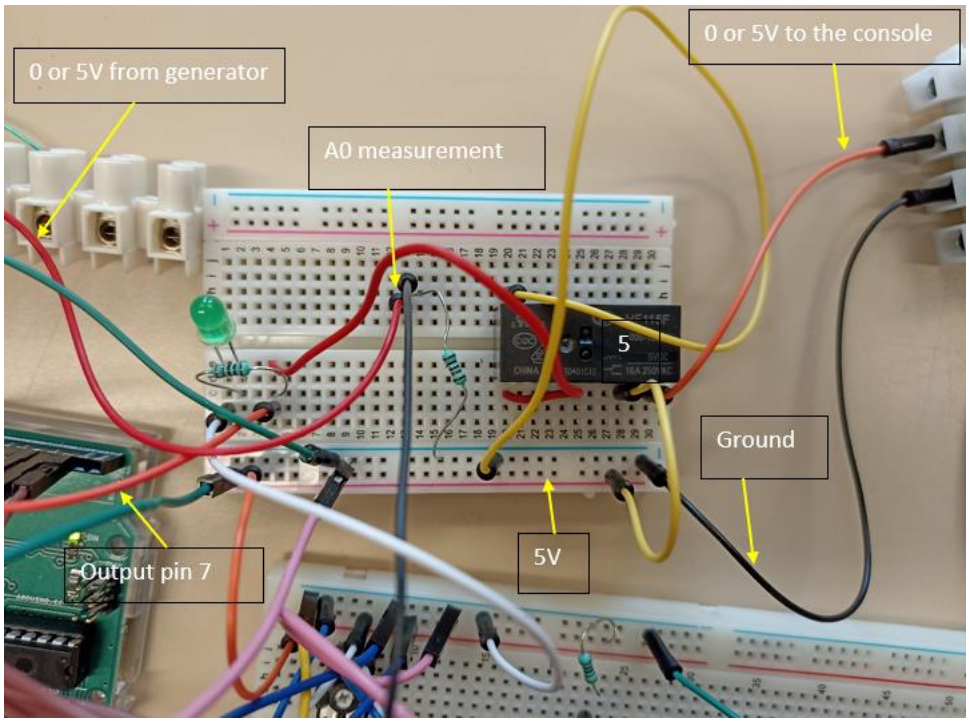


Figure 8: LED circuit for real.

Relay (5) connection:



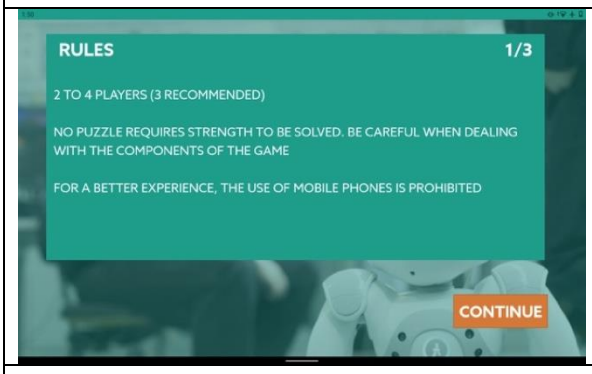
There is below the code employed for the system:

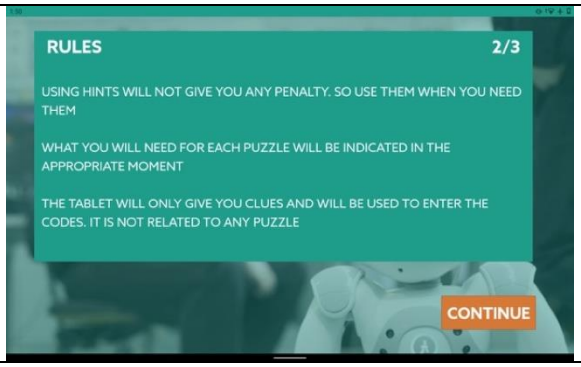
```
#include <LiquidCrystal.h>

// Analog pin to measure battery voltage
const int batteryPin = A0;

// Battery charge percentage
int batteryPercent = 0;

// Minimum voltage for battery operation
const float minVoltage = 5.0;

// Time since last battery charge update
unsigned long lastUpdateTime = 0;

// Digital output pin for the relay
const int relayPin = 7;

// Initialize LCD screen
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

void setup() {
  // Initialize serial communication
  Serial.begin(9600);
```

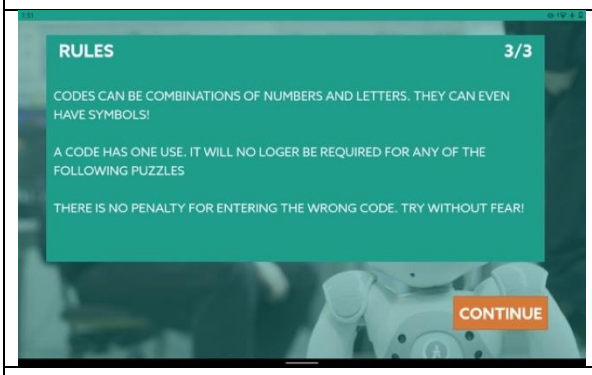
```
  // Initialize relay pin as an output
  pinMode(relayPin, OUTPUT);
  // Initialize LCD screen
  lcd.begin(16, 2);
}
void loop() {
  // Measure battery voltage
  float batteryVoltage = (analogRead(batteryPin) / 1023.0) * 5.0;
  // Check if battery voltage is sufficient for charging
  if (batteryVoltage >= minVoltage) {
    // Check time since last update
    unsigned long timeSinceLastUpdate = millis() - lastUpdateTime;
    if (timeSinceLastUpdate >= 1000) {  // Update once per second
      // Increase battery charge by 1%
      batteryPercent = min(batteryPercent + 1, 100);
      lastUpdateTime = millis();
    }
  } else {
    // Check time since last update
    unsigned long timeSinceLastUpdate = millis() - lastUpdateTime;
    if (timeSinceLastUpdate >= 3000) {  // Update once per 3 seconds
      // Decrease battery charge by 1%
      batteryPercent = max(batteryPercent - 1, 0);
      lastUpdateTime = millis();
    }
  }
  // Print battery charge percentage to serial monitor
  Serial.print("Battery charge: ");
  Serial.print(batteryPercent);
```

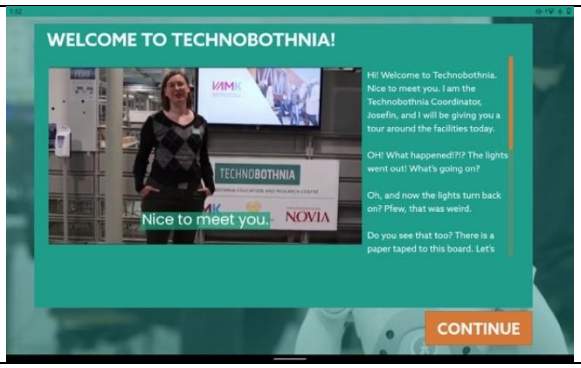
```
  Serial.println("%");
  // Print battery charge percentage to LCD screen
  lcd.setCursor(0, 0);
  lcd.print("Battery: ");
  lcd.print(batteryPercent);
  lcd.print("%");
  // Print special message if battery is empty or full
  if (batteryPercent == 0) {
    lcd.setCursor(0, 1);
    lcd.print("Battery empty    ");
    digitalWrite(relayPin, LOW); // turn off relay
  } else if (batteryPercent == 100) {
    lcd.setCursor(0, 1);
    lcd.print("Battery full     ");
    digitalWrite(relayPin, HIGH); // turn on relay
  } else {
    lcd.setCursor(0, 1);
    lcd.print("                ");
    if (batteryPercent > 0) {
      digitalWrite(relayPin, HIGH); // turn on relay
    } else {
      digitalWrite(relayPin, LOW); // turn off relay
    }
  }
  delay(100);  // Wait for 100 milliseconds to avoid overloading the serial port
}
```

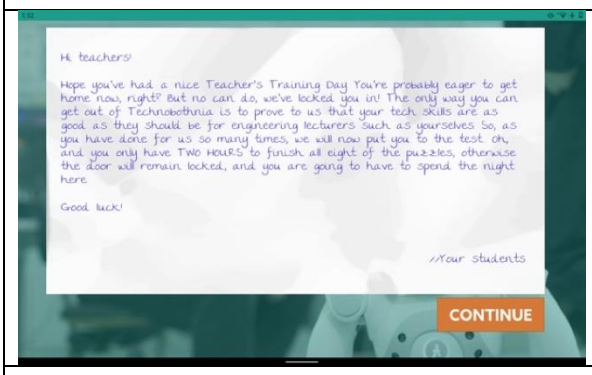
Appendix 10: Screenshots of the application on the tablet.

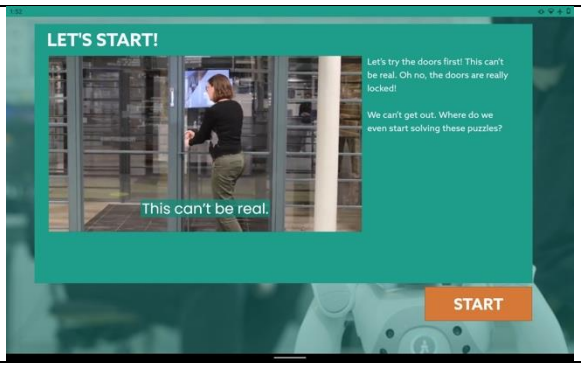


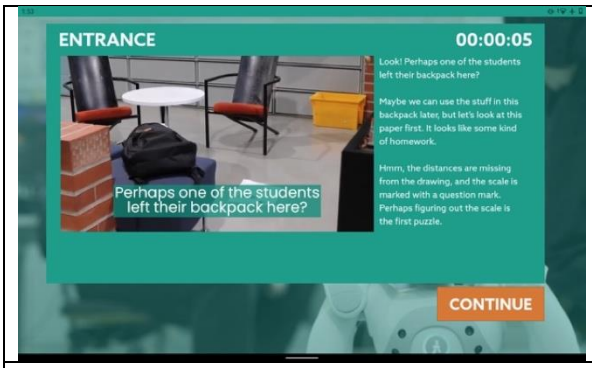


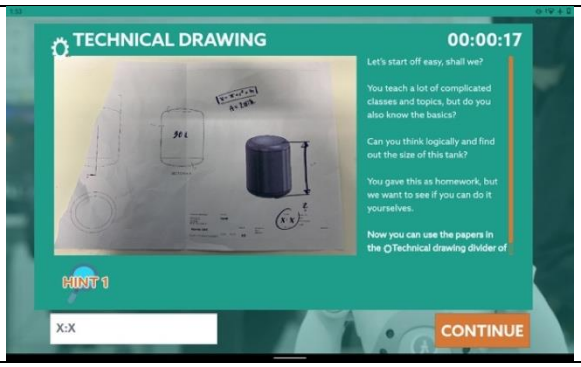


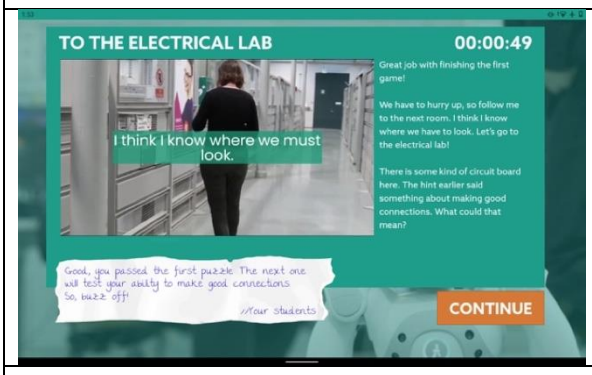


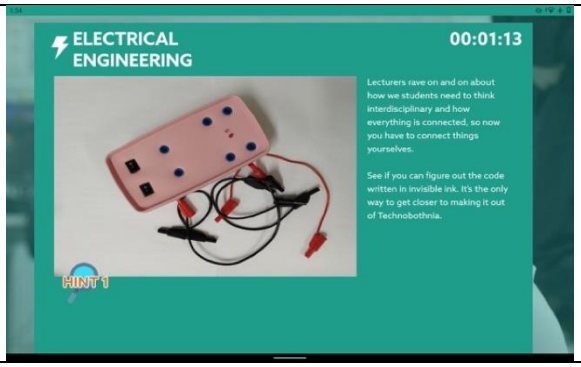




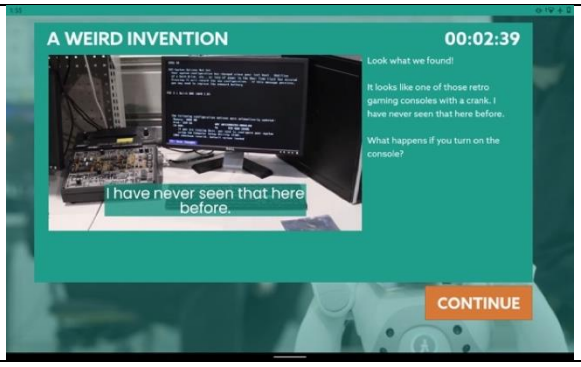

ENTRANCE
00:00:05
Look! Perhaps one of the students left their backpack here?
Maybe we can use the stuff in this backpack later, but let's look at this paper first. It looks like some kind of homework.
Hmm, the distances are missing from the drawing, and the scale is marked with a question mark. Perhaps figuring out the scale is the first puzzle.
Perhaps one of the students left their backpack here?
CONTINUE

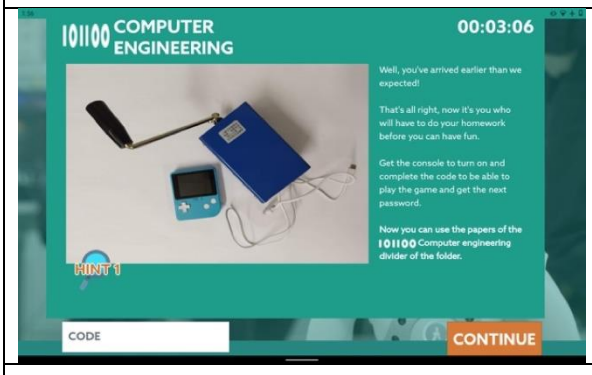

TECHNICAL DRAWING
00:00:17
Let's start off easy, shall we?
You teach a lot of complicated classes and topics, but do you also know the basics?
Can you think logically and find out the size of this tank?
You gave this as homework, but we want to see if you can do it yourselves.
Now you can use the papers in the ⬡Technical drawing divider of
HINT 1
X:X
CONTINUE

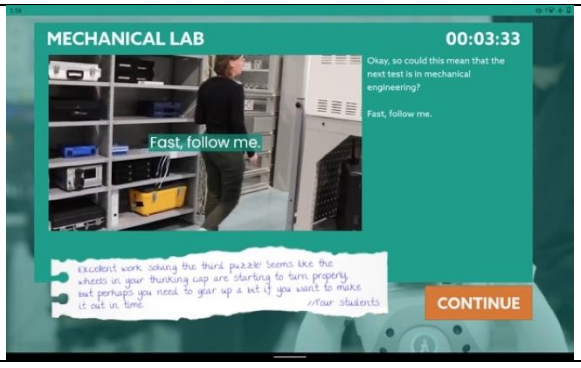

TO THE ELECTRICAL LAB
00:00:49
Great job with finishing the first game!
We have to hurry up, so follow me to the next room. I think I know where we have to look. Let's go to the electrical lab!
There is some kind of circuit board here. The hint earlier said something about making good connections. What could that mean?
I think I know where we must look.
Good, you passed the first puzzle. The next one will test your ability to make good connections. So, buzz off!
//Your students
CONTINUE

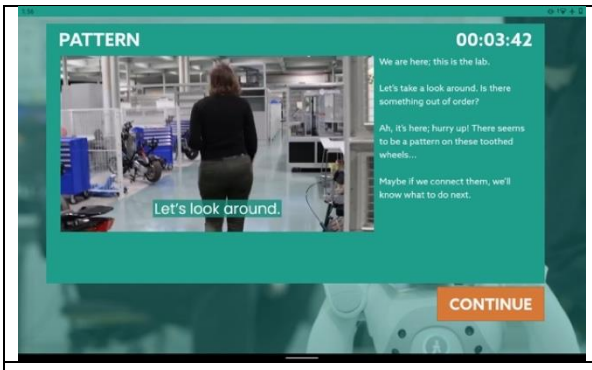

ELECTRICAL ENGINEERING
00:01:13
Lecturers rave on and on about how we students need to think interdisciplinary and how everything is connected, so now you have to connect things yourselves.
See if you can figure out the code written in invisible ink. It's the only way to get closer to making it out of Technobothnia.
HINT 1

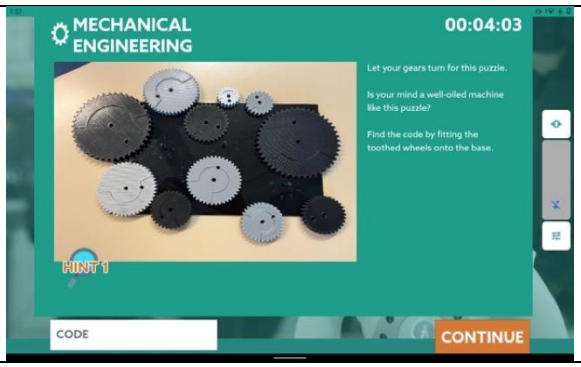

TOWARDS THE IT LAB
00:02:20
So where do you think we should go next?
What about the IT Lab, "language" as in "programming language"?
Okay, let's go, quick!
Okay, let's go, quick!
Second test passed, well done! Language is power. Do you have what IT takes to power things up?
//Your students
CONTINUE

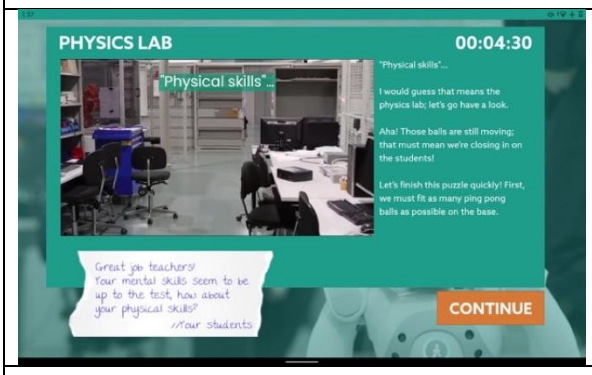

A WEIRD INVENTION
00:02:39
Look what we found!
It looks like one of those retro gaming consoles with a crank. I have never seen that here before.
What happens if you turn on the console?
I have never seen that here before.
CONTINUE

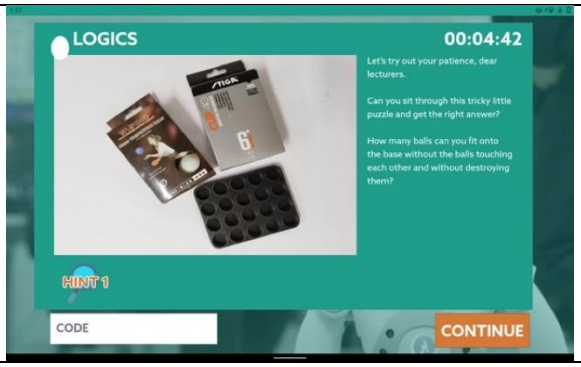

COMPUTER ENGINEERING
00:03:06
Well, you've arrived earlier than we expected!
That's all right, now it's you who will have to do your homework before you can have fun.
Get the console to turn on and complete the code to be able to play the game and get the next password.
Now you can use the papers of the Computer engineering divider of the folder.
HINT 1
CODE
CONTINUE


MECHANICAL LAB
00:03:33
Okay, so could this mean that the next test is in mechanical engineering?
Fast, follow me.
Fast, follow me.
Excellent work solving the third puzzle! Seems like the wheels in your thinking cap are starting to turn properly, but perhaps you need to gear up a bit if you want to make it out in time.
//Your students
CONTINUE

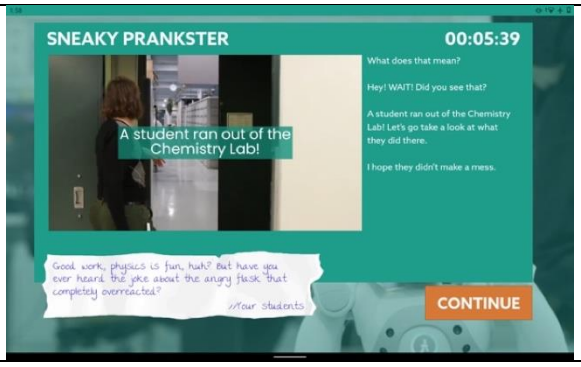

PATTERN
00:03:42
We are here; this is the lab.
Let's take a look around. Is there something out of order?
Ah, it's here; hurry up! There seems to be a pattern on these toothed wheels...
Maybe if we connect them, we'll know what to do next.
Let's look around.
CONTINUE

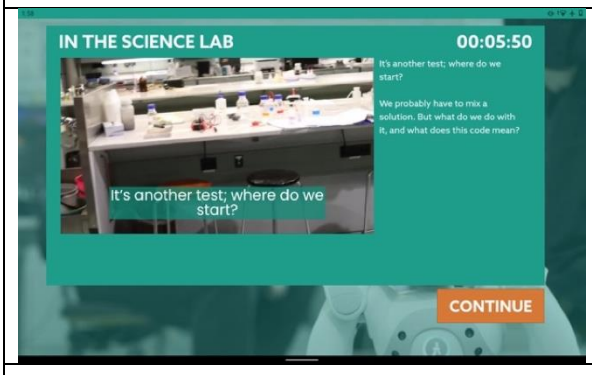

MECHANICAL ENGINEERING
00:04:03
Let your gears turn for this puzzle.
Is your mind a well-oiled machine like this puzzle?
Find the code by fitting the toothed wheels onto the base.
HINT 1
CODE
CONTINUE

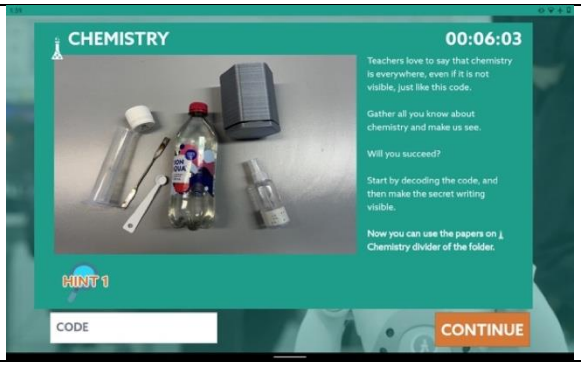

PHYSICS LAB
00:04:30
"Physical skills"...
I would guess that means the physics lab; let's go have a look.
Aha! Those balls are still moving; that must mean we're closing in on the students!
Let's finish this puzzle quickly! First, we must fit as many ping pong balls as possible on the base.
"Physical skills"...
Great job teachers! Your mental skills seem to be up to the test, how about your physical skills?
//Your students
CONTINUE

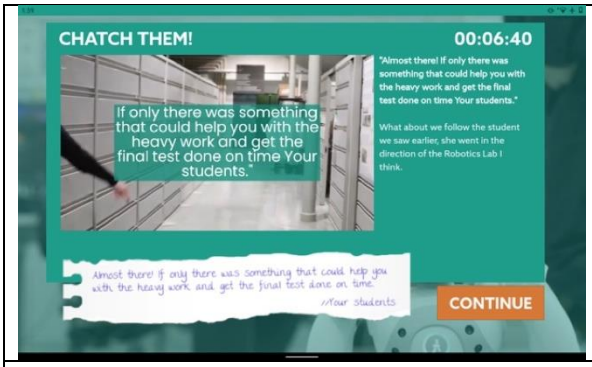

LOGICS
00:04:42
Let's try out your patience, dear lecturers.
Can you sit through this tricky little puzzle and get the right answer?
How many balls can you fit onto the base without the balls touching each other and without destroying them?
HINT 1
CODE
CONTINUE

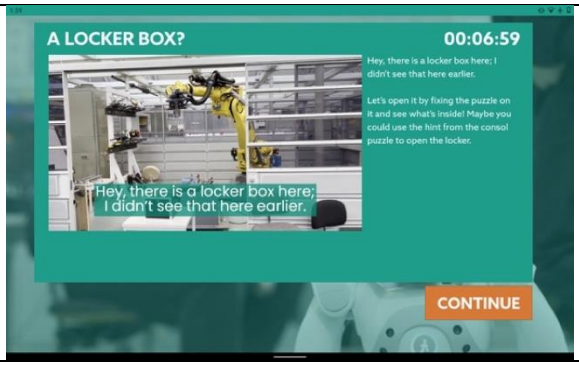

PHYSISCS
00:04:56
Today, we can use CAD programs for digitalizing ideas and creating technical drawings or blueprints.
You teach us how to use these programs, but can you think logically without them?
Which shape does the Cylinder surfaces have if the old-timey cone is cut open?
Now you can use the papers in Physics divider of the folder.
HINT 1
CODE
CONTINUE


SNEAKY PRANKSTER
00:05:39
What does that mean?
Hey! WAIT! Did you see that?
A student ran out of the Chemistry Lab! Let's go take a look at what they did there.
I hope they didn't make a mess.
A student ran out of the Chemistry Lab!
Good work, physics is fun, huh? But have you ever heard the joke about the angry flask that completely overreacted?
//Your students
CONTINUE

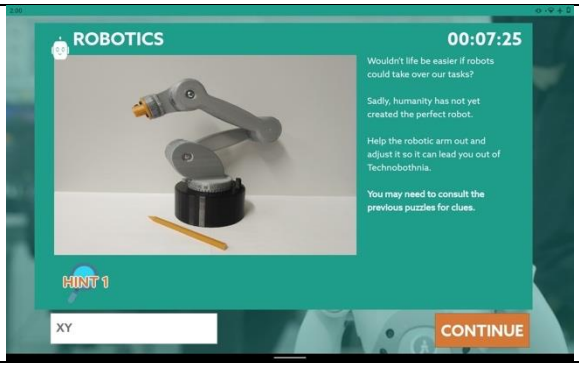

IN THE SCIENCE LAB
00:05:50
It's another test; where do we start?
We probably have to mix a solution. But what do we do with it, and what does this code mean?
It's another test; where do we start?
CONTINUE

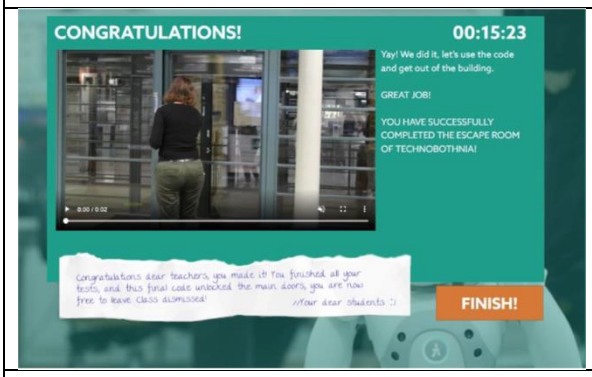

CHEMISTRY
00:06:03
Teachers love to say that chemistry is everywhere, even if it is not visible, just like this code.
Gather all you know about chemistry and make us see.
Will you succeed?
Start by decoding the code, and then make the secret writing visible.
Now you can use the papers on Chemistry divider of the folder.
HINT 1
CODE
CONTINUE


CHATCH THEM!
00:06:40
If only there was something that could help you with the heavy work and get the final test done on time Your students."
"Almost there! If only there was something that could help you with the heavy work and get the final test done on time Your students."
What about we follow the student we saw earlier, she went in the direction of the Robotics Lab I think.
Almost there! If only there was something that could help you with the heavy work and get the final test done on time.
//Your students
CONTINUE


A LOCKER BOX?
00:06:59
Hey, there is a locker box here; I didn't see that here earlier.
Let's open it by fixing the puzzle on it and see what's inside! Maybe you could use the hint from the consol puzzle to open the locker.
Hey, there is a locker box here; I didn't see that here earlier.
CONTINUE


A LOCKER BOX?
00:05:06
Hey there is a locker box here I didn't see that here earlier...
Let's open it and see what's inside!
Good work so far as a reward, here is the code to the safe
380
//Your students
CONTINUE


ROBOTICS
00:07:25
Wouldn't life be easier if robots could take over our tasks?
Sadly, humanity has not yet created the perfect robot.
Help the robotic arm out and adjust it so it can lead you out of Technobothnia.
You may need to consult the previous puzzles for clues.
HINT 1
XY
CONTINUE


CONGRATULATIONS!
00:15:23
Yay! We did it, let's use the code and get out of the building.
GREAT JOB!
YOU HAVE SUCCESSFULLY COMPLETED THE ESCAPE ROOM OF TECHNOBOTHNIA!
Congratulations dear teachers, you made it! You finished all your tests, and this final code unlocked the main doors, you are now free to leave class dismissed!
//Your dear students :)
FINISH!


THE TECHNOBOTHNIA ESCAPE ROOM GAME
LEADERBOARD
Position Group Hints used Time Date
1 fast 0 00:00:01 26.11.2022
2 we are top 5 0 00:00:11 28.11.2022
3 Equipo 2 00:00:15 28.11.2022
4 Adios 2 00:00:22 28.11.2022
5 Hola 2 00:00:25 28.11.2022
BACK TO START

Appendix 11: Player's instruction updated from (Leah Ebert, 2022)

Dear Player!

In the following you can find the instructions to set up, run, and complete this Technobothnia Escape Room Game.

You will find all items you need for this game included in the suitcase. The First Aid Kit only contains spare items should something be missing or damaged, you do not need it for the puzzles.

Before you start playing you should make sure that you have enough time (approx. 2h : 1h30 of playing and 30 min of set up- explication/introduction then tidying) on hand as you cannot stop the game once you start playing. You should also be in an uninterrupted space without other teams playing. This could be a classroom or a room at Technobothnia or in a random school.

To begin the Escape Room, turn on the Tablet and start the Game App. Do not open any of the Suitcase organiser bags. These bags/cases include all necessary materials you will need for the successful execution of the individual puzzles and the overall game. Open up the bags only when the App tells you to do so, and you are at the correct puzzle.

Once the App works, follow the instructions it gives you. You will be able to select the language you prefer (Finnish, English, Swedish). Nevertheless, only the English one is accomplished. You will then get an introduction into the game story. Afterwards you can start the game. Attention: The timer will start once you press 'Play'. You will not have the chance to stop the game after this.

While playing you will find clues you will have to follow in order to find codes. Put these codes into the App.

If you are stuck, you can use the hints given to you at the bottom of the screen. Should you not succeed even with the hints you can also use the solution and it will show you the final code. Attention: You can only use Hint 2 if you used Hint 1 and only use the Solution if you used Hint 2. Also, you must wait and try to solve the game before getting another hint.

After the game:

After you played the game, please put all items back into the Ziplock bags they belong in (in case you don't remember what goes where look at the labels on the bags).

Fill out the checklist included in the game about what items you put back in the box, which ones were destroyed etc. to help us make the game ready for the next teams.

Thank you for playing,

Your Technobothnia Team

(Leah Ebert, 2022)

Box Checklist

Items	Included	Not included	Notes/Written on?
GENERAL BOX			
All suitcase organiser bags			
Tablet with case and screen protector			
Backpack			
Pencil Case			
All pens in different colours			
Triangle ruler			
Scissors			
Sharpener			
Two Erasers			
Water Bottle			
MAOL-taulukot			
Plasticated Folders with printed label and map			
Technobothnia papers notes			
INVISIBE INK			
Puzzle box big with closed sodium carbonate bottle inside, open			
Puzzle Box small with code written on paper inside, open			
Spray bottle			
Code Paper			
Big dot code Paper			
Dots and Lines Code Paper			
Warning Signs paper in English			
Greek Alphabet Paper			
Periodic Table of Elements Paper			
11 pages of H-, P- and EUH sentences			
Molar mass paper			
Pipette			
Marked measuring cylinder			
Marked spoon			
Spatula			
Case for packaging with printed label and map			
PING PONG			
Base Plate			
12 Ping Pong Balls, 1 with code			

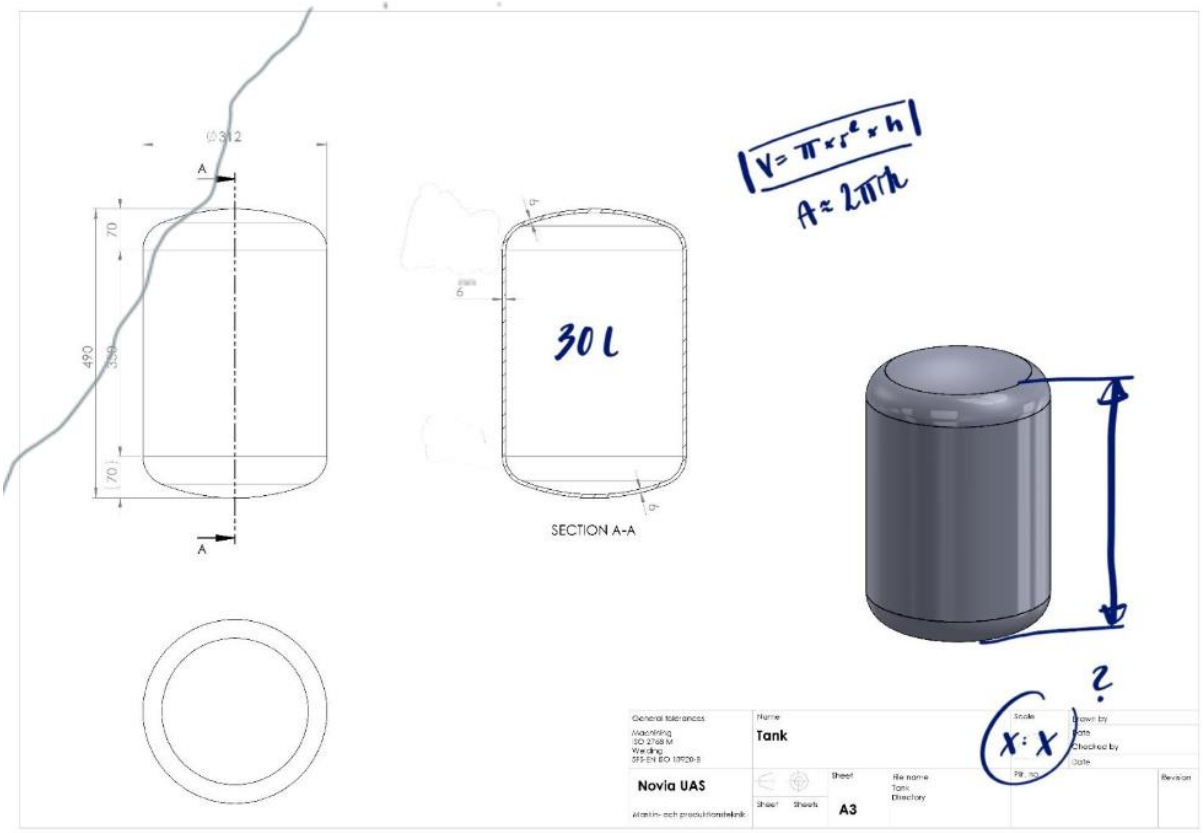
Packaging with printed label and map			
CONE			
Cone model			
4 Papers with shapes printed on			
Packaging with printed label and map			
TOOTHED WHEELS			
10 toothed wheels in different sizes			
Base board			
6 Pins + 4 supports			
UV-CIRCUIT			
Box with circuit			
5 Cables for connecting			
Packaging with printed label and map			
CONSOLE			
Console			
Crank			
Connecting Wire			
Helping Paper			
Electronic equipment			
Case for packaging with printed label and map			
TECHNICAL DRAWING			
Technical drawing paper			
ROBOTIC ARM			
Safe box			
Robotic arm			
Base board			
Special pen in pencil case			
Puzzle on the box			
Robot packaging with printed label and map			

(Leah Ebert, 2022)

Replication Instructions

Technical Drawing

How to prepare:
Print paper 'Technical Drawing.pdf' on A3 paper
Rip off upper left corner so the left side of the left tank with the height measurements is missing

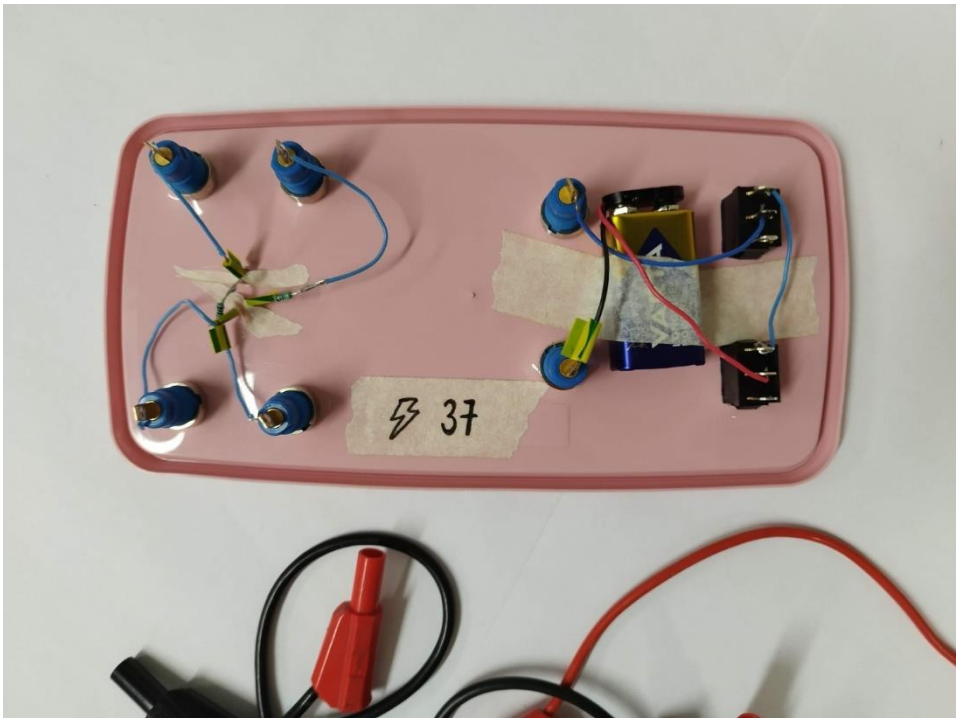


Box should include:

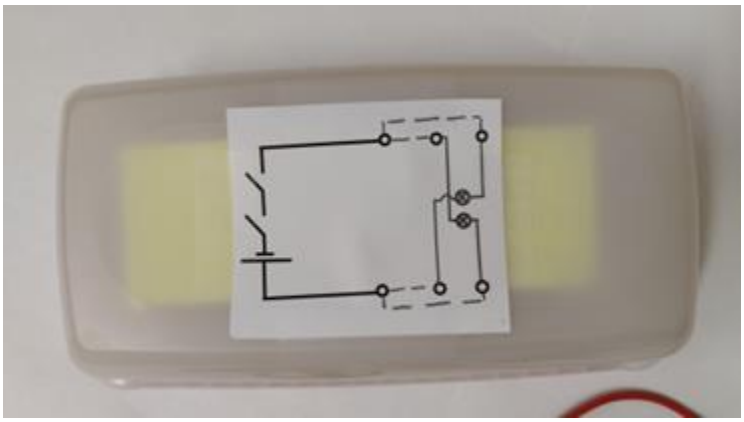
- One paper with the Technical Drawing

UV-circuit

How to prepare:
Take a lunch box (23x11x6) and add holes according to the following measurements (hand drill is sufficient)
Connect the LED, UV-LED, two light switches and battery according to the following picture:



Check the connections and add the code “hp7w3” with the invisible edding 8280 securitas uv marker directly above the UV lamp (be careful: don’t make them too big or the players will not be able to see them properly, also maybe go over the letters twice and let dry properly)
Write code “37” on box with black permanent marker, alternatively on tape and tape it to bottom of lid
Print the paper “sticker” on sticker paper and add to bottom of box



Add the following caution note on box inside

Box should include:

- Circuit box
- Two cables
- Paper with clue taped to bottom
- Caution note

Toothed Wheel

How to prepare:
3D-print wheels from stl files: Wheels stl (best to print on S3 with 0.15 layers, use different colours, does not matter which wheels is which colour -> colours in names of files do not matter)

Base must be laser cut, best to ask Osku for help: you need 300x300mm acrylic plates in black
Then laser cut the file: base tw.gnh
Watch out: the toothed wheel symbol with the number 75 next to it should be laser cut in the back of the board

The holes in the middle
30 power
60 speed

3 times
800 dpi

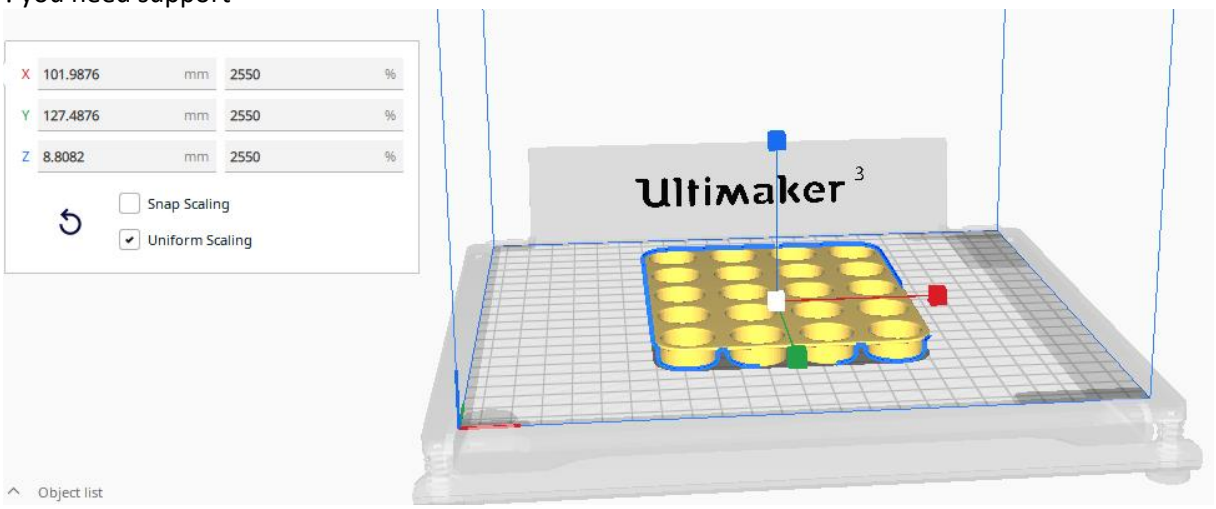
To cut off the bottom that is too big use:
80 power
5 speed
1 times
800 dpi

Then 3D print ten times the file pins.stl and four times the file Foot-Board.stl
Superglue the pins to the holes on the base board and the foots on the backside of the board
Cut stickers with the Brother scanncut sdx1200 on the white sticker sheets in the Fablab. The text and numbers can be set on the machine itself or taken from the history of the machine.
Stick the stickers on the board
Box should include:

- Base board
- 10 toothed wheels
- Super glue in the first aid pouch just in case
- Spare pins
- Stickers of the puzzle name
- Stickers of the code

Ping Pong

How to prepare:
Open 'PingPong_base.stl' and change size to 2250% (keep uniform scaling), PLA, (should take around 6h)
! you need support



Take the black pen and write a circle and '– 22' on one of the balls

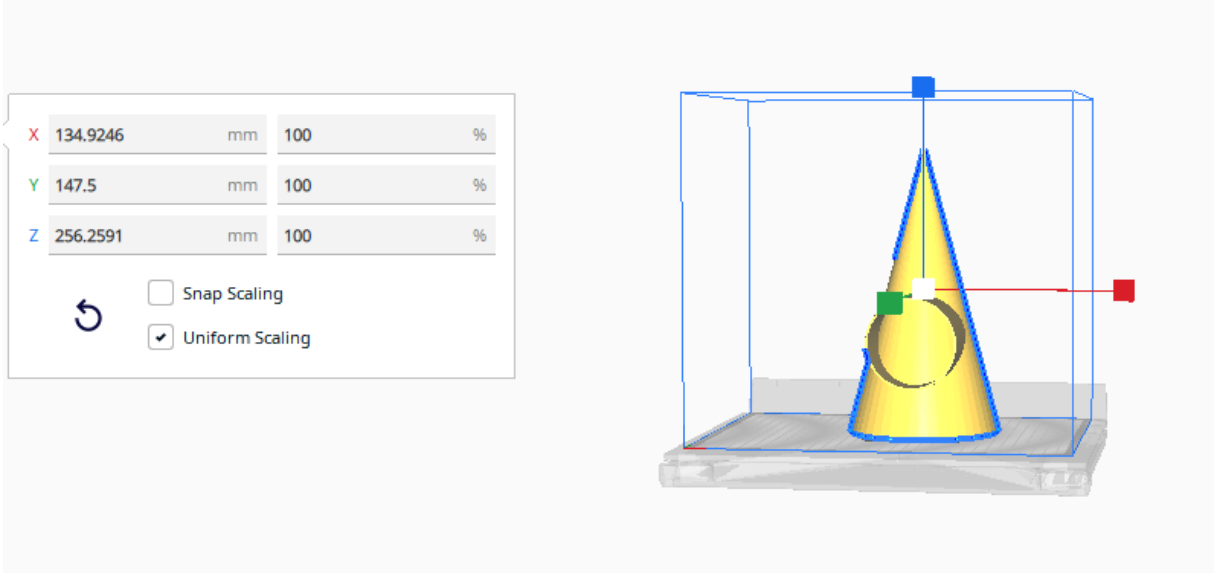
Box should include:

- Base
- 12 Ping Pong Balls
- 1 of the balls with hidden code

Cone

How to prepare:

3D-Print the file ‘cone.stl’
! you need support, print on S5 (AA 0.8, use same printer head for cone and support), PLA, Extra fast 0.3



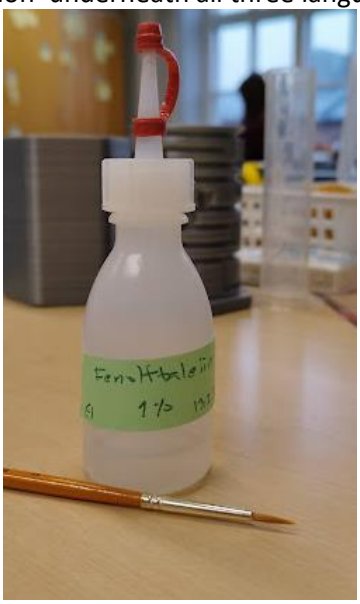
Print papers ‘surface shapes.docx’ on A3 papers
Do NOT use backside for printing

Box should include:

- Cone
- 4 Papers with shapes printed on

Invisible Ink

How to prepare:
Use the brush and the 1% Fenoliftaleiini/C20H14O4/Phenolphthalein and write code “64r7w3” on all three papers in ‘Code without solution’ underneath all three language code possibilities

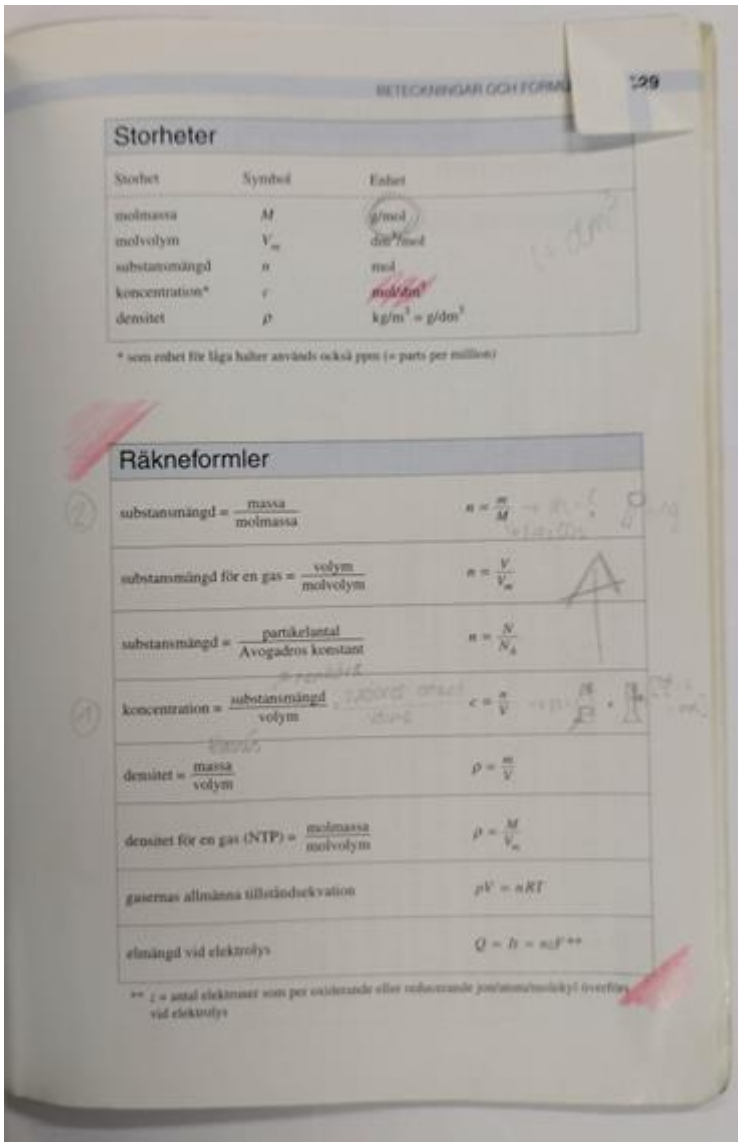


EN:

-.-- --- ..- .-. / … ..- .--. . .-. / … . -.-. .-. . - / -.-. --- -.. . / .. … / -… . .-.. --- .--/.-.-.-

Print the papers under ‘H- & P-sentences’ and ‘other keys&papers’ and ‘substances-molar mass’, plastify them and add them to the binder

Write the notes as follows in the MAOL



BETECKNINGAR OCH FORM 29

Storheter

Storhet	Symbol	Enhet
molmassa	M	g/mol
molvolym	V_m	dm^3/mol
substansmängd	n	mol
koncentration*	c	mol/dm^3
densitet	ρ	$kg/m^3 = g/dm^3$

* som enhet för låga halter används också ppm (= parts per million)

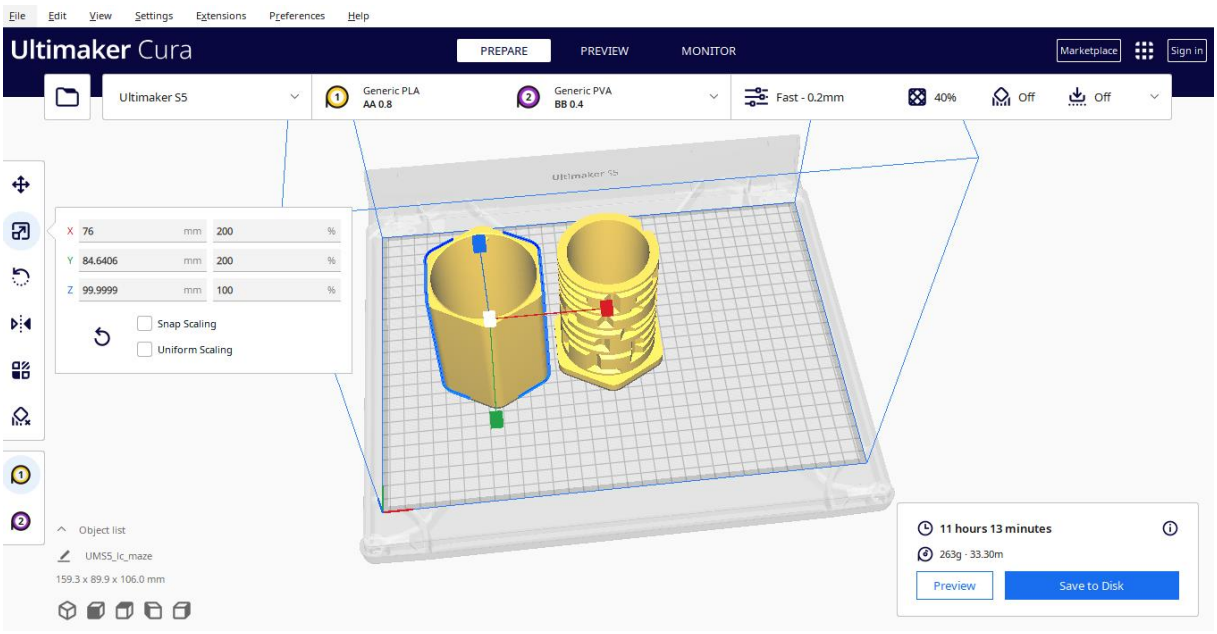
Räkneformler

substansmängd = massa / molmassa	$n = \frac{m}{M}$
substansmängd för en gas = volym / molvolym	$n = \frac{V}{V_m}$
substansmängd = partikelantal / Avogadros konstant	$n = \frac{N}{N_A}$
koncentration = substansmängd / volym	$c = \frac{n}{V}$
densitet = massa / volym	$\rho = \frac{m}{V}$
densitet för en gas (NTP) = molmassa / molvolym	$\rho = \frac{M}{V_m}$
gasernas allmänna tillståndsekvation	$pV = nRT$
elmängd vid elektrolys	$Q = It = nzF$ **

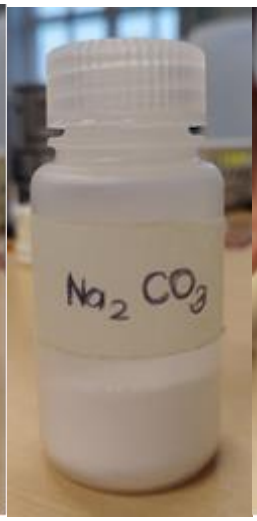
** z = antal elektroner som per oxiderande eller reducerande jon/atom/molekyl överförs vid elektrolys

Feel free to add some other markings to the book

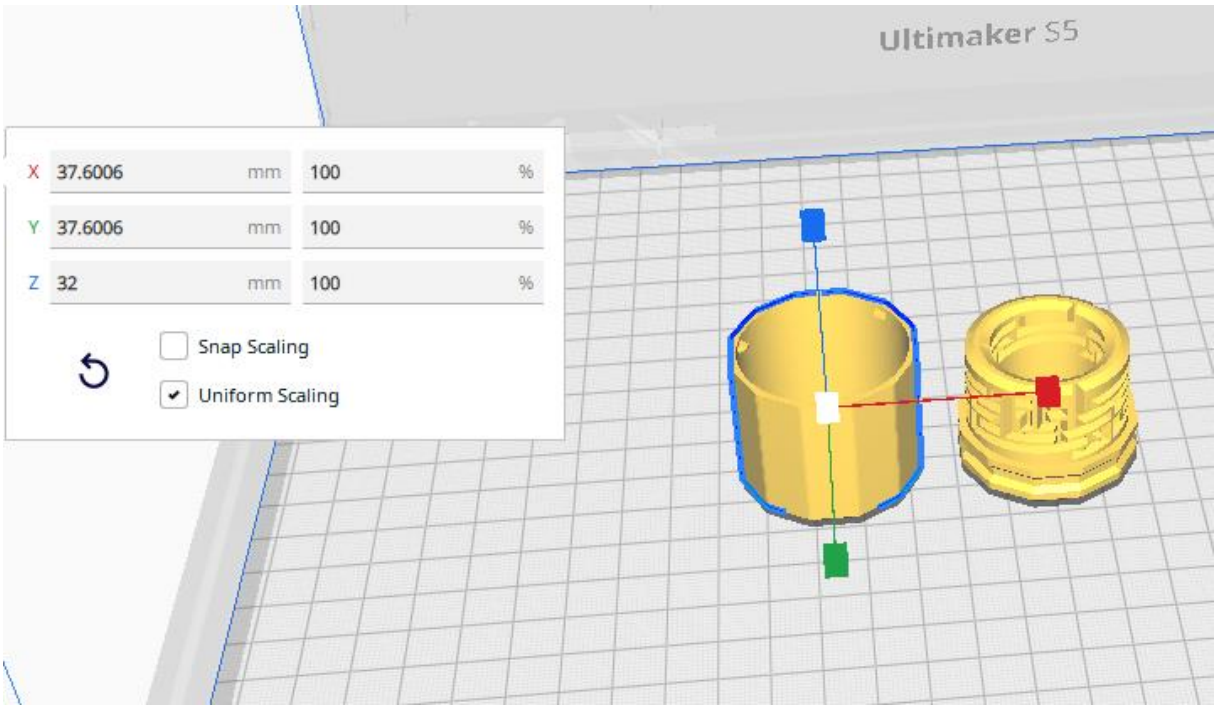
3D- print the box under ‘big_maze.stl’ and ‘big_top.stl’: unclick ‘Uniform Scaling’ and sit the box upright, then make X and Y 200%, use PLA -> Ultimaker S5, AA 0.8, Fast-0.2, no support and adhesion needed: should take 11h 13min



Take bottle and fill with Na_2CO_3/Sodium carbonate, take tape and write on: "Na_2CO_3" as well as "H319", take attention sticker and put on bottle -> put this bottle in big puzzle box and close box
Also add note: "DO NOT EAT" to it



3D-print the small box under 'small_maze.stl' and 'small_top.stl', no adjustments necessary, no support and adhesion needed, 0.2 should be good enough



Add the flask symbol and the code “-45” written in the invisible ink on a little paper inside and close
Draw the flask symbol on tape and add it on lid of the small maze box

Take marker and mark 30ml on 50ml measuring cylinder

Take 1ml spoon and write on bottom 2 kpl/spoons

Take small spray bottle and add the right blue dots on a sticker, says: H2O

Make sure to leave enough space between letters

Box should include:

- Puzzle box big with Sodium carbonate inside, closed
- Puzzle Box small with code inside, closed
- Spray Bottle
- Papers printed and added in a folder
- Marked measuring cylinder
- Marked spoon
- Pipette or similar item for mixing
- MAOL-taulukot with notes
- Another version of both papers with the invisible ink in first aid pouch
- Spatula

Robotic Arm

How to prepare:

Buy safe box and make code 380

Reprint all files under “my models stl”: base should be black, the arms metallic silver or grey and top part (scale and pen holder + pen) in another colour, maybe neon or gold

Print it on S3 and make wall speed 35 (this ensures the scale numbers to be more visible)

Best to print over night as it takes a long time and use glue for the arm with Technobothnia written on it (results are nicer)

Screw the arms together and add the screwdriver and the printed pen to the pencil case

For base you need an acrylic plate of the measurements 300x300x3 (lxbxh) for the laser cutter engrave the base file under base_robo.gnh (again ask Osku for help, same values as for Toothed Wheel Puzzle)
cut out the moon from the base (you should try some settings as it did not work with this prototype base)
Cut the arrow stickers with the Brother scanncut sdx1200 on the white sticker sheets in the Fablab. The arrows can be set on the machine itself or taken from the history of the machine.
Stick the sticker arrows on the board and crane

Box should include:

- Safe box with code 380
- Fully built robotic arm with black base, 4 silver metallic/grey arms and different coloured scale + pen holder
- Pen in same colour as pen holder in pencil case
- Base plate

Console

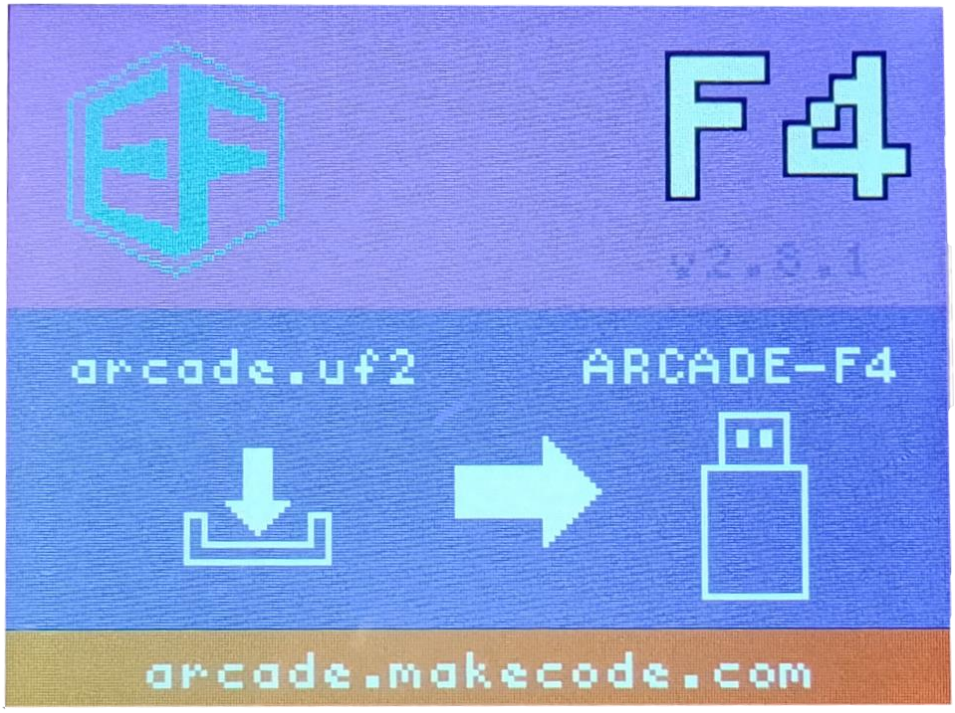
For the electronic system replication, read the “Console game” document, in the folder “old material” or in appendix of the final report.

See file “Explanatory guide to the video game code”

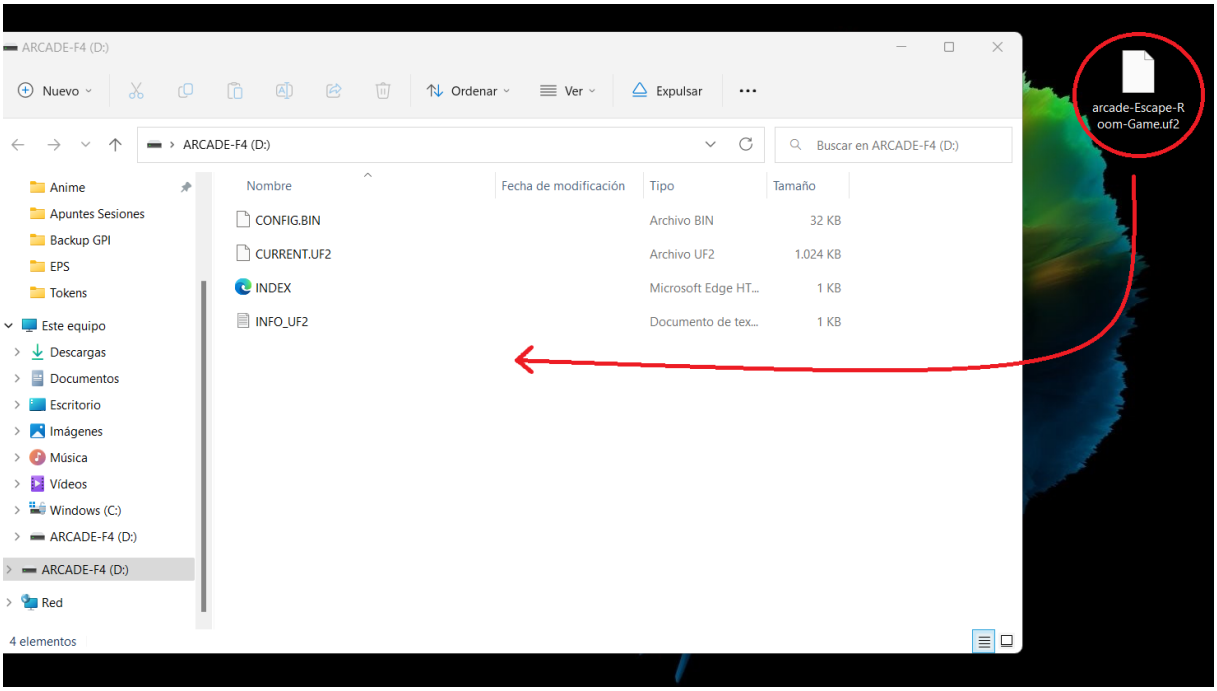
How to prepare:

1. Acces
the file repository and download the file named “arcade-Escape-Room-Game.uf2” in the computer.

2. Connect the Retro Arcade to the computer using the USB cable. The game console should turn on and display the following screen:



3. Once connected, a similar window should open on the computer. Insert the file with the video game into it.



4. After the previous step, the console screen should show the video game running:

5. In the video game select the option "CODE" and then always the first menu option until you return to the main menu. This will ensure that in the future players will have to solve the code correctly before they can play.
6. Disconnect the console from the computer and let the battery drain.
7. Print the file “CrankGeneratorSticker.png”, preferably on adhesive paper, and stick it on top of the generator.
8. Print copies of “CheatCode.pdf” and “Console instructions_two lovers united.pdf”, one of each.
9. Put everything in the appropriate box.

Trouble Shooting:

Why don't I get the right result after passing the code file to the console?

In case the appropriate result is not achieved during step 4, press  on the console and repeat from step 3. If it still doesn't work, check the code for possible errors.

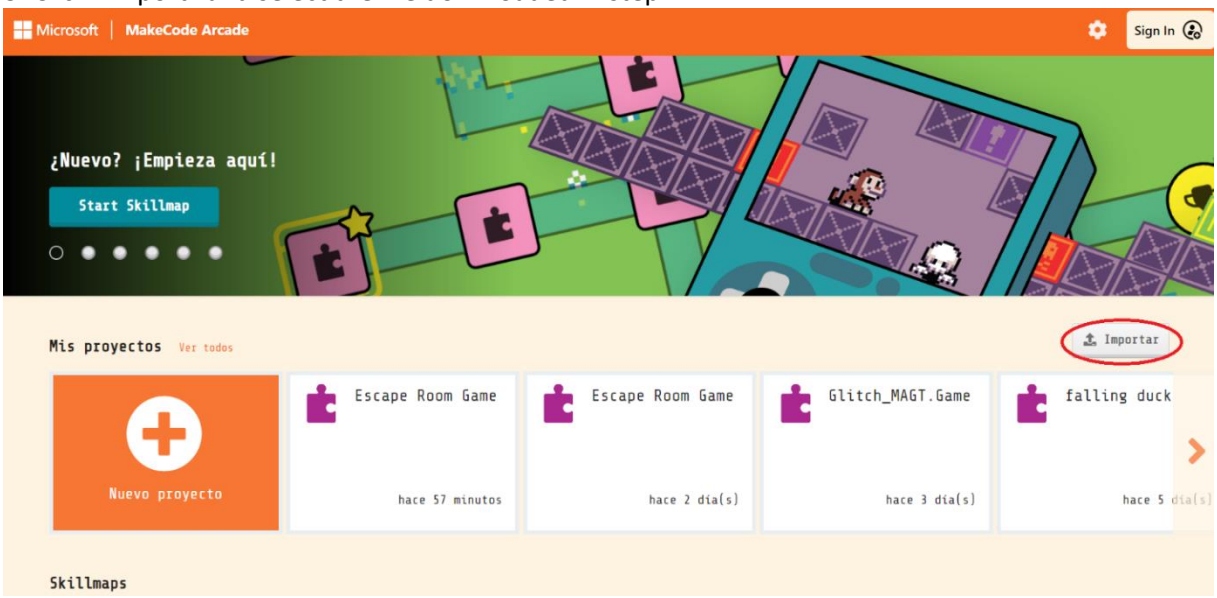
Do I have to configure anything on the crank generator?
No, the console only needs to be connected to one of the USB ports on the generator. If it doesn't work, try replacing one of the components.

Steps to follow for code modification:

1. Access the file repository and download the file named “arcade-Escape-Room-Game.uf2” in the computer.

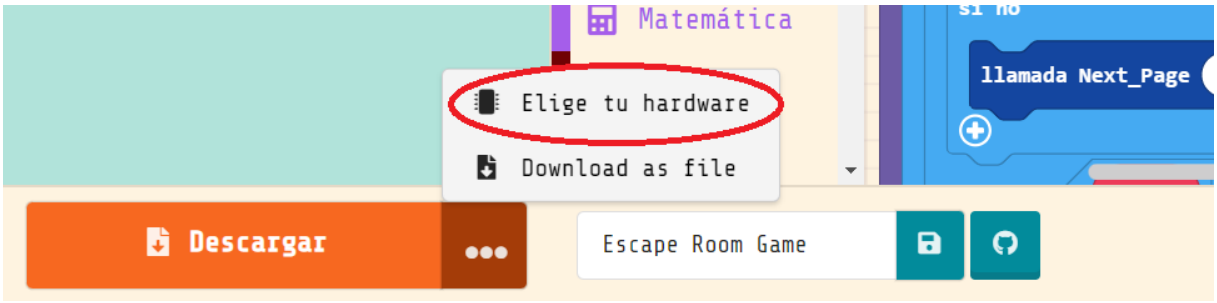
2. Access the website https://arcade.makecode.com/ in the web browser.

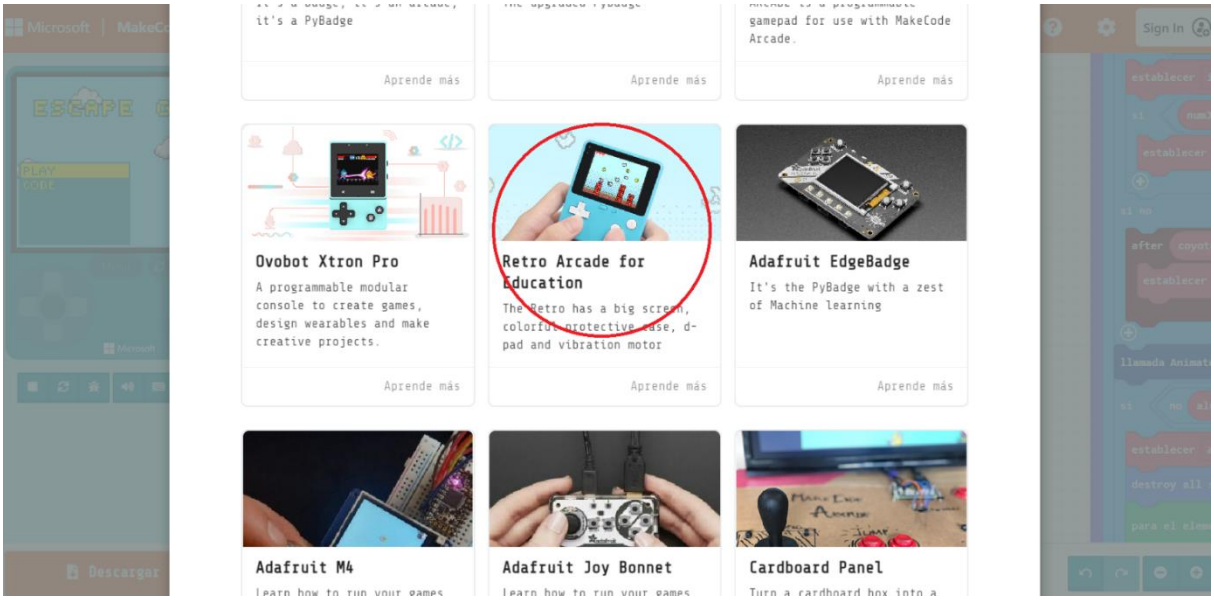
3. Click "Import" and select the file downloaded in step 1.



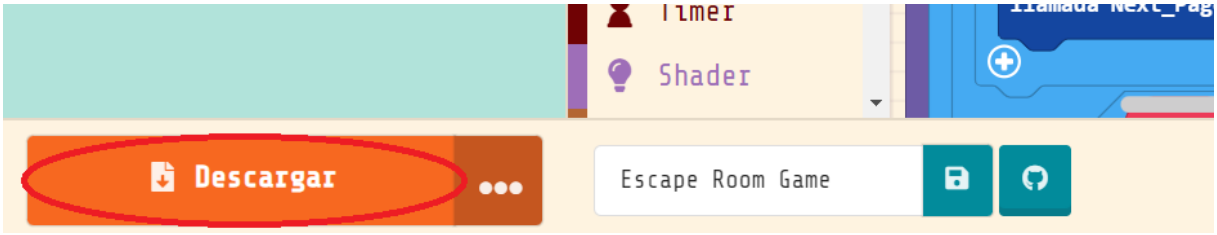
4. Modify the game code as desired. For more details see "Explanatory guide to the video game code".

5. Click on "Choose your hardware" in the bottom left corner and then select Retro Arcade for Education.





6. Click on “Download” to get the new uf2 file.



7. Finally, follow the tutorial "Steps to follow for preparation" with the obtained file.

Steps to take after the end of a game:

1. In the video game select the option "CODE" and then always the first menu option until you return to the main menu.
2. Let the battery of the video console drain.
3. Check the notes related to the puzzle to make sure they are in good condition and have nothing written or scribbled on them.
4. Put everything in the appropriate box.

Box should include:

- Retro Arcade for Education
- USB wire
- Crank

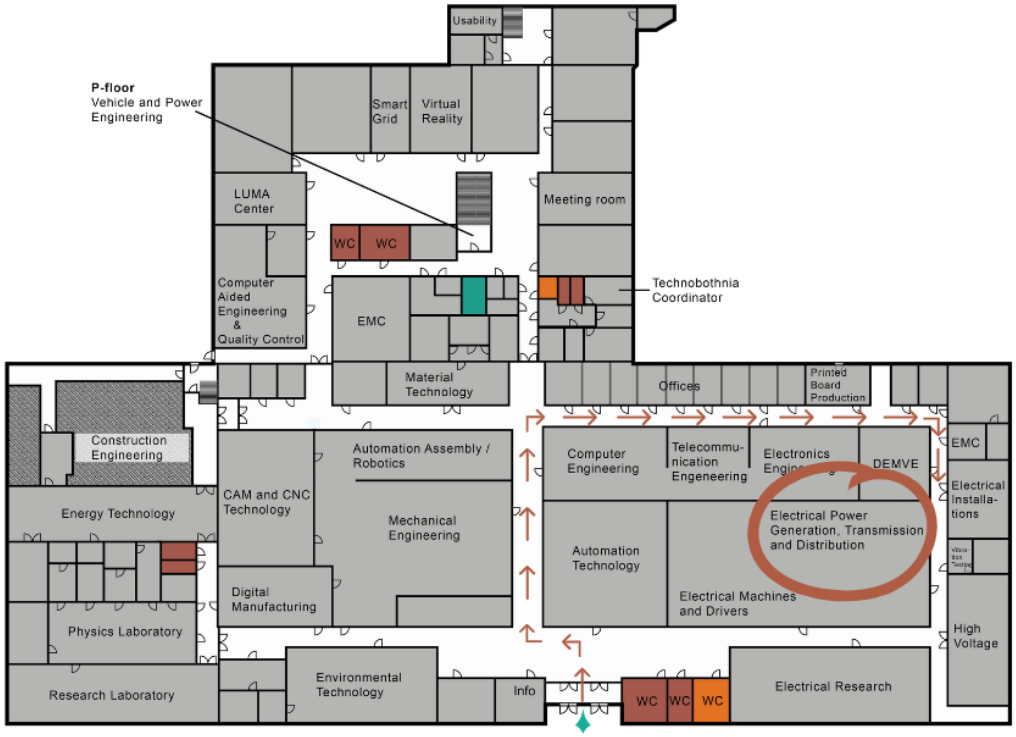
Updated from (Leah Ebert, 2022)

Packaging

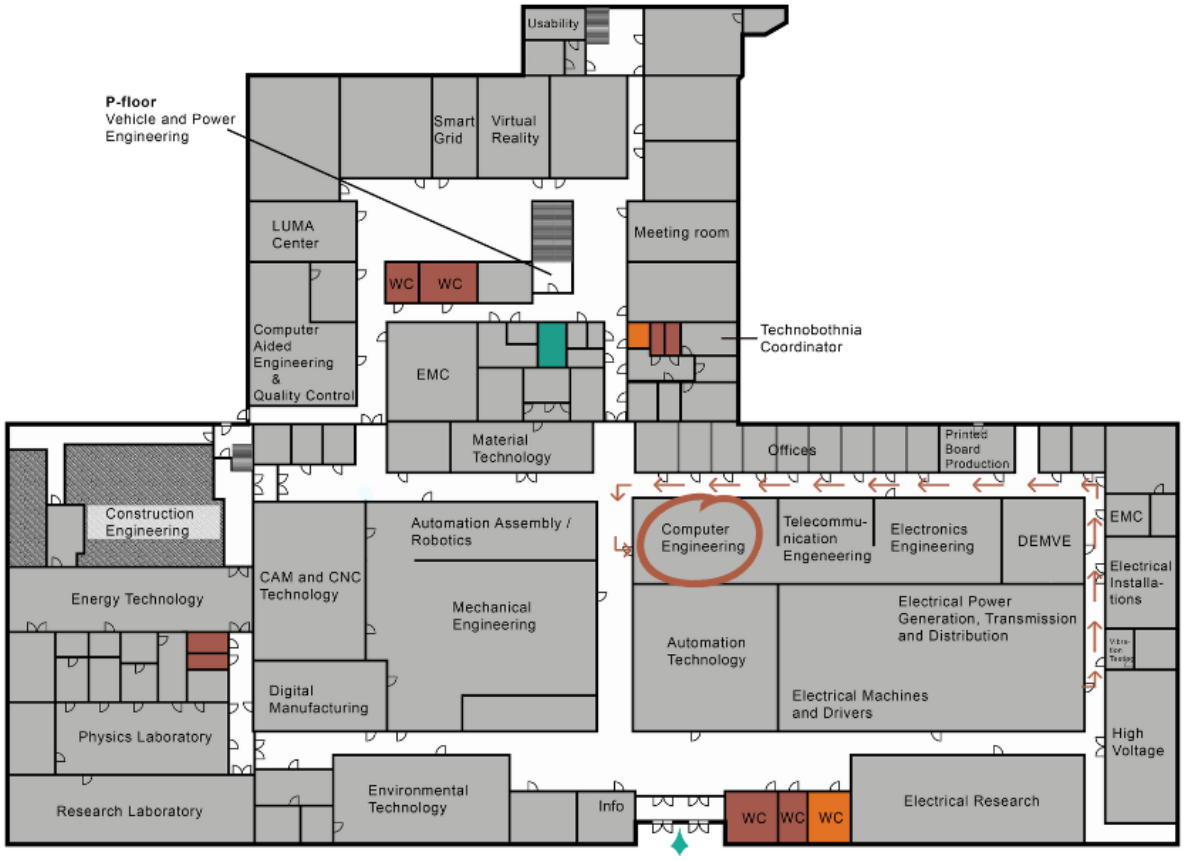
For boxes packaging:
Print the papers under ‘Map design for box packaging A3’, plastify them and stick them in the inside of the box with double-sided tape
For fabric packaging:
Print the papers under ‘Map design for fabric packaging A4’ on textile transfer paper. To attach the prints on the fabric, the heat press in the Fablab can be used. Set the press to 170 degrees and press

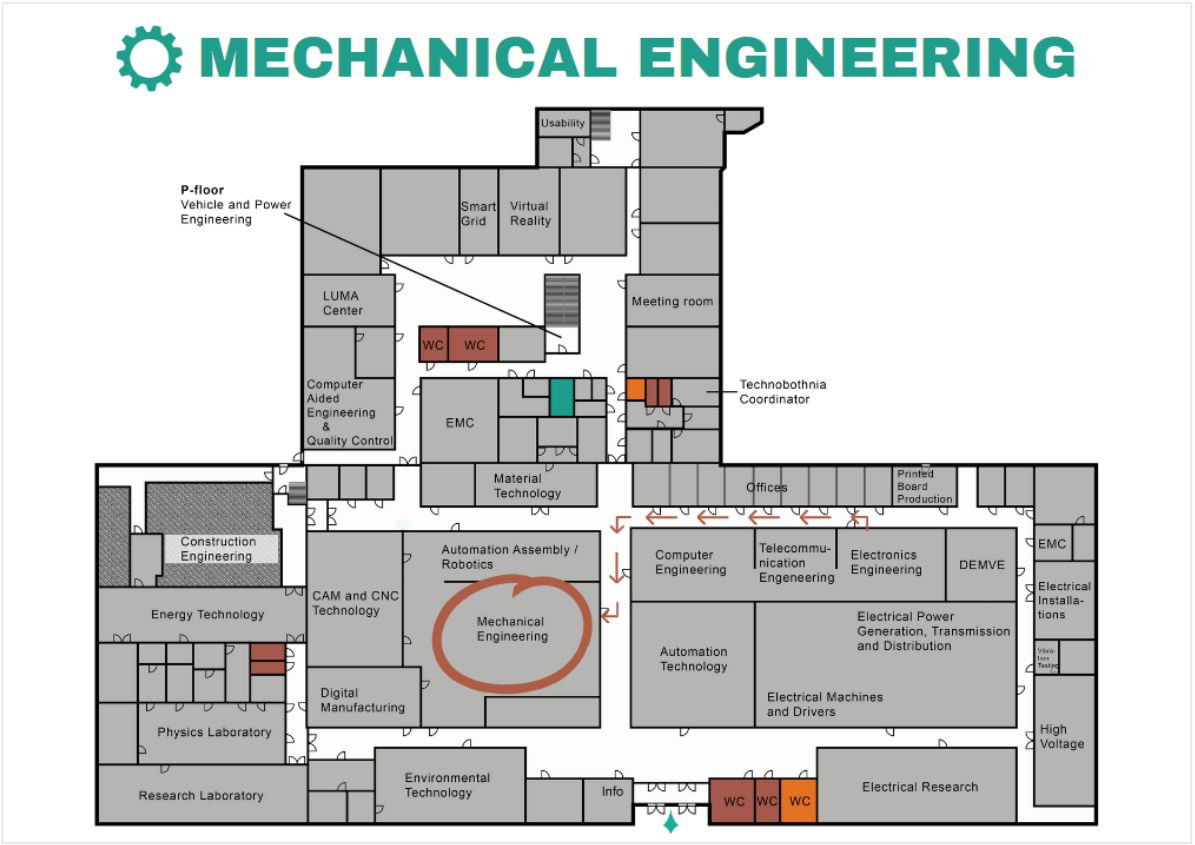
the print for 10 sec. on the textile. These settings may differ depending on the type of transfer paper, so read the instructions on the package from the transfer paper carefully.

ELECTRICAL ENGINEERING

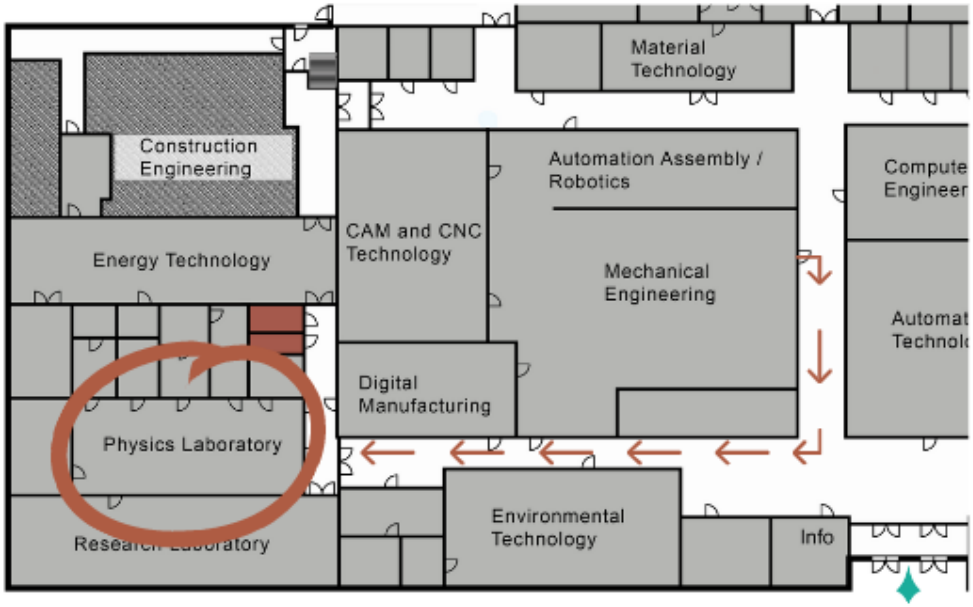


IOIIOO COMPUTER ENGINEERING

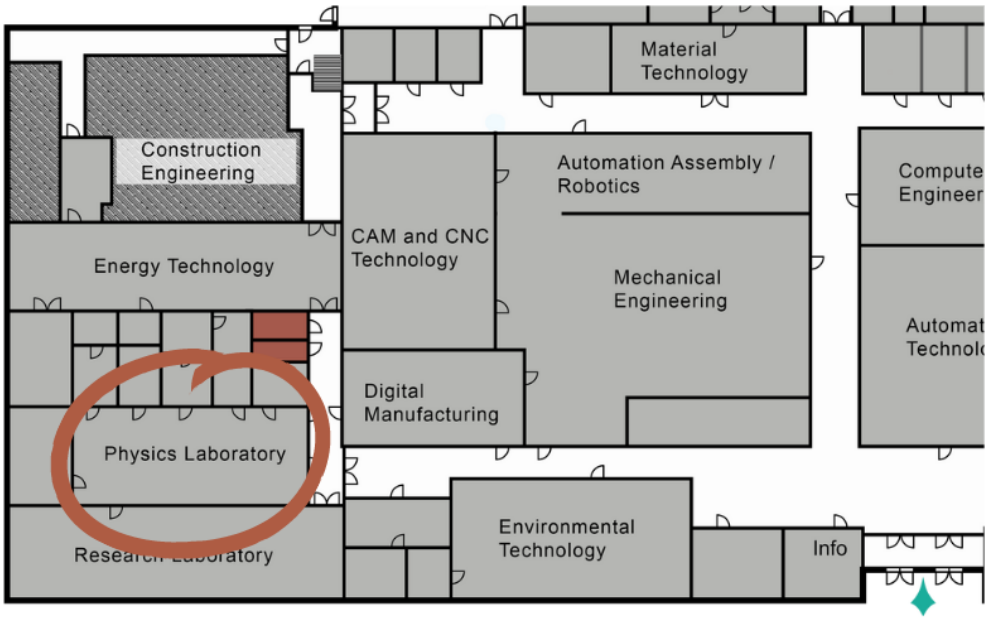


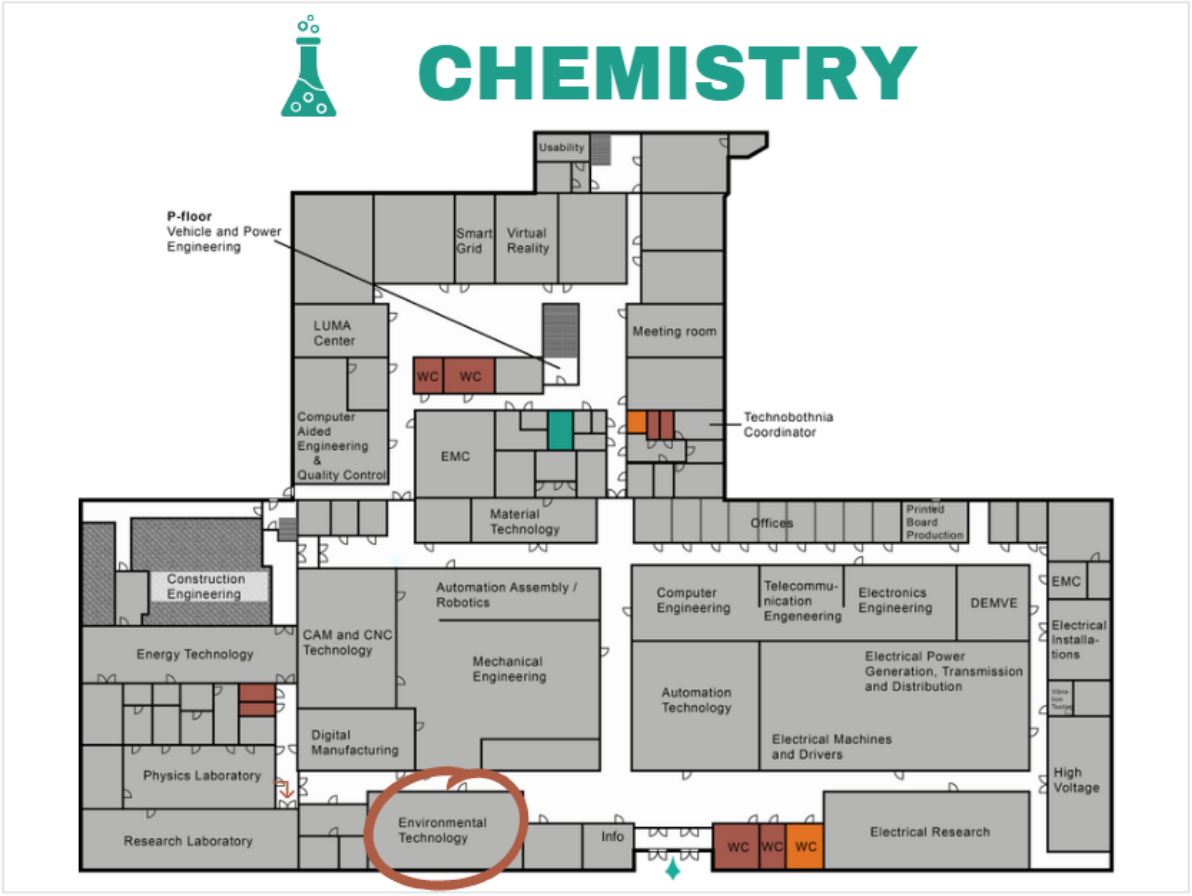

MECHANICAL ENGINEERING
P-floor
Vehicle and Power Engineering
Usability
Smart Grid
Virtual Reality
LUMA Center
Meeting room
WC
WC
Computer Aided Engineering & Quality Control
EMC
Technobothnia Coordinator
Material Technology
Offices
Printed Board Production
Construction Engineering
Automation Assembly / Robotics
Computer Engineering
Telecommu-nication Engeneering
Electronics Engineering
DEMVE
EMC
Electrical Installa-tions
Energy Technology
CAM and CNC Technology
Mechanical Engineering
Automation Technology
Electrical Power Generation, Transmission and Distribution
Digital Manufacturing
Electrical Machines and Drivers
Physics Laboratory
High Voltage
Research Laboratory
Environmental Technology
Info
WC
WC
WC
Electrical Research

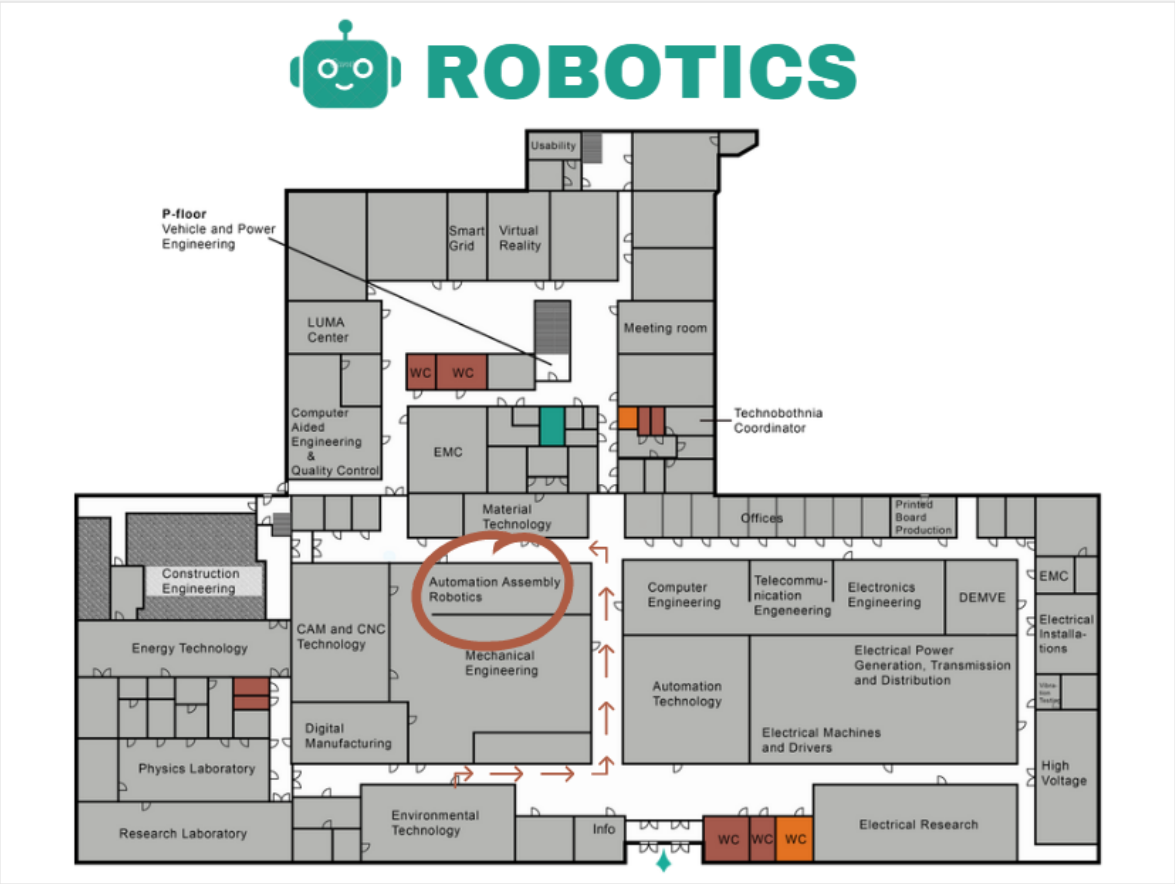
LOGICS



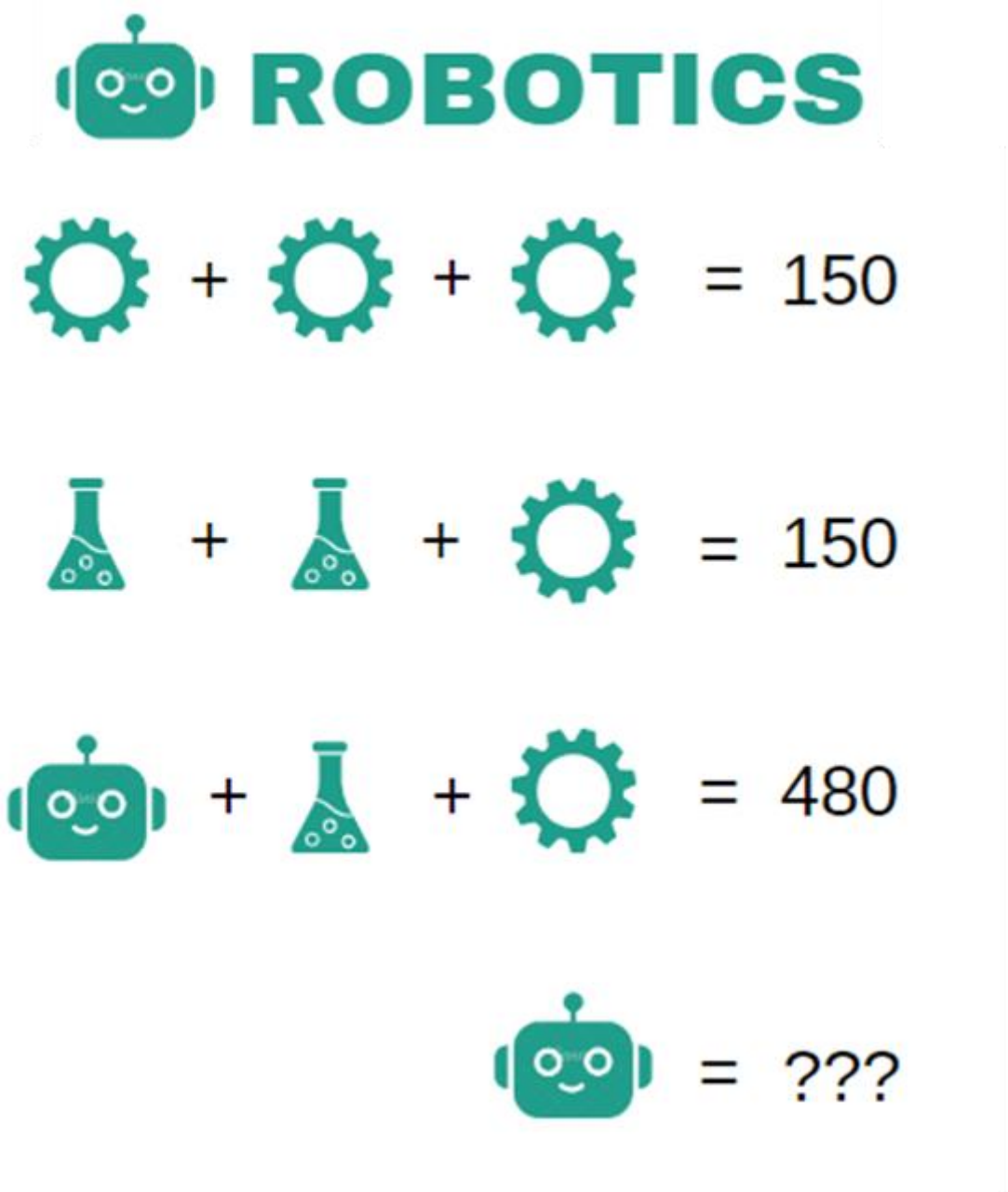
PHYSICS




CHEMISTRY
Usability
P-floor
Vehicle and Power Engineering
Smart Grid
Virtual Reality
LUMA Center
Meeting room
WC
WC
Computer Aided Engineering & Quality Control
EMC
Technobothnia Coordinator
Material Technology
Offices
Printed Board Production
Construction Engineering
Automation Assembly / Robotics
Computer Engineering
Telecommu-nication Engeneering
Electronics Engineering
DEMVE
EMC
Electrical Installa-tions
CAM and CNC Technology
Energy Technology
Mechanical Engineering
Automation Technology
Electrical Power Generation, Transmission and Distribution
Digital Manufacturing
Electrical Machines and Drivers
Physics Laboratory
High Voltage
Environmental Technology
Info
WC
WC
WC
Electrical Research
Research Laboratory



For the robotic arm code:
Print the papers under 'Puzzle robotic arm lock A4', plastify them and stick them on the lock with double-sided tape


ROBOTICS
+ + = 150
+ + = 150
+ + = 480
= ???

Setup-up instructions for teachers

This is an instruction manual for everyone who wants to play our game. In this step-by-step process we guide you through the hole process of setting up the game. It can be that some steps are already done. Then you can go through the following step.

Step 1 (Unpack the suitcase)

Unpack the following materials from the suitcase.

Backpack		Electrical Engineering bag	
Computer Engineering box		Mechanical Engineering box	
Chemistry box		Tablet	
Physics bag		Robotics board	
Logics bag		Locker	

Step 2 (line up everything)

When the suitcase is unpacked make sure you put everything on a table with the tablet for the players and put everything on the table.

Step 3 (check the console)

Open the computer engineering box and take the console and the charging cable out of the box, see figure 3.1. Connect the console with the charging cable to a computer, see figure 3.2. Now the console is turned on, you can see a file transfer screen, see figure 3.3. Press now on the refresh button red market button. If this button doesn't work, go to step 4. Now you see a screen with escape game and play code, see figure 3.4. Select play by using the up and down key and press A, red mark in figure 3.4. if the game starts, if you see the same screen as in figure 3.5 got than to step 4. If the game doesn't start and has a screen that looks like figure 3.6 go to step 9.

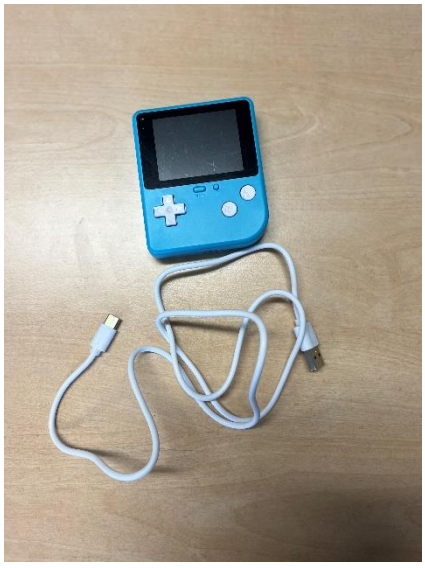


Figure 3.1: console with charging cable

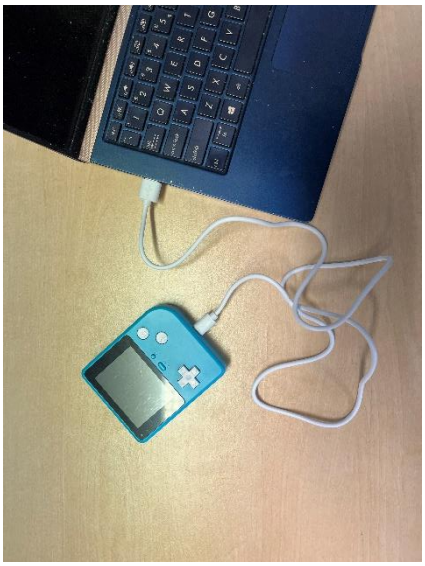


Figure 3.3: file transfer screen

Figu C.

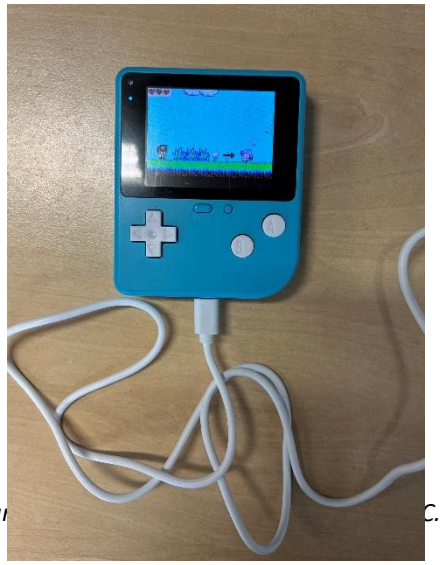


Figure 3.5: Console game screen

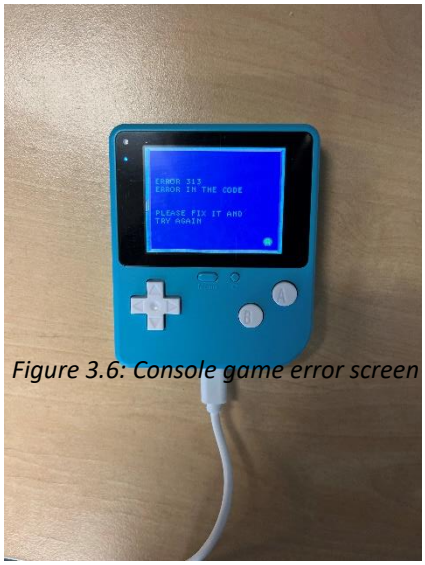


Figure 3.6: Console game error screen

Step 4 (download file)

Upload the file “arcade-escape-room.uf2” from a usb stick and place it somewhere on your computer.

Step 5 (go to the upload screen)

If you aren’t on the file transfer screen, figure 5.2, press than on the refresh button, marked red in figure 5.1.

Figure 5.1: console start screen

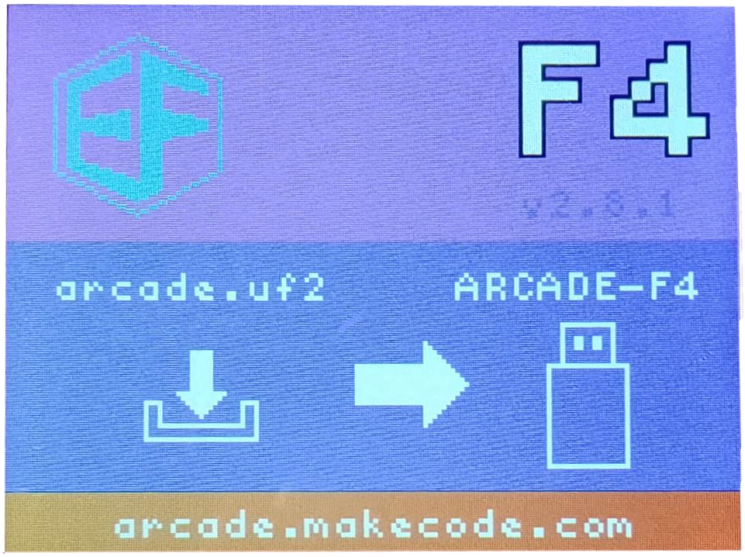


Figure 5.2: file transfer screen

Step 6 (put the game on the console)

Once connected, a similar window should open on the computer. Insert the file with the video game into it.

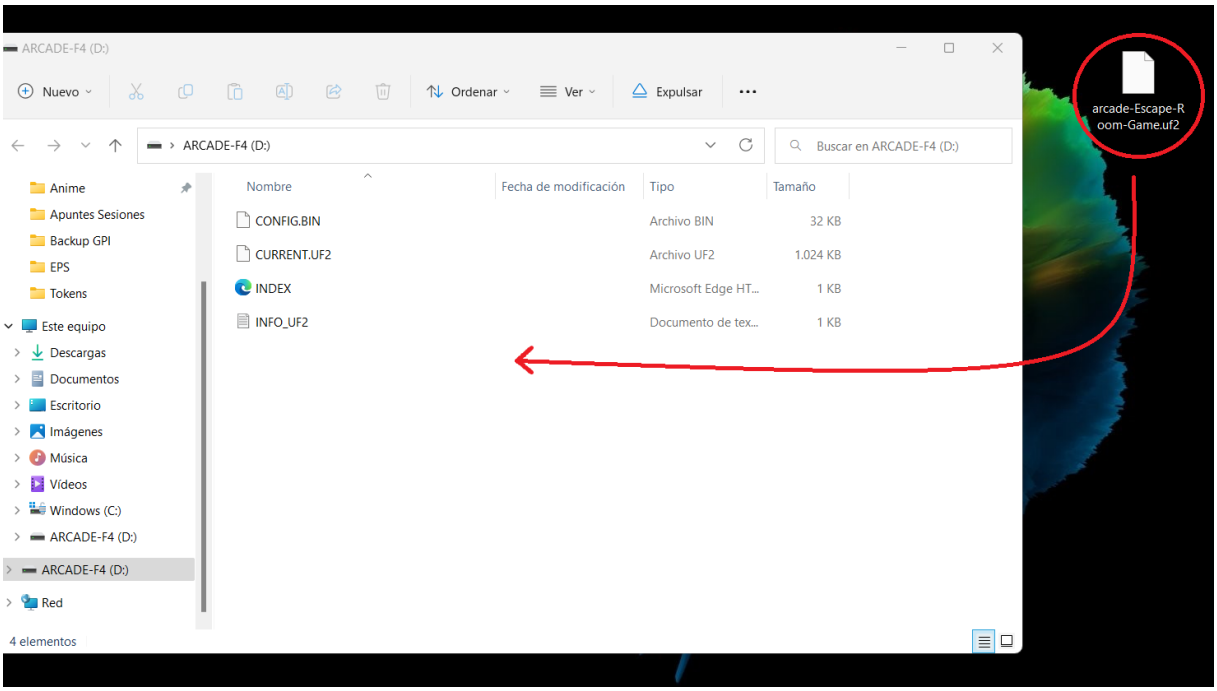


Figure 6: Arcade-F4 folder

Step 7 (the game is running)

After the previous step, the console screen should show the video game running:

Figure 7: console start screen

Step 8 (configure the game)

In the video game select the option "CODE" and then always the first menu option until you return to the main menu. This will ensure that in the future players will have to solve the code correctly before they can play.

Step 9 (disconnect the console)

Disconnect the console from the computer and let the battery drain. And put it back in the Computer Engineering box, sown in figure 9.

Figure 9: Computer engineering box

Step 10 (open the app)

Turn on the tablet by pressing on the turn on and of button, red market in figure 10.1. Then lock screen appears swipe up to unlock the tablet, the red arrow in figure 10.2. The home screen appears, figure 10.3, click on the escaperoomgame app, red marked in figure 10.3. The app now opens, figure 10.4, press on the English button to start the game, red marked in figure 10.4.

Figure 10.1: tablet turned off.

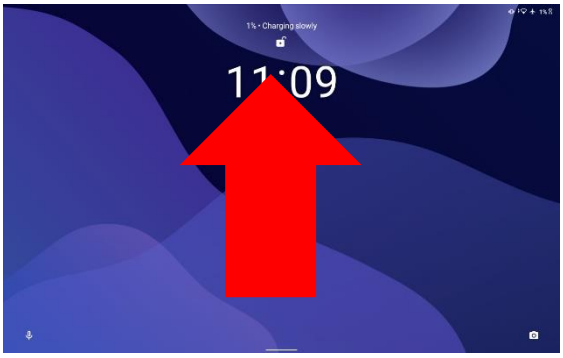


Figure 10.2: lock screen tablet

Figure 10.3: tablet home screen

Figure 10.4: Escape room game home screen